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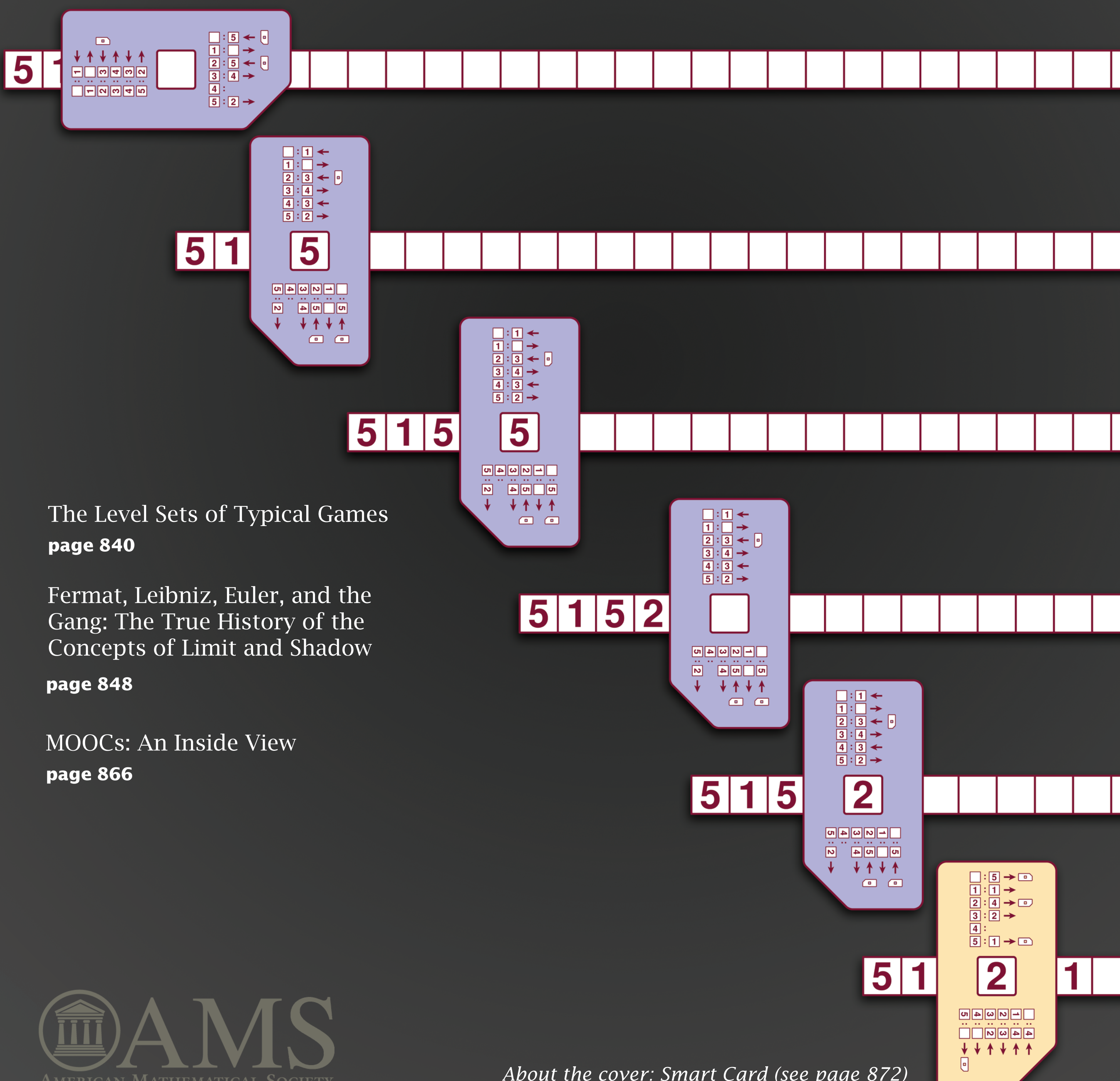

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About the cover: Smart Card (see page 872)

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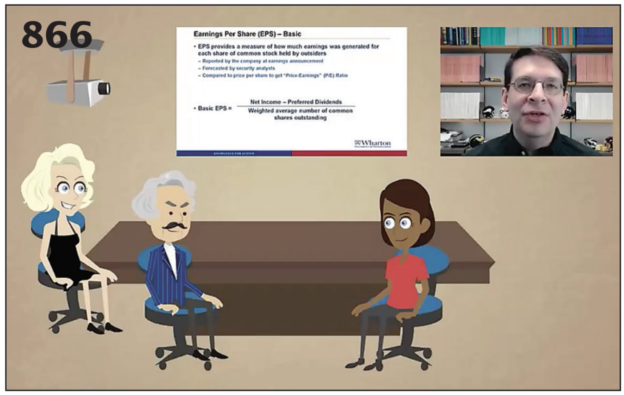
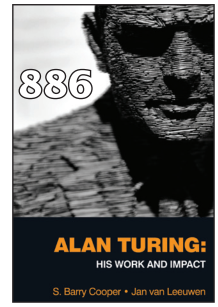
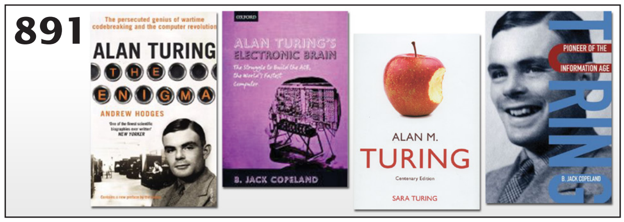
Communications

Commentary







Fall is upon us and the Notices offers stimulating reading as you begin your teaching duties. We feature an article offering an analysis of the level sets of games. There is also a feature about the hot-button topic of MOOCs (Massive Open Online Courses). Finally, we have an article about the history of the limit concept in calculus. We round out the picture with a WHAT IS…? column about periods, and with two particularly stimulating book reviews.

—Steven G. Krantz, Editor

Features

Notices

of the American Mathematical Society

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From the AMS Secretary

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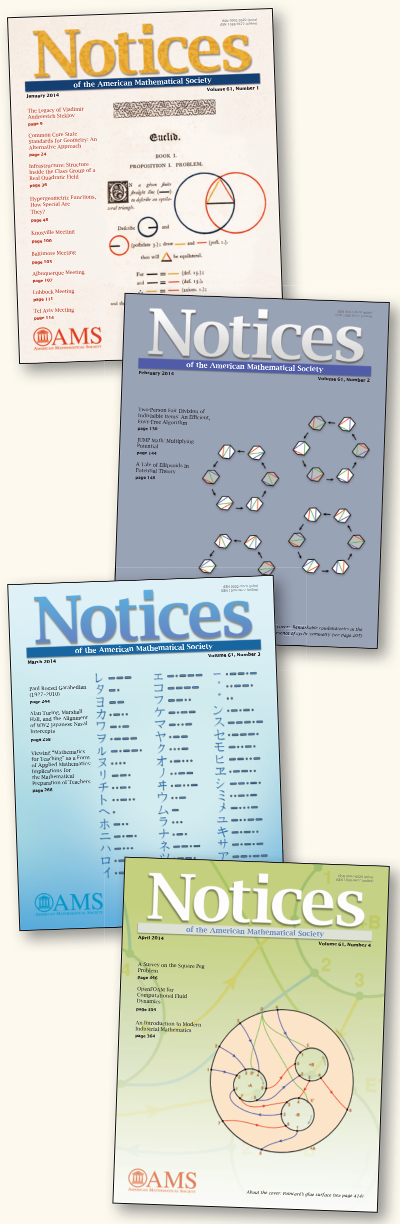
Call for Applications & Nominations

Chief Editor of the *Notices*



Applications and nominations are invited for the position of Editor of the *Notices of the American Mathematical Society*, to commence with the January 2016 issue. The Society seeks an individual with strong mathematical research experience, broad mathematical interests, and a commitment to communicating mathematics to a diverse audience at a wide range of levels. The applicant must demonstrate excellent written communication skills.

The Editor has editorial responsibility for a major portion of the *Notices* within broad guidelines. The goal of the *Notices* is to serve all mathematicians by providing a lively and informative magazine containing exposition about mathematics and mathematicians, and information about the profession and the Society.

The Editor is assisted by a board of Associate Editors, nominated by the Editor, who help to fashion the contents of the *Notices* and solicit material for publication. Some writing, and all publication support, will be provided by AMS staff in Providence. The Editor will operate from his or her home institution with part-time secretarial support. In order to begin working on the January 2016 issue, some editorial work would begin in early 2015.

Nominations and applications (including curriculum vitae) should be sent to the Executive Director, Donald E. McClure, at exdir@ams.org. Confidential inquiries may also be sent directly to the Executive Director or to any other member of the search committee (Dan Abramovich, Amber Puha, Carla Savage, or David Vogan).

To receive full consideration, nominations and applications should be sent on or before August 31, 2014.

AMERICAN MATHEMATICAL SOCIETY

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The Level Sets of Typical Games

Julie Rowlett

What is a noncooperative game? You probably know the Rock-Paper-Scissors (RPS) game. Let's play: ready, set, go! What did you choose? I chose rock. If you chose scissors, then I win, because rock crushes scissors. If you chose paper, then you win, because paper covers rock. If you also chose rock, then it's a draw. This is an example of a two-player game in which each player has the same three pure strategies: rock, paper, and scissors. In order for this game to have any significance, we ought to define a *payoff function.* For example, we could say the winner receives \$1, which the loser must pay to the winner, so the loser's payoff is $-\$1$. If it's a draw, then neither of us receives anything, so the payoffs are both 0.

This is an example of what we'll call a *discrete game.* A more general notion is a continuous game, also called a mixed game, which we will simply call a *game.* Rather than just thinking about playing the game once, we think of the game being repeated an arbitrary or possibly infinite number of times. Instead of deciding upon one of rock, paper, or scissors, we decide upon a probability distribution which is a list of three numbers corresponding to the probabilities of drawing rock, paper, or scissors. The sum of these three numbers is 1, because we assume that we must draw something. One example is $(1/3, 1/3, 1/3)$, which means the probabilities of drawing rock, paper, or scissors are equal to 1/3. If you only want to draw rock, then your probability distribution would be $(1, 0, 0)$. We can use these to compute our *expected payoffs;* these are known as *expected values* in probability theory. The expected payoff is the sum of the probabilities of each possible outcome multiplied with the payoff according to that outcome. For me, there is a 1/3 chance I will win, which happens if I draw paper; there is a 1/3 chance I will lose, which happens if I draw scissors; and there is a 1/3 chance we will have a draw, which happens if I also draw rock. Summing these probabilities multiplied with the corresponding payoffs, my expected payoff is

$$\$1 * \frac{1}{3} + -\$1 * \frac{1}{3} + 0 * \frac{1}{3} = 0.$$

In your case, there is also a 1/3 chance you will win, which happens if I draw scissors; and there is a 1/3 chance you will lose, which happens if I draw paper; and there is a 1/3 chance we will have a draw, which happens if I draw rock. So, your expected payoff is also

$$\$1 * \frac{1}{3} + -\$1 * \frac{1}{3} + 0 * \frac{1}{3} = 0.$$

More generally, if my probability distribution is (a, b, c), and yours is (x, y, z), corresponding to probabilities of executing rock, paper, or scissors, respectively, then we compute my expected payoff as

$$-ay + az + bx - bz + cy - cx.$$

Exercise 1. *What is your expected payoff?*

For those of you with some background in game theory, you know that RPS is an example of a two-player, symmetric, zero-sum game which can be given in normal form. We will see how to express RPS in normal form in the section entitled "Preliminaries". The general field of game theory is enormous and has connections to many areas of mathematics, including geometry and analysis. It would be quite bold to claim to present an exhaustive survey of games and game theory. Instead, I would like to present an introduction to games which are especially appealing to geometric analysts. A *noncooperative (continuous) game,* which we will simply call a game, is canonically identified with a *payoff function,* from $\mathbb{R}^N$ to $\mathbb{R}^n$, where n is the number of players, and N is the total number of pure strategies summed over all players. This

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function will be assumed to be consistent with the definition of expected payoff and expected value.

Exercise 2. *What are n and N in the RPS game?*

For mathematicians in the fields of analysis and geometry, these games are appealing because we can prove theorems about them using the tools of geometry and analysis. A perfect example is the Nobel-prize winning Nash Equilibrium Theorem. To state this, we need a few definitions.

In an n-player game, each player has some number of pure strategies, like rock, paper, and scissors. For more general games it is possible that, unlike in RPS, different players have different sets of pure strategies. We will use m_i to denote the number of pure strategies the i^{th} player has. A *strategy* for the i^{th} player is a list of m_i nonnegative numbers which sum to 1. These correspond to the probabilities of executing each pure strategy. Note that these are sometimes called mixed strategies, but since they include the pure strategies, we will simply call them strategies. We can identify each pure strategy with a unit vector in $\mathbb{R}^{m_i}$, because each pure strategy means doing that strategy with probability 1, and the others with probability 0. So, for instance in RPS, we could identify $(1,0,0) \in \mathbb{R}^3$ with rock, $(0,1,0) \in \mathbb{R}^3$ with paper, and $(0,0,1) \in \mathbb{R}^3$ with scissors.

The set of strategies for the i^{th} player is the set of all m_i-tuples $(c_1, c_2, \ldots, c_{m_i})$ such that

$$(1) \qquad 0 \le c_j \le 1, \quad j = 1, 2, \ldots, m_i, \quad \sum_{j=1}^{m_i} c_j = 1.$$

This is nice for geometers because we can geometrically represent the set of strategies for the i^{th} player as the convex hull of the standard unit vectors $\{e_1, e_2, \ldots, e_{m_i}\}$ in $\mathbb{R}^{m_i}$. The pure strategies are the vertices of this convex set. We will represent this set by $\mathfrak{S}_i$ and the total strategy space for all players,

$$\mathfrak{S} = \prod_{i=1}^{n} \mathfrak{S}_i.$$

The total strategy space is the product of each of the strategy spaces, so we can view this as a subset of $\mathbb{R}^N$, where

$$N := \sum_{i=1}^{n} m_i.$$

The game is represented by n payoff functions which give the expected payoff to each player determined by the strategies across all players

$$\wp_i : \mathfrak{S} \to \mathbb{R}, \quad i = 1, \ldots, n.$$

Exercise 3. *Prove that, in order for the payoff function to correspond to the expected value given by the probability distributions over pure strategies, each player's payoff function must be linear in the strategy of that player.*

This means that, if all other players' strategies are fixed, then each $\wp_i : \mathfrak{S}_i \to \mathbb{R}$ is a linear function.

The (total) payoff function is

$$\wp : \mathfrak{S} \to \mathbb{R}^n, \quad \wp = (\wp_1, \wp_2, \ldots, \wp_n).$$

Each component function $\wp_i$ of the total payoff function depends on the strategies of *all* players. Although each function $\wp_i$ is a linear function on $\mathfrak{S}_i$ alone, it need *not* in general be simultaneously linear in the strategies of the other players. For example, the i^{th} player's payoff could depend on the j^{th} player's strategy in a *nonlinear* way. We will see more about this in the section called "Main Result".

Now, let us introduce the last bit of notation necessary to state Nash's celebrated theorem. For $s \in \mathfrak{S}$ and $\sigma \in \mathfrak{S}_i$ let $(s; i; \sigma)$ be the strategy in which the i^{th} player's strategy is replaced by σ, and all other players' strategies are given by s. An *equilibrium strategy,* which is also called an *equilibrium point,* is $s \in \mathfrak{S}$ such that

$$\wp_i(s) \ge \wp_i(s; i; \sigma) \quad \forall \sigma \in \mathfrak{S}_i, \quad \forall i = 1, 2, \ldots, n.$$

This means that no player can increase his payoff by changing his strategy if the strategies of the other players remain fixed.

Theorem 1 (Nash)**.** *There exists at least one equilibrium strategy in $\mathfrak{S}$.*

The proof is a clever application of the Kakutani Fixed Point Theorem. Nash defined a function which has a fixed point precisely at an equilibrium point. He then used the continuity of the total payoff function and the Fixed Point Theorem to prove that this cleverly defined function must have at least one fixed point.

In the spirit of Nash's theorem, one can apply geometric analysis to prove a characterization of the level sets of the total payoff function for most games. We begin in the section entitled "Preliminaries" with an example from popular culture and a preliminary result based on linear algebra. We will see in "Main Result" that continuity of the payoff function and further properties follow from its definition and use these properties to prove the main theorem. This result is already recognized by game theorists; see for example [23]. Nonetheless the proof is instructive for readers learning the theory of noncooperative games and combines elements of analysis, geometry, geometric measure theory, and algebraic geometry, yet deep knowledge of these areas is not required. Consequently, we hope the reader also finds the result and its proof interesting. Although this theorem does not appear to be new, we have made a novel application in biology to the "paradox of the plankton", which is described in the section called "Applications."

Preliminaries

In the film "A Beautiful Mind," based on the life and work of John Nash [19], there is a scene which purportedly depicts Theorem 1.

A Beautiful Mind

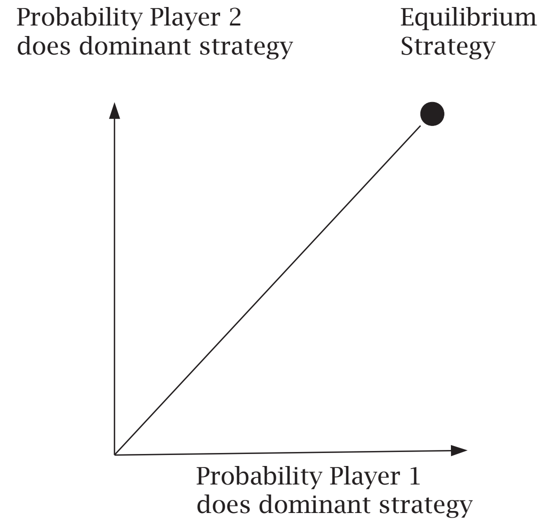
In this scene Nash is together with a group of male colleagues at a bar as a group of women enters. One woman is depicted as being thought of as the most attractive to the men, whereas the other women are depicted as being considered only of average attractiveness to the men. In a flash of insight, Nash's character apparently realizes that he can apply the mathematics he has been studying to determine the best course of action for the men: he imagines each of the men approaching a different, averagely attractive woman and leaving with her, whereas the most attractive woman is left alone. At this point Nash hurriedly leaves the bar to work on his new insight.

The situation is depicted as a competition between the men, where each man decides without communicating with the others which woman he will court. This corresponds to a noncooperative game. For simplicity, let's assume there are 2 men, denoted by man 1 and man 2, and 3 women, denoted by "M" (for most attractive) and "A" (for averagely attractive). Each man has two pure strategies: M which corresponds to courting the most attractive woman, and A which corresponds to courting one of the averagely attractive women. The *normal form* of the game is the following.

	M	A
M	(0, 0)	(1, −1)
A	(−1, 1)	(0, 0)

This is also known as a *payoff matrix,* since it lists the payoffs to each player according to the corresponding strategies. This is an example of a two-player, symmetric, zero-sum game, with one dominant (winning) strategy. The winning strategy is successfully courting the most attractive woman. The interpretation of the payoffs is that if both men do strategy M, then they are both unsuccessful. This means that neither man has won, so they each receive a neutral payoff, 0. Similarly, if both men do strategy A, and presumably each court a different woman, then they are both successful, but since neither man has won, they each receive a neutral payoff. In the last case one man does strategy M while the other does strategy A, and so the man doing M has won and receives a payoff of 1, whereas the other man can be seen as the loser and receives a payoff of −1.

Exercise 4. *Represent the rock-paper-scissors game in normal form.*



For a two-player, symmetric, zero-sum game with one dominant strategy, the level sets of the total payoff function are line segments. This depicts the general idea of Theorem 2; the level sets of most games almost always have positive j-dimensional Hausdorff measure for some $j \geq 1$.

If the probability that man 1 does M is x, and the probability that man 2 does M is y, then the payoff functions are

$$\wp_1(x, y) = x - y, \quad \wp_2(x, y) = y - x.$$

Exercise 5. *Show that the unique equilibrium strategy is $x = y = 1$.*

The interpretation of the equilibrium strategy is that both men should with probability 1 attempt to court the most attractive woman. This contradicts the film which indicates that the equilibrium strategy ought to be $x = y = 0$.

One possible explanation is that, if indeed the above model was used to determine the best strategy for the characters in the film, perhaps the filmmakers understood that the payoff according to the equilibrium strategy is $(0, 0)$. There is precisely one strategy contained in the level set $\wp^{-1}(0, 0) = \{0 \leq x = y \leq 1\}$ for which each man pairs up with a woman with probability 1, and that is the strategy $(x = y = 0)$ given in the film. While not the equilibrium strategy, it is just as good in the sense that the payoff is identical to the payoff according to the equilibrium strategy, so perhaps this is the reason it is considered to be the best.

It may however seem more natural to define the game with a different payoff matrix.

Exercise 6. *Is it possible to define a game in normal form such that the equilibrium strategy is consistent with the film?*

For the solution to this exercise, see [1].

Linear Payoff Functions

While it is always true that the i^{th} player's payoff function depends linearly on his own strategy, it need not be the case that his payoff function also depends linearly on the *other* players' strategies. If, however, this is the case, then we can prove the following result. This is a good warm-up for the more general characterization of the level sets of payoff functions for typical games.

Proposition 1. *For an n-player game, assume that each player has at least two pure strategies and at least one of the following holds.*

(1) *At least one player has three or more pure strategies.*
(2) *The game is zero-sum.*

Let N denote the total number of pure strategies over all players as above. If only (1) holds, let $k = N - 2n$. If (2) holds, let $k = N - 2n + 1$. If the payoff functions are all linear functions in the strategies of all players, then the level sets of the total payoff function are affine linear subsets of dimension $j \geq k$, where j is given in the proof below.

Recall that a game is *zero-sum* precisely when, for each $s \in \mathbb{S}$,

$$\sum_{i=1}^{n} \wp_i(s) = 0. \tag{2}$$

Zero-sum games imply that gains by some players are met by equal losses to other players and can therefore be used to model competition for limited resources.

Proof. Do you remember the Rank-Nullity Theorem from linear algebra? This theorem states that, for an $m \times n$ matrix, the sum of the dimension of the column space (rank) together with the dimension of the kernel (nullity) is equal to n. The idea is that if one uses Gauss-Jordan elimination to put the matrix in row-reduced echelon form, then each column is either a pivot column or not. The number of pivot columns is the rank, and the number of nonpivot columns is the nullity. This number must sum up to the total number of columns, and that is n. So, what does this mean if we have a matrix which is longer than it is tall, so that $n > m$? Since the column space is the dimension of the space spanned by the columns, and each column is an element of $\mathbb{R}^m$, this dimension is at most m. Since $n > m$, the nullity must be at least $n - m$. It turns out that the payoff function $\wp$ for most games can be canonically identified with a map from a higher-dimensional Euclidean space to a lower-dimensional Euclidean space.

Exercise 7. *Show that the strategy space $\mathbb{S}$ is an $N - n$-dimensional subset of $\mathbb{R}^N$. Using* (2) *if the game is zero-sum, show that the payoff function is canonically identified with a map from $\mathbb{R}^{N-n}$ to $\mathbb{R}^{N-n-k}$.*

Since the payoff function can be represented by an affine linear function from $\mathbb{R}^{N-n}$ to $\mathbb{R}^{N-n-k}$, there exists an $(N-n-k) \times (N-n)$ matrix M and an $(N-n-k) \times 1$ vector b such that $\wp(s) = Ms + b$. The level sets of $\wp$ are translations of the kernel of M, and since M is k-columns wider than it is tall, by the Rank-Nullity Theorem the dimension of the kernel of M is $j \geq k$. □

This proposition may be helpful in familiarizing readers with games and payoff functions, since it relies only on the definitions and linear algebra. What is more interesting is that this result can be generalized to payoff functions which are *not* linear in the strategies of *all* players. The assumptions (1) and (2) above are satisfied by a "typical game," because if a player has only one pure strategy, then he cannot affect the outcome of play, so his role is trivial. Moreover, many games have at least three pure strategies per player and/or are zero-sum.

Main Result

While John Nash was a graduate student at Princeton in 1950, he proved the existence of equilibrium strategies for noncooperative games [19]. In 1952, he published *Real Algebraic Manifolds* and proved that two real algebraic manifolds are equivalent if and only if they are analytically homeomorphic [20]. He then proceeded in 1954–1956 to study the imbedding problem for Riemannian manifolds [21], [22]. That work involved what are now known as Nash functions and Nash manifolds; the payoff functions considered here are examples of Nash functions. Based on his work in game theory, differential geometry, and algebraic geometry, we can be pretty sure that Nash was the first to recognize this result and therefore acknowledge it to him.[1]

Theorem 2 (Nash)**.** *For an n-player game, assume that each player has at least two pure strategies, and at least one of the following holds.*

(1) *At least one player has three or more pure strategies.*
(2) *The game is zero-sum.*

The image $\wp(\mathbb{S})$ is then a k-dimensional semialgebraic set for some $k \leq n$ in case only (1) holds or $k \leq n - 1$ in case (2) holds. For almost every $y \in \wp(\mathbb{S})$ with respect to k-dimensional Hausdorff measure, the level set $\wp^{-1}(y)$ has positive (or infinite) $N - n - k$-dimensional Hausdorff measure, noting that $N - n - k \geq 1$.

[1] *The author would like to note that this result and its proof, although implicitly or explicitly known by experts, was obtained independently.*

Proof. The main idea is to put a game which satisfies these hypotheses in normal form. The strategy space is

$$\mathfrak{S} \cong \prod_{i=1}^{n} \mathfrak{S}_i,$$

$$\mathfrak{S}_i \cong \left\{ \sum_{j=1}^{m_i} c_j e_j \in \mathbb{R}^{m_i} : 0 \le c_j \le 1,\ \sum_{j=1}^{m_i} c_j = 1 \right\},$$

where e_j are used to denote the standard unit vectors in Euclidean space. The normal form of a game lists the payoffs to all players corresponding to all possible combinations of pure strategies. These combinations of pure strategies geometrically correspond to the vertices of $\mathfrak{S}$. We denote this set by $\mathcal{V}$ and use binary expansions of integers to represent the elements of $\mathcal{V}$. There are

$$M := \prod_{i=1}^{n} m_i$$

elements of $\mathcal{V}$. Each element is of the form

$$v_x = \sum_{j=1}^{N} x_j e_j,\ x_j \in \{0, 1\}\ \forall j,$$

$$x := \sum_{j=1}^{N} x_j 2^j \in \{2, 4, \ldots, 2^{N+1} - 2\}.$$

So we see that each vertex v_x corresponds to a unique x, because binary expansions are unique (see Chapter 6 of [26]). There is one further restriction on the vertices: each player executes *one* pure strategy at a vertex v_x. Mathematically we can express this using the orthogonal projections

$$\phi_i : \mathfrak{S} \to \mathfrak{S}_i,$$

together with

$$\mathbb{1}_i := \sum_{j=1}^{m_i} e_j,$$

so that

$$\phi_i(v_x) \cdot \mathbb{1}_i = 1, \quad \forall i = 1, \ldots, n.$$

The normal form for such a game would in this generality be a rather large matrix. Each player requires one dimension, so the matrix is n-dimensional. Along the i^{th} dimension there are m_i slots, corresponding to each of the m_i possible pure strategies for the i^{th} player. In an entry of this matrix, we list the payoffs to each player for the corresponding list of pure strategies. Once we know all these payoffs, then just like the RPS game, we can write the payoff for any mixed strategy, because this must be consistent with the expected value. So, for a strategy

$$s = \sum_{j=1}^{N} c_j e_j \in \mathfrak{S}, \quad \wp_i(s) = \sum_{v_x \in \mathcal{V}} \text{Prob}_{v_x}(s) \wp_i(v_x).$$

Above, we used $\text{Prob}_{v_x}(s)$ to denote the probability according to s of the combination of pure strategies in v_x. This is the product of the probabilities according to s of each pure strategy in v_x,

$$\text{Prob}_{v_x}(s) = \prod_{j=1}^{N} x_j c_j.$$

So what does this mean? The payoff functions are

$$\wp_i(s) = \sum_{v_x \in \mathcal{V}} \left(\prod_{j=1}^{N} x_j c_j \right) \wp_i(v_x).$$

The important observation is that this is a polynomial function in the variables $\{c_j\}_{j=1}^N$. The total payoff function is therefore a real polynomial function from $\mathfrak{S} \subset \mathbb{R}^N \to \mathbb{R}^n$. Since $\mathfrak{S}$ is defined by a finite set of inequalities and linear equations, it is by definition a semialgebraic set (see Definition 2.1.4 on p. 24 of [3]). By the Tarski-Seidenberg Theorem (see pp. 28–29 of [3]), $\wp(\mathfrak{S})$ is also a semialgebraic set. Such a set has the structure of a stratified space, which is a disjoint union of a finite number of smooth manifolds (strata) which are themselves semialgebraic sets, and such that this stratification can be taken to satisfy the Whitney conditions [14]. In this case, since the payoff function is continuous, and $\mathfrak{S}$ is compact, the image $\wp(\mathfrak{S})$ is compact, and so this semialgebraic set is triangulable and is semialgebraically isomorphic to a finite polyhedron [14]. It has some dimension $k \le n$. Note that if the game is zero-sum, then

$$\wp_n(s) = 1 - \sum_{i=1}^{n-1} \wp_i(s),$$

which implies that $\wp(\mathfrak{S})$ has dimension $k \le n - 1$. The level sets, $\wp^{-1}(\wp(s))$ for $\wp(s) \in \wp(\mathfrak{S})$ are known in this setting as fibers. By Theorem 9.3.2 and Corollary 9.3.3 on pp. 221–224 of [3], we can decompose $\wp(\mathfrak{S})$ as the union of semialgebraic sets

$$\wp(\mathfrak{S}) = \bigcup_{l=0}^{L} T_l,\ \dim(T_0) = k,\ \dim(T_l) < k,\ \forall l \ge 1,$$

such that each T_l is closed for $l \ge 1$, and $\wp$ has a semialgebraic trivialization over each T_l. This means that, for each l, the fibers $\wp^{-1}(y)$ have dimension d_l for all $y \in T_l$. By removing the lower-dimensional strata, T_0 is an open k-dimensional semialgebraic set. By Proposition 2.38 on p. 71 of [2], $\wp^{-1}(T_0)$ is an open semialgebraic set (openness follows since $\wp$ is a polynomial and therefore continuous). By the Semialgebraic Sard Theorem (see Theorem 9.6.2 on p. 235 of [3]) the set of critical values in T_0 has dimension strictly smaller than k. At a regular (not critical) point, the derivative matrix $D\wp(s)$ has rank equal to k, and the level set $\wp^{-1}(\wp(s))$ is an $N - n - k$-dimensional submanifold of $\mathfrak{S}$ (recall that $\mathfrak{S}$ is $N - n$-dimensional).

Since the dimension of the fibers over T_0 are all the same, this means that the level sets $\wp^{-1}(y)$ have dimension $N - n - k$ for all $y \in T_0$. Furthermore the sets $\wp(\mathbb{S})$ and T_0 differ by a set of zero k-dimensional Hausdorff measure. Consequently, for almost all (with respect to k-dimensional Hausdorff measure) $y \in \wp(\mathbb{S})$, the level set $\wp^{-1}(y)$ is an $N - n - k$-dimensional submanifold and therefore has positive (or infinite) $N - n - k$-dimensional Hausdorff measure. □

Remark 1. One could likely say more about the structure of the level sets (fibers) using the tools of real algebraic geometry; references include [3], [4], [2], [28], [10]. For our biological application discussed in the section "Applications," the above theorem was sufficient.

Bibliographical Note

Since I was rather new to game theory, it was natural to search the literature for results concerning the level sets of payoff functions. In [15], the level sets of the value (payoff) function for linear differential games of fixed terminal time with a convex payoff function were numerically investigated. For a linear pursuit-evasion game with two pursuers and one evader, the level sets of the value function were numerically studied in [8]. For zero-sum games, [29] studied a certain Hamiltonian flow which can be used to study the best response dynamic in two-person games, and showed that under certain assumptions the level sets of the associated Hamiltonian function are topological spheres. Further examples of the study of the level sets of the payoff functions for specific games include [18], [24], [25], and [27]. Investigating connections between real algebraic geometry and game theory led to Neyman's work including [23]. It appears that many results in game theory tend to be more computational whereas the results in real algebraic geometry tend to be more theoretical. We hope to encourage further communication between game theorists and real algebraic geometers.

Applications

The structure of the level sets of the payoff functions has a novel application to biology by providing a new and rigorous solution to the long-standing "paradox of the plankton" in [16].

Biodiversity of Micro-Organisms

The "paradox of the plankton" coined by Hutchinson in 1961 [13] is the observation that the number of co-existing plankton species appears to contradict the explicable number based on competition theory [11], [9]. The number of co-existing species is orders of magnitude larger than expected, based on competition theories and predictions which yield reasonably accurate numbers for macro-organisms. There have been numerous explanations proposed by biologists, but a mathematical theory consistent with all these explanations, which is based on a biological factor subject to natural selection and is not in contradiction with competition theory, appears to have been missing. In [16], we realized that Theorem 2 has implications for a game modeling competition of plankton organisms which may resolve the paradox.

How can we use a game to model competition of plankton organisms? Plankton reproduce asexually and are genetically identical within a species. Justified by this clonal nature we define a "player" as consisting of many individuals belonging to one species. The survival of the species is a cumulative function of the survival of its individuals. Due to the asexual reproduction, success in competition among microbes can be identified with population increase or decrease, which corresponds to positive or negative payoff. The strategies for each player (=species) are probability distributions across the various behaviors of which that species is capable. Each of these probabilities is the probability that a randomly selected individual organism does the corresponding behavior (like swim up, for example). In this way, we can use a game to model competition between plankton species.

What is the connection with the structure of the level sets of typical games? In a broad sense evolution can be described as a feedback loop; we refer readers interested in evolutionary game dynamics to [12] and the references therein. This means that, within a level set of a game modeling competition, the feedback to all species is identical. There is absolutely no difference. In the generic sense made precise in Theorem 2, the level sets of typical games are typically *large.* How do the hypotheses of the theorem fit with plankton ecology? The hypotheses mean that all species are capable of at least two *different behaviors.* This corresponds to *individual variability* which seems to be the underlying mechanism supporting the large plankton biodiversity and may explain the unexpectedly large biodiversity of other microbes as well. The assumptions (1) and (2) mean that either species possess further variability and/or are competing for limited resources which also appears to be the case.

Although plankton individuals are genetic clones within a species, they exhibit significant variability among individuals; see §1 of [16] and the references cited therein. This individual variability is inherent to a species and is subject to natural selection and consequently to the evolutionary feedback loop [7]. We propose that it is this individual variability which is driving the large biodiversity. Mathematically, by Theorem 2, this variability implies that the level sets of the payoff function are large. These large level sets correspond to the large variety of strategies which are all "equally good", in the sense that they produce identical feedback. The various strategies in the level sets may characterize different species and correspond to the large number of species which may co-exist, which we describe as "many different ways to stay in the game" [16].

Our theory may be thought of as "survival of the cumulatively fit" rather than "survival of the fittest" and is applicable to micro-organisms which reproduce asexually. Defining a player as consisting of several organisms belonging to one species, while reasonable for micro-organisms which reproduce asexually, no longer makes sense for larger macro-organisms which do not reproduce asexually, because the death of an individual implies the loss of that individual's unique genome. Consequently, our theory does not contradict competition theories or predictions of species abundance for macro-organisms.

Compatibility. It may seem counterintuitive to apply noncooperative game theory to evaluate a relationship, but many everyday decisions are made quickly according to self-interest, without cooperative discussion. In [1] we used noncooperative game theory to design a new type of compatibility test to measure the balance and overall happiness of two people in a relationship. Our test may be customized to analyze the overall balance and satisfaction in any relationship between two people, romantic or otherwise; this is discussed in [1]. If you are in a relationship, we challenge you to take this test!

Concluding Remarks

In situations modeled by noncooperative games, players do not communicate; the only feedback they experience is their payoff. This means that not only equilibrium strategies but also the structure of the level sets of the payoff function are important to understand. Some readers may be of the opinion that only seasoned experts ought to write about a certain topic. However, approaching a field from a different perspective may at times be helpful, and so I hope that this note written from a geometric analyst's perspective has provided some basic insight into noncooperative (mixed/continuous) games, and that it may inspire further investigation and collaboration.

Acknowledgments

I wish to express sincere gratitude to Susanne Menden-Deuer, Sylvie Paycha, Ulrich Menne, Leobardo Rosales, Jarod Alper, David Trotman, and Wolfgang Ebeling for helpful discussions and suggestions. The comments of the anonymous referees are also sincerely appreciated and contributed positively to the quality of this note. As a geometric analyst claiming to be neither an expert in game theory nor in real algebraic geometry, I would like to humbly request that readers consider this an acknowledgement to any references which they feel should have been included and assure that any failure to do so was not intentional! Finally, I am grateful for the support of the Max Planck Institut für Mathematik in Bonn, the Georg-August Universität Göttingen, the Leibniz Universität Hannover, and the Australian National University.

References

[1] K. Bever and J. Rowlett, Love Games: A game theory approach to compatibility, accepted pending revisions to appear in *J. Humanistic Mathematics*, preprint arXiv:1312.5483 (2013).

[2] S. Basu, R. Pollack, and M.-F. Roy, *Algorithms in Real Algebraic Geometry*, second edition, Springer, (2006).

[3] J. Bochnak, M. Coste, and M.-F. Roy, Real algebraic geometry, translated from the 1987 French original, revised by the authors, *Ergebnisse der Mathematik und ihrer Grenzgebiete* (3) [*Results in Mathematics and Related Areas* (3)], 36, Springer-Verlag, Berlin, (1998) x+430 pp. ISBN: 3-540-64663-9.

[4] J. Bochnak, M. Coste, and M.-F. Roy, Géométrie algébrique réelle, *Ergebnisse der Mathematik*, vol. 12, Springer, Berlin, Heidelberg, New York (1987).

[5] T. L. Czárán, R. F. Hoekstra, and L. Pagie, Chemical warfare between microbes promotes biodiversity, *P. N. A. S.*, vol. 99, no. 2, (2002), 786–790.

[6] M. Coste, Ensembles semi-algébriques, Real algebraic geometry and quadratic forms (Rennes, 1981), pp. 109–138, *Lecture Notes in Math.*, 959, Springer, Berlin-New York, (1982).

[7] P. G. Falkowski, M. E. Katz, A. H. Knoll, A. Quigg, J. A. Raven, O. Schofield, and F. J. R. Taylor, The evolution of modern eukaryotic phytoplankton, *Science* **305**, no. 5682, (2004), 354–360.

[8] S. S. Ganebny, S. S. Kumkov, S. Le Ménec, and V. S. Patsko, Numerical study of a linear differential game with two pursuers and one evader, *Contributions to Game Theory and Management*, Volume IV, Graduate School of Management, St. Petersburg Univ., St. Petersburg, (2011), 154–171.

[9] G. F. Gause, Experimental studies on the struggle for existence: 1. Mixed population of two species of yeast, *Journal of Experimental Biology* **9** (1932), 389–402.

[10] M. Goresky and R. MacPherson, Stratified Morse theory, *Ergebnisse der Mathematik und ihrer Grenzgebiete* (3) [*Results in Mathematics and Related Areas* (3)], 14, Springer-Verlag, Berlin, (1988), xiv+272 pp.

[11] G. Hardin, The competitive exclusion principle, *Science* **131** (1960), 1292–1297.

[12] J. Hofbauer and K. Sigmund, Evolutionary game dynamics, *Bull. Amer. Math. Soc.* **40** (2003), 479–519.

[13] G. E. Hutchinson, The paradox of the plankton, *The American Naturalist* **95**, no. 882, (1961), 137–145.

[14] H. King, Book Reviews of *Real Algebraic Geometry* by J. Bochnak, M. Coste, and M. F. Roy, and *Nash Manifolds*

by M. Shiota, *Bull. (new series) of the A. M. S.* **22**, no. 1, (1990), 208–214.

[15] S. S. Kumkov, V. S. Patsko, and J. Shinar, On level sets with "narrow throats" in linear differential games, *Int. Game Theory Rev.* **7**, no. 3, (2005), 285–311.

[16] Susanne Menden-Deuer and Julie Rowlett, Many ways to stay in the game: Individual variability maintains high biodiversity in planktonic micro-organisms, to appear in *J. of the Royal Society Interface.*

[17] J. F. Mertens, Stable equilibria reformulation, II, Discussion of the definition, and further results. With errata to: "Stable equilibria, reformulation, I, Definition and basic properties" *Math. Oper. Res.* **14**, no. 4, (1989), 575–625.

[18] K. G. Murty, A new practically efficient interior point method for convex quadratic programming, *Mathematical Programming and Game Theory for Decision Making*, Stat. Sci. Interdiscip. Res., 1, World Sci. Publ., Hackensack, NJ, (2008), 21–31.

[19] J. Nash, Non-cooperative games, *Annals of Mathematics*, Second Series, vol. 54, no. 2, (1951), 286–295.

[20] ______, Real algebraic manifolds, *Ann. of Math.*, vol. 2, no. 56, (1952), 405–421.

[21] ______, C^1 isometric imbeddings, *Ann. of Math.*, vol. 2, no. 60, (1954), 383–396.

[22] ______, The imbedding problem for Riemannian manifolds, *Ann. of Math.*, vol. 2, no. 63 (1956), 20–63.

[23] A. Neyman, Real algebraic tools in stochastic games, *Stochastic Games and Applications*, Stony Brook, NY, (1999), 57–75.

[24] V. S. Patsko and V. L. Turova, *Homicidal Chauffeur Game: History and Modern Studies*, Russian Academy of Sciences Ural Branch, Institute of Mathematics and Mechanics, Ekaterinburg, (2009), 44 pp., ISBN: 978-5-7691-2041-1.

[25] ______, Level sets of the value function in differential games with the homicidal chauffeur dynamics, *Int. Game Theory Rev.* **3**, no. 1, (2001), 67–112.

[26] J. Rowlett, *Blast into Math! A Fun and Rigorous Introduction to Pure Mathematics*, ©bookboon.com (Ventus Publishing ApS) ISBN 978-87-403-0330-8, (2013), 215 pages.

[27] K. Saukkonen, Continuity, manifolds, and Arrow's social choice problem, *Mathematical Programming and Game Theory for Decision Making*, Stat. Sci. Interdiscip. Res., 1, World Sci. Publ., Hackensack, NJ, (2008), 415–450.

[28] M. Shiota, Nash manifolds, *Lecture Notes in Mathematics* 1269. Springer-Verlag, Berlin, (1987) vi+223 pp.

[29] S. van Strien, Hamiltonian flows with random-walk behaviour originating from zero-sum games and fictitious play, *Nonlinearity* **24**, no. 6, (2011), 1715–1742.

Fermat, Leibniz, Euler, and the Gang: The True History of the Concepts of Limit and Shadow

Tiziana Bascelli, Emanuele Bottazzi, Frederik Herzberg, Vladimir Kanovei, Karin U. Katz, Mikhail G. Katz, Tahl Nowik, David Sherry, and Steven Shnider

The theories as developed by European mathematicians prior to 1870 differed from the modern ones in that none of them used the modern theory of limits. Fermat develops what is sometimes called a "precalculus" theory, where the optimal value is determined by some special condition such as equality of roots of some equation. The same can be said for his contemporaries like Descartes, Huygens, and Roberval.

Leibniz's calculus advanced beyond them in working on the derivative function of the variable x. He had the indefinite integral whereas his predecessors only had concepts more or less equivalent to it. Euler, following Leibniz, also worked with such functions, but distinguished the variable (or variables) with constant differentials dx, a status that corresponds to the modern assignment that x is the independent variable, the other variables of the problem being dependent upon it (or them) functionally.

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Fermat determined the optimal value by imposing a condition using his *adequality* of quantities. But he did not really think of quantities as functions, nor did he realize that his method produced only a necessary condition for his optimization condition. For a more detailed general introduction, see chapters 1 and 2 of the volume edited by Grattan-Guinness (Bos et al. 1980 [19]).

The doctrine of *limits* is sometimes claimed to have replaced that of *infinitesimals* when analysis was rigorized in the nineteenth century. While it is true that Cantor, Dedekind and Weierstrass attempted (not altogether successfully; see Ehrlich 2006 [32], Mormann & Katz 2013 [79]) to eliminate infinitesimals from analysis, the history of the limit concept is more complex. Newton had explicitly written that his *ultimate ratios* were not actually ratios but, rather, *limits* of prime ratios (see Russell 1903 [89, item 316, pp. 338-339]; Pourciau 2001 [84]). In fact, the sources of a rigorous notion of limit are considerably older than the nineteenthth century.

In the context of Leibnizian mathematics, the limit of $f(x)$ as x tends to x_0 can be viewed as the "assignable part" (as Leibniz may have put it) of $f(x_0 + dx)$ where dx is an "inassignable" infinitesimal increment (whenever the answer is independent of the infinitesimal chosen). A modern formalization of this idea exploits the standard part principle (see Keisler 2012 [67, p. 36]).

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In the context of ordered fields E, the *standard part principle* is the idea that, if E is a proper extension of the real numbers $\mathbb{R}$, then every finite (or *limited*) element $x \in E$ is infinitely close to a suitable $x_0 \in \mathbb{R}$. Such a real number is called the *standard part* (sometimes called the *shadow*) of x, or in formulas, $\mathrm{st}(x) = x_0$. Denoting by E_f the collection of finite elements of E, we obtain a map

$$\mathrm{st} : E_f \to \mathbb{R}.$$

Here x is called *finite* if it is smaller (in absolute value) than *some* real number (the term *finite* is immediately comprehensible to a wide mathematical public, whereas *limited* corresponds to correct technical usage); an *infinitesimal* is smaller (in absolute value) than *every* positive real; and x is *infinitely close* to x_0 in the sense that $x - x_0$ is infinitesimal.

Briefly, the standard part function "rounds off" a finite element of E to the nearest real number (see Figure 1).

The proof of the principle is easy. A finite element $x \in E$ defines a Dedekind cut on the subfield $\mathbb{R} \subset E$ (alternatively, on $\mathbb{Q} \subset \mathbb{R}$), and the cut in turn defines the real x_0 via the usual correspondence between cuts and real numbers. One sometimes writes down the relation

$$x \approx x_0$$

to express infinite closeness.

We argue that the sources of such a relation, and of the standard part principle, go back to Fermat, Leibniz, Euler, and Cauchy. Leibniz would discard the *inassignable* part of $2x + dx$ to arrive at the expected answer, $2x$, relying on his *law of homogeneity* (see the section entitled "Leibniz's Transcendental Law of Homogeneity"). Such an inferential move is mirrored by a suitable proxy in the hyperreal approach, namely the standard part function.

Fermat, Leibniz, Euler, and Cauchy all used one or another form of approximate equality, or the idea of discarding "negligible" terms. Their inferential moves find suitable proxies in the context of modern theories of infinitesimals, and specifically the concept of *shadow*.

The last two sections present an application of the standard part to decreasing rearrangements of real functions and to a problem on divergent integrals due to S. Konyagin.

This article continues efforts in revisiting the history and foundations of infinitesimal calculus and modern nonstandard analysis. Previous efforts in this direction include Bair et al. (2013 [6]), Bascelli (2014 [7]), Błaszczyk et al. (2013 [15]), Borovik et al. (2012 [16], [17]), Kanovei et al. (2013 [55]), Katz, Katz & Kudryk (2014 [61]), Mormann et al. (2013 [79]), Sherry et al. (2014 [92]), Tall et al. (2014 [97]).

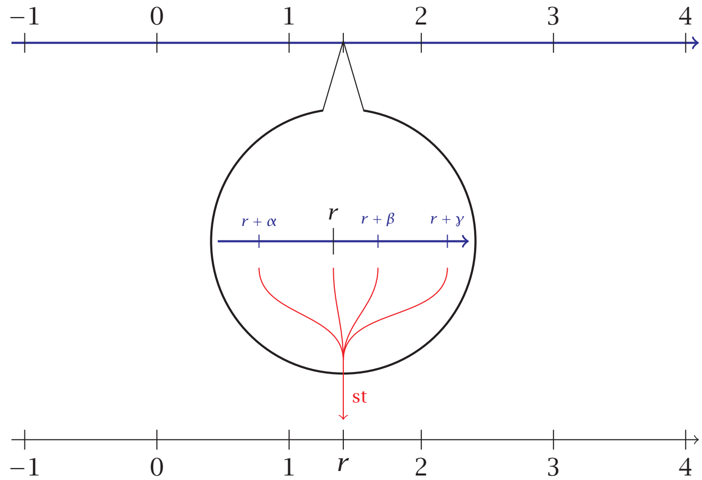

Figure 1. The standard part function, st, "rounds off" a finite hyperreal to the nearest real number. The function st is here represented by a vertical projection. An "infinitesimal microscope" is used to view an infinitesimal neighborhood of a standard real number r, where α, β, and γ represent typical infinitesimals. Courtesy of Wikipedia.

Methodological Remarks

To comment on the historical subtleties of judging or interpreting past mathematics by present-day standards,[1] note that neither Fermat, Leibniz, Euler, nor Cauchy had access to the *semantic* foundational frameworks as developed in mathematics at the end of the nineteenthth and first half of the twentieth centuries. What we argue is that their *syntactic* inferential moves ultimately found modern proxies in Robinson's framework, thus placing a firm (relative to ZFC)[2] semantic foundation underneath the classical procedures of these masters. Benacerraf (1965 [10]) formulated a related dichotomy in terms of mathematical practice vs. mathematical ontology.

For example, the Leibnizian laws of continuity (see Knobloch 2002 [69, p. 67]) and homogeneity can be recast in terms of modern concepts such as the *transfer principle* and the *standard part principle* over the hyperreals, without ever appealing to the semantic content of the technical development of the hyperreals as a *punctiform* continuum; similarly, Leibniz's proof of the product rule for differentiation is essentially identical, at the syntactic level, to a modern infinitesimal proof (see, again, the section "Leibniz's Transcendental Law of Homogeneity").

[1] *Some reflections on this can be found in Lewis (1975* [76]*).*
[2] *The Zermelo-Fraenkel Set Theory with the Axiom of Choice.*

A-track and B-track

The crucial distinction between syntactic and semantic aspects of the work involving mathematical continua appears to have been overlooked by R. Arthur who finds fault with the hyperreal proxy of the Leibnizian continuum, by arguing that the latter was *non-punctiform* (see Arthur 2013 [5]). Yet this makes little difference at the syntactic level, as explained above. Arthur's brand of the syncategorematic approach following Ishiguro (1990 [52]) involves a reductive reading of Leibnizian infinitesimals as *logical* (as opposed to *pure*) fictions involving a hidden quantifier à la Weierstrass, ranging over "ordinary" values. This approach was critically analyzed in (Katz & Sherry 2013 [65]), (Sherry & Katz 2013 [92]), and (Tho 2012 [101]).

Robinson's framework poses a challenge to traditional historiography of mathematical analysis. The traditional thinking is often dominated by a kind of Weierstrassian teleology. This is a view of the history of analysis as univocal evolution toward the radiant Archimedean framework as developed by Cantor, Dedekind, Weierstrass, and others starting around 1870, described as the *A-track* in a recent piece in the *Notices* (see Bair et al. 2013 [6]).

Robinson's challenge is to point out not only the possibility, but also the existence of a parallel Bernoullian[3] track for the development of analysis, or *B-track* for short. The B-track assigns an irreducible and central role to the concept of infinitesimal, a role it played in the work of Leibniz, Euler, mature Lagrange,[4] Cauchy, and others.

The caliber of some of the response to Robinson's challenge has been disappointing. Thus, the critique by Earman (1975 [30]) is marred by a confusion of second-order infinitesimals like dx^2 and second-order hyperreal extensions like ${}^{**}\mathbb{R}$; see (Katz & Sherry 2013 [65]) for a discussion.

Victor J. Katz (2014 [66]) appears to imply that a B-track approach based on notions of infinitesimals or indivisibles is limited to "the work of Fermat, Newton, Leibniz, and many others in the seventeenth and eighteenth centuries." This does not appear to be Felix Klein's view. Klein formulated a condition, in terms of the mean value theorem,[5] for what would qualify as a successful theory of infinitesimals, and concluded:

> I will not say that progress in this direction is impossible, but it is true that none of the investigators have achieved anything positive (Klein 1908 [68, p. 219]).

Klein was referring to the current work on infinitesimal-enriched systems by Levi-Civita, Bettazzi, Stolz, and others. In Klein's mind, the infinitesimal track was very much a current research topic; see Ehrlich (2006 [32]) for a detailed coverage of the work on infinitesimals around 1900.

Formal Epistemology: Easwaran on Hyperreals

Some recent articles are more encouraging in that they attempt a more technically sophisticated approach. K. Easwaran's study (2014 [31]), motivated by a problem in formal epistemology,[6] attempts to deal with technical aspects of Robinson's theory such as the notion of *internal set*, and shows an awareness of recent technical developments, such as a *definable hyperreal system* of Kanovei & Shelah (2004 [57]).

Even though Easwaran, in the tradition of Lewis (1980 [77]) and Skyrms (1980 [94]), tries to engage seriously with the intricacies of employing hyperreals in formal epistemology,[7] not all of his findings are convincing. For example, he assumes that physical quantities cannot take hyperreal values.[8] However, there exist physical quantities that are not directly observable. Theoretical proxies for unobservable physical quantities typically depend on the chosen mathematical model. And, not surprisingly, there are mathematical models of physical phenomena which operate with the hyperreals, in which physical quantities take hyperreal values. Many such models are discussed in the volume by Albeverio et al. (1986 [1]).

For example, certain probabilistic laws of nature have been formulated using hyperreal-valued probability theory. The construction of mathematical

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[3] *Historians often name Johann Bernoulli as the first mathematician to have adhered systematically and exclusively to the infinitesimal approach as the basis for the calculus.*

[4] *In the second edition of his* Mécanique Analytique *dating from 1811, Lagrange fully embraced the infinitesimal in the following terms: "Once one has duly captured the spirit of this system [i.e., infinitesimal calculus], and has convinced oneself of the correctness of its results by means of the geometric method of the prime and ultimate ratios, or by means of the analytic method of derivatives, one can then exploit the infinitely small as a reliable and convenient tool so as to shorten and simplify proofs." See (Katz & Katz 2011* [58]*) for a discussion.*

[5] *The Klein–Fraenkel criterion is discussed in more detail in Kanovei et al. (2013* [55]*).*

[6] *The problem is concerned with saving philosophical Bayesianism, a popular position in formal epistemology, which appears to require that one be able to find on every algebra of doxastically relevant propositions some subjective probability assignment such that only the impossible event ($\emptyset$) will be assigned an initial/uninformed subjective probability, or credence, of* 0.

[7] *For instance, he concedes: "And the hyperreals may also help, as long as we understand that they do not tell us the precise structure of credences." (Easwaran 2014* [31], *Introduction, last paragraph).*

[8] *Easwaran's explicit premise is that "All physical quantities can be entirely parametrized using the standard real numbers." (Easwaran 2014* [31, Section 8.4, Premise 3]*).*

Brownian motion by Anderson (1976 [4]) provides a hyperreal model of the botanical counterpart. It is unclear why (and indeed rather implausible that) an observer A, whose degrees of belief about botanical Brownian motion stem from a mathematical model based on the construction of mathematical Brownian motion by Wiener (1923 [104]), should be viewed as being more rational than another observer B, whose degrees of belief about botanical Brownian motion stem from a mathematical model based on Anderson's construction of mathematical Brownian motion.[9]

Similarly problematic is Easwaran's assumption that an infinite sequence of probabilistic tests must necessarily be modeled by the set of standard natural numbers (this is discussed in more detail in the subsection "Williamson, Complexity, and Other Arguments"). Such an assumption eliminates the possibility of modeling it by a sequence of infinite hypernatural length. Indeed, once one allows for infinite sequences to be modeled in this way, the problem of assigning a probability to an infinite sequence of coin tosses that was studied in (Elga 2004 [33]) and (Williamson 2007 [105]) allows for an elegant hyperreal solution (Herzberg 2007 [48]).

Easwaran reiterates the common objection that the hyperreals are allegedly "nonconstructive" entities. The bitter roots of such an allegation in the radical constructivist views of E. Bishop have been critically analyzed in (Katz & Katz 2011 [59]), and contrasted with the liberal views of the intuitionist A. Heyting, who felt that Robinson's theory was "a standard model of important mathematical research" (Heyting 1973 [51, p. 136]). It is important to keep in mind that Bishop's target was *classical mathematics* (as a whole), the demise of which he predicted in the following terms:

> Very possibly classical mathematics will cease to exist as an independent discipline (Bishop 1968 [14, p. 54]).

Zermelo–Fraenkel Axioms and the Feferman–Levy Model

In his analysis, Easwaran assigns substantial weight to the fact that "it is consistent with the ZF [Zermelo–Fraenkel set theory] without the Axiom of Choice" that the hyperreals do not exist (Easwaran 2014 [30, Section 8.4]); see Figure 2. However, on the same grounds, one would have to reject parts of mathematics with important applications. There are fundamental results in functional analysis that depend on the Axiom of Choice such as the Hahn–Banach theorem; yet no one would suggest that mathematical physicists or mathematical economists should stop exploiting them.

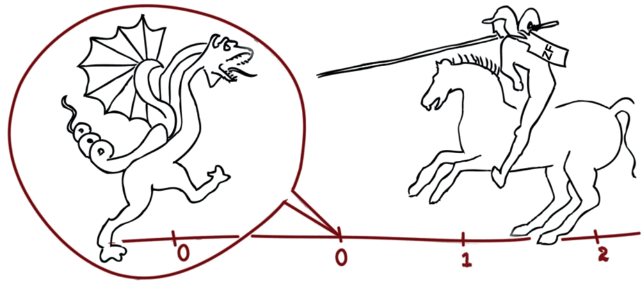

Figure 2. Easwaran's attempted slaying of the infinitesimal, following P. Uccello. Uccello's creature is shown as inhabiting an infinitesimal neighborhood of 0.

Most real analysis textbooks prove the σ-additivity (i.e., countable additivity) of Lebesgue measure, but σ-additivity is not deducible from ZF, as shown by the Feferman–Levy model; see (Feferman & Levy 1963 [36]); (Jech 1973 [54, chapter 10]). Indeed, it is consistent with ZF that the following holds:

($*$) the continuum $\mathbb{R}$ of real numbers is a countable union $\mathbb{R} = \bigcup_{n\in\mathbb{N}} X_n$ of countable sets X_n.

See (Cohen 1966 [26, chapter IV, section 4]) for a description of a model of ZF in which ($*$) holds.[10] Note that ($*$) implies that the Lebesgue measure is not countably additive, as all countable sets are null sets whereas $\mathbb{R}$ is not a null set. Therefore countable additivity of the Lebesgue measure cannot be established in ZF.

Terence Tao wrote:

> By giving up countable additivity, one loses a fair amount of measure and integration theory, and in particular the notion of the expectation of a random variable becomes problematic (unless the random variable takes only finitely many values). (Tao 2013 [100])

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[9] *One paradoxical aspect of Easwaran's methodology is that, despite his anti-hyperreal stance in (2014* [30]*), he* does *envision the possibility of useful infinitesimals in an earlier joint paper (Colyvan & Easwaran 2008* [27]*), where he cites John Bell's account (Bell's presentation of Smooth Infinitesimal Analysis in* [9] *involves a category-theoretic framework based on intuitionistic logic); but never the hyperreals. Furthermore, in the 2014 paper he cites the* surreals *as possible alternatives to the real number–based description of the "structure of physical space" as he calls it; see subsection "Williamson, Complexity, and Other Arguments" for a more detailed discussion.*

[10] *Property* ($*$) *may appear to be asserting the countability of the continuum. However, in order to obtain a bijective map from a countable collection of countable sets to* $\mathbb{N}\times\mathbb{N}$ *(and hence, by diagonalization, to* $\mathbb{N}$*), the Axiom of Choice (in its "countable" version which allows a countably-infinite sequence of independent choices) will necessarily be used.*

Tao's remarks suggest that deducibility from ZF is not a reasonable criterion of mathematical plausibility by any modern standard.

There are models of ZF in which there are infinitesimal numbers, if properly understood, among the real numbers themselves. Thus, there exist models of ZF which are also models of Nelson's (1987 [82]) *radically elementary* mathematics, a subsystem of Nelson's (1977 [81]) Internal Set Theory. Here *radically elementary* mathematics is an extension of classical set theory (which may be understood as ZF[11]) by a unary predicate, to be interpreted as

"… is a standard natural number,"

with additional axioms that regulate the use of the new predicate (notably external induction for standard natural numbers) and ensure the existence of nonstandard numbers. Nelson (1987 [82, Appendix]) showed that a major part of the theory of continuous-time stochastic processes is in fact equivalent to a corresponding *radically elementary* theory involving infinitesimals, and indeed, *radically elementary* probability theory has seen applications in the sciences; see for example (Reder 2003 [85]).

In sum, mathematical descriptions of nontrivial natural phenomena involve, by necessity, some degree of mathematical idealization, but Easwaran has not given us a good reason why only such mathematical idealizations that are feasible in *every* model of ZF should be acceptable. Rather, as we have already seen, there are very good arguments (e.g., from measure theory) against such a high reverence for ZF.

Skolem Integers and Robinson Integers

Easwaran recycles the well-known claim by A. Connes that a hypernatural number leads to a nonmeasurable set. However, the criticism by Connes[12] is in the category of dressing down a feature to look like a bug, to reverse a known dictum from computer science slang.[13] This can be seen as follows. The Skolem nonstandard integers $\mathbb{N}_{\text{Sko}}$ are known to be purely constructive; see Skolem (1955 [93]) and Kanovei et al. (2013 [55]). Yet they imbed in Robinson's hypernaturals $\mathbb{N}_{\text{Rob}}$:

$$\mathbb{N}_{\text{Sko}} \hookrightarrow \mathbb{N}_{\text{Rob}}. \tag{1}$$

Viewing a purely constructive Skolem hypernatural

$$H \in \mathbb{N}_{\text{Sko}} \setminus \mathbb{N}$$

as a member of $\mathbb{N}_{\text{Rob}}$ via the inclusion (1), one can apply the transfer principle to form the set

$$X_H = \{A \subset \mathbb{N} : H \in {}^*A\},$$

where ${}^*A \subset \mathbb{N}_{\text{Rob}}$ is the natural extension of A. The set X_H is not measurable. What propels the set $X_H \subset \mathcal{P}(\mathbb{N})$ into existence is not a purported *weakness* of a nonstandard integer H itself, but rather the remarkable *strength* of both the Łoś-Robinson transfer principle and the consequences it yields.

Williamson, Complexity, and Other Arguments

Easwaran makes a number of further critiques of hyperreal methodology. His section 8.1, entitled "Williamson's Argument," concerns infinite coin tosses. Easwaran's analysis is based on the model of a countable sequence of coin tosses given by Williamson [105]. In this model, it is assumed that

> … for definiteness, [the coin] will be flipped once per second, assuming that seconds from now into the future can be numbered with the natural numbers (Easwaran 2014 [31, section 8.1]).

What is lurking behind this is a double assumption which, unlike other "premises," is not made explicit by Easwaran. Namely, he assumes that

(1) a vast number of independent tests is best modeled by a temporal arrangement thereof, rather than by a simultaneous collection; and
(2) the collection of seconds ticking away "from now [and] into the future" gives a faithful representation of the natural numbers.

These two premises are not self-evident and some research mathematicians have very different intuitions about the matter, as much of the literature on applied nonstandard analysis (e.g., Albeverio et al. 1986 [1], Reder 2003 [85]) illustrates.

It seems that in Easwaran's model, an agent can choose not to flip the coin at some seconds, thus giving rise to events like "a coin that is flipped starting at second 2 comes up heads on every flip." However, in all applications we are aware of, this additional structure used to rule out the use of hyperreals as the range of probability functions seems not to be relevant.

Williamson and Easwaran appear to be unwilling to assume that, once one decides to use hyperreal infinitesimals, one should also replace the original algebra "of propositions in which the agent has credence" with an internal algebra of the hyperreal setting. In fact, such an additional step allows one to avoid both the problems raised by Williamson's

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[11] *Even though Nelson would probably argue for a much weaker system; see Herzberg (2013* [49, Appendix A.1]*), citing Nelson (2011* [83]*).*

[12] *Note that Connes relied on the Hahn-Banach theorem, exploited ultrafilters, and placed a nonconstructive entity (namely the Dixmier trace) on the front cover of his* magnum opus*; see (Katz & Leichtnam 2013* [62]*) and (Kanovei et al. 2013* [55]*) for details.*

[13] *See* https://en.wikipedia.org/wiki/Undocumented_feature

argument in his formulation using conditional probability, and those raised by Easwaran in section 8.2 of his paper.

A possible model with hyperreal infinitesimals for an infinite sequence of coin tosses is given by representing every event by means of a sequence $\{a_1, \ldots, a_N\}$, where a_n represents the outcome of the nth flip and N is a fixed hypernatural number. In this model, consider the events "a_n = Heads for $n \le N$", which we will denote $H(1)$, and "a_n = Heads for $2 \le n \le N$", that we will denote $H(2)$. In such a setting, events $H(1)$ and $H(2)$ are not isomorphic, contrary to what was argued in (Williamson [105, p. 3]). This is due to the fact that hypernatural numbers are an elementary extension of the natural numbers, for which the formula $k \neq k+1$ always holds. Moreover, the probability of $H(1)$ is the infinitesimal 2^{-N}, while the probability of $H(2)$ is the strictly greater infinitesimal $2^{-(N-1)}$, thus obeying the well-known rule for conditional probability.

Easwaran's section 8.4 entitled "The complexity argument" is based on four premises. However, his premise 3, to the effect that "all physical quantities can be entirely parameterized using the standard real numbers," is unlikely to lead to meaningful philosophical conclusions based on "first principles." This is because all physical quantities can be entirely parameterized by the usual rational numbers alone, due to the intrinsic limits of our capability to measure physical quantities. A clear explanation of this limitation was given by Dowek. In particular, since

> a measuring instrument yields only an approximation of the measured magnitude, [...] it is therefore impossible, except according to this idealization, to measure more than the first digits of a physical magnitude. [...] According to this principle, this idealization of the process of measurement is a fiction. This suggests the idea, reminiscent of Pythagoras' views, that Physics could be formulated with rational numbers only. We can therefore wonder why real numbers have been invented and, moreover, used in Physics. A hypothesis is that the invention of real numbers is one of the many situations, where the complexity of an object is increased, so that it can be apprehended more easily. (Dowek 2013 [29])

Related comments by Wheeler (1994 [103, p. 308]), Brukner & Zeilinger (2005 [22, p. 59]), and others were analyzed by Kanovei et al. (2013 [55, Section 8.4]). See also Jaroszkiewicz (2014 [53]).

If all physical quantities can be entirely parameterized by using rational numbers, there should be no compelling reason to choose the real number system as the value range of our probability measures. However, Easwaran is apparently comfortable with the idealization of exploiting a larger number system than the rationals for the value range of probability measures. What we argue is that the real numbers are merely one among possible idealizations that can be used for this purpose. For instance, in hyperreal models for infinite sequence of coin tosses developed by Benci, Bottazzi, & Di Nasso (2013 [11]), all events have *hyperrational* probabilities. This generalizes both the case of finite sequences of coin tosses, and the Kolmogorovian model for infinite sequences of coin tosses, where a real-valued probability is generated by applying Carathéodory's extension theorem to the rational-valued probability measure over the cylinder sets.

Given Easwaran's firm belief that "the function relating credences to the physical is not so complex that its existence is independent of Zermelo-Fraenkel set theory" (see his section 8.4, premise 2), it is surprising to find him suggesting that

> the surreal numbers seem more promising as a device for future philosophers of probability to use (Easwaran 2014 [31, Appendix A.3]).

However, while the construction of the surreals indeed "is a simultaneous generalization of Dedekind's construction of the real numbers and von Neumann's construction of the ordinals," as observed by Easwaran, it is usually carried out in the Von Neumann–Bernays–Gödel set theory (NBG) with Global Choice; see, for instance, the "Preliminaries" section of (Alling 1987 [3]). The assumption of the Global Axiom of Choice is a strong foundational assumption.

The construction of the surreal numbers can be performed within a version of NBG that is a conservative extension of ZFC, but does not need Limitation of Size (or Global Choice). However, NBG clearly is not a conservative extension of ZF; and if one wishes to prove certain interesting features of the surreals one needs an even stronger version of NBG that involves the Axiom of Global Choice. Therefore the axiomatic foundation that one needs for using the surreal numbers is at least as strong as the one needed for the hyperreals.

Infinity and Infinitesimal: Let Both Pretty Severely Alone

At the previous turn of the century, H. Heaton wrote:

> I think I know exactly what is meant by the term zero. But I can have no conception either of infinity or of the infinitesimal, and I think it would be well if mathematicians would let both pretty severely alone (Heaton 1898 [47, p. 225]).

Heaton's sentiment expresses an unease about a mathematical concept of which one may have an intuitive grasp[14] but which is not easily formalizable. Heaton points out several mathematical inconsistencies or ill-chosen terminology among the conceptions of infinitesimals of his contemporaries. This highlights the brilliant mathematical achievement of a consistent "calculus" for infinitesimals attained through the work of Hewitt (1948 [50]), Łoś (1955 [78]), Robinson (1961 [87]), and Nelson (1977 [81]), but also of their predecessors like Fermat, Euler, Leibniz, and Cauchy, as we analyze respectively in sections entitled "Fermat's Adequality," "Leibniz's Transcendental Law of Homogeneity," "Euler's Principle of Cancellation," and "What Did Cauchy Mean by Limit?".

Fermat's Adequality

Our interpretation of Fermat's technique is compatible with those by Strømholm (1968 [95]) and Giusti (2009 [43]). It is at variance with the interpretation by Breger (1994 [21]), considered by Knobloch (2014 [70]) to have been refuted.

Adequality, or $\pi\alpha\rho\iota\sigma\acute{o}\tau\eta\varsigma$ (parisotēs) in the original Greek of Diophantus, is a crucial step in Fermat's method of finding maxima, minima, tangents, and solving other problems that a modern mathematician would solve using infinitesimal calculus. The method is presented in a series of short articles in Fermat's collected works. The first article, *Methodus ad Disquirendam Maximam et Minimam*, opens with a summary of an algorithm for finding the maximum or minimum value of an algebraic expression in a variable A. For convenience, we will write such an expression in modern functional notation as $f(a)$.

Summary of Fermat's Algorithm

One version of the algorithm can be broken up into six steps in the following way:

(1) Introduce an auxiliary symbol e, and form $f(a+e)$;
(2) Set *adequal* the two expressions $f(a+e) =_{AD} f(a)$ (the notation "$=_{AD}$" for adequality is ours, not Fermat's);
(3) Cancel the common terms on the two sides of the adequality. The remaining terms all contain a factor of e;
(4) Divide by e (see also next step);
(5) In a parenthetical comment, Fermat adds: "or by the highest common factor of e;"
(6) Among the remaining terms, suppress all terms which still contain a factor of e. Solving the resulting equation for a yields the extremum of f.

In modern mathematical language, the algorithm entails expanding the difference quotient

$$\frac{f(a+e)-f(a)}{e}$$

in powers of e and taking the constant term.[15] The method (leaving aside step (5)) is immediately understandable to a modern reader as the elementary calculus exercise of finding the extremum by solving the equation $f'(a) = 0$. But the real question is how Fermat understood this algorithm in his own terms, in the mathematical language of his time, prior to the invention of calculus by Barrow, Leibniz, Newton, and others.

There are two crucial points in trying to understand Fermat's reasoning: first, the meaning of "adequality" in step (2), and second, the justification for suppressing the terms involving positive powers of e in step (6). The two issues are closely related because interpretation of adequality depends on the conditions on e. One condition which Fermat always assumes is that e is positive. He did not use negative numbers in his calculations.[16]

Fermat introduces the term *adequality* in *Methodus* with a reference to Diophantus of Alexandria. In the third article of the series, *Ad Eamdem Methodum* (*Sur la Même Méthode*), he quotes Diophantus's Greek term $\pi\alpha\rho\iota\sigma\acute{o}\tau\eta\varsigma$, which he renders following Xylander and Bachet, as *adaequatio* or *adaequalitas* (see A. Weil [102, p. 28]).

Tangent Line and Convexity of Parabola

Consider Fermat's calculation of the tangent line to the parabola (see Fermat [38, pp. 122–123]). To simplify Fermat's notation, we will work with the parabola $y = x^2$, or

$$\frac{x^2}{y} = 1.$$

[14] *The intuitive appeal of infinitesimals make them an effective teaching tool. The pedagogical value of teaching calculus with infinitesimals was demonstrated in a controlled study by Sullivan (1976* [96]*).*

[15] *Fermat also envisions a more general technique involving division by a higher power of e as in step* (5).

[16] *This point is crucial for our argument below using the transverse ray. Since Fermat is only working with positive values of his e, he only considers a ray (rather than a full line) starting at a point of the curve. The convexity of the curve implies an inequality, which Fermat transforms into an* adequality *without giving much explanation of his procedure, but assuming implicitly that the ray is tangent to the curve. But a transverse ray would satisfy the inequality no less than a tangent ray, indicating that Fermat is relying on an additional piece of geometric information. His procedure of applying the defining relation of the curve itself to a point on the tangent ray is only meaningful when the increment e is small (see subsection "Tangent Line and Convexity of Parabola").*

To understand what Fermat is doing, it is helpful to think of the parabola as a level curve of the two-variable function $\frac{x^2}{y}$.

Given a point (x, y) on the parabola, Fermat wishes to find the tangent line through the point. Fermat exploits the geometric fact that, by convexity, a point

$$(p, q)$$

on the tangent line lies *outside* the parabola. He therefore obtains an inequality equivalent in our notation to $\frac{p^2}{q} > 1$, or $p^2 > q$. Here $q = y - e$, and e is Fermat's magic symbol we wish to understand. Thus we obtain

$$\frac{p^2}{y - e} > 1. \tag{2}$$

At this point Fermat proceeds as follows:

(i) he writes down the inequality $\frac{p^2}{y-e} > 1$, or $p^2 > y - e$;
(ii) he invites the reader to *adégaler* (to "adequate");
(iii) he writes down the adequality $\frac{x^2}{p^2} =_{\text{AD}} \frac{y}{y-e}$;
(iv) he uses an identity involving similar triangles to substitute
$$\frac{x}{p} = \frac{y + r}{y + r - e}$$
where r is the distance from the vertex of the parabola to the point of intersection of the tangent to the parabola at y with the axis of symmetry,
(v) he cross multiplies and cancels identical terms on right and left, then divides out by e, discards the remaining terms containing e, and obtains $y = r$ as the solution.[17]

What interests us here are steps (i) and (ii). How does Fermat pass from an inequality to an adequality? Giusti noted that

> Comme d'habitude, Fermat est autant détaillé dans les exemples qu'il est réticent dans les explications. On ne trouvera donc presque jamais des justifications de sa règle des tangentes (Giusti 2009 [43]).

In fact, Fermat provides no explicit explanation for this step. However, what he does is apply the defining relation for a curve to points on the tangent line to the curve. Note that here the quantity e, as in $q = y - e$, is positive: Fermat did not have the facility we do of assigning negative values to variables. Strømholm notes that Fermat

> never considered negative roots, and if $A = 0$ was a solution of an equation, he did not mention it as it was nearly always geometrically uninteresting (Strømholm 1968 [95, p. 49]).

Fermat says nothing about considering points $y + e$ "on the other side," i.e., further away from the vertex of the parabola, as he does in the context of applying a related but different method, for instance in his two letters to Mersenne (see [95, p. 51]), and in his letter to Brûlart [39].[18] Now for positive values of e, Fermat's inequality (2) would be satisfied by a *transverse ray* (i.e., secant ray) starting at (x, y) and lying outside the parabola, just as much as it is satisfied by a tangent ray starting at (x, y). Fermat's method therefore presupposes an additional piece of information, privileging the tangent ray over transverse rays. The additional piece of information is geometric in origin: he applies the defining relation (of the curve itself) to a point on the tangent ray to the curve, a procedure that is only meaningful when the increment e is small.

In modern terms, we would speak of the tangent line being a "best approximation" to the curve for a small variation e; however, Fermat does not explicitly discuss the size of e. The procedure of "discarding the remaining terms" in step (v) admits of a proxy in the hyperreal context. Namely, it is the standard part principle (see the Introduction). Fermat does not elaborate on the justification of this step, but he is always careful to speak of the *suppressing* or *deleting* the remaining term in e, rather than setting it equal to zero. Perhaps his rationale for suppressing terms in e consists in ignoring terms that don't correspond to an actual measurement, prefiguring Leibniz's *inassignable quantities.* Fermat's inferential moves in the context of his adequality are akin to Leibniz's in the context of his calculus; see the section called "Leibniz's Transcendental Law of Homogeneity".

Fermat, Galileo, and Wallis

While Fermat never spoke of his e as being *infinitely small*, the technique was known both to Fermat's contemporaries like Galileo (see Bascelli 2014 [7], [8]) and Wallis (see Katz & Katz [60, Section 24]) as well as Fermat himself, as his correspondence with Wallis makes clear; see Katz, Schaps & Shnider (2013 [63, Section 2.1]).

Fermat was very interested in Galileo's treatise *De motu locali*, as we know from his letters to Marin Mersenne dated Apr/May 1637, 10 August, and 22 October 1638. Galileo's treatment of infinitesimals in *De motu locali* is discussed by Wisan (1974 [106, p. 292]) and Settle (1966 [91]).

[17] *In Fermat's notation $y = d$, $y + r = a$. Step (v) can be understood as requiring the expression $\frac{y}{y-e} - \frac{(y+r)^2}{(y+r-e)^2}$ to have a double root at $e = 0$, leading to the solution $y = r$ or in Fermat's notation $a = 2r$.*

[18] *This was noted by Giusti (2009* [43]*).*

Alexander (2014 [2]) notes that the clerics in Rome forbade the doctrine of the *infinitely small* on 10 August 1632 (a month before Galileo was put on trial over heliocentrism); this may help explain why the Catholic Fermat might have been reluctant to speak of the *infinitely small* explicitly.[19]

In a recent text, U. Felgner analyzes the Diophantus problems which exploit the method of $\pi\alpha\rho\iota\sigma\acute{o}\tau\eta\varsigma$, and concludes that

> Aus diesen Beispielen wird deutlich, dass die Verben $\pi\acute{\alpha}\rho\iota\sigma o\tilde{\upsilon}\nu$ und adaequare nicht ganz dasselbe ausdrücken. Das griechische Wort bedeutet, der Gleichheit nahe zu sein, während das lateinische Wort das Erreichen-der Gleichheit (sowohl als vollendeten als auch als unvollendeten Prozeß) ausdrückt (Felgner 2014 [37]).

Thus, in his view, even though the two expressions have slightly different meanings, the Greek meaning "being close to equality" and the Latin meaning "equality which is reached (at the end of either a finite or an infinite process)," they both involve approximation. Felgner goes on to consider some of the relevant texts from Fermat, and concludes that Fermat's method has nothing to do with differential calculus and involves only the property of an auxiliary expression having a double zero:

> Wir hoffen, deutlich gemacht zu haben, dass die fermatsche "Methode der Adaequatio" gar nichts mit dem Differential-Kalkül zu hat, sondern vielmehr im Studium des Wertverlaufs eines Polynoms in der Umgebung eines kritischen Punktes besteht, und dabei das Ziel verfolgt zu zeigen, dass das Polynom an dieser Stelle eine doppelte Nullstelle besitzt. (ibid.)

However, Felgner's conclusion is inconsistent with his own textual analysis which indicates that the idea of approximation is present in the methods of both Diophantus and Fermat. As Knobloch (2014 [70]) notes, "Fermat's method of adequality is not a single method but rather a cluster of methods." Felgner failed to analyze the examples of tangents to transcendental curves, such as the cycloid, in which Fermat does *not* study the order of the zero of an auxiliary polynomial. Felgner mistakenly asserts that, in the case of the cycloid, Fermat did not reveal how he thought of the solution: "Wie FERMATsich die Lösung dachte, hat er nicht verraten." (ibid.) Quite to the contrary, as Fermat explicitly stated, he applied the defining property of the curve to points on the tangent line:

> Il faut donc adégaler (à cause de la propriété spécifique de la courbe qui est à considérer sur la tangente)

(see Katz et al. (2013 [63]) for more details). Fermat's approach involves applying the defining relation of the curve, to a point on a *tangent* to the curve. The approach is consistent with the idea of approximation inherent in his method, involving a negligible distance (whether infinitesimal or not) between the tangent and the original curve when one is near the point of tangency. This line of reasoning is related to the ideas of the differential calculus. Note that Fermat does not say anything here concerning the multiplicities of zeros of polynomials. As Felgner himself points out, in the case of the cycloid the only polynomial in sight is of first order and the increment "e" cancels out. Fermat correctly solves the problem by obtaining the defining equation of the tangent.

For a recent study of seventeenth century methodology, see the article (Carroll et al. 2013 [23]).

Leibniz's Transcendental Law of Homogeneity

In this section, we examine a possible connection between Fermat's adequality and Leibniz's Transcendental Law of Homogeneity (TLH). Both of them enable certain inferential moves that play parallel roles in Fermat's and Leibniz's approaches to the problem of maxima and minima. Note the similarity in titles of their seminal texts: *Methodus ad Disquirendam Maximam et Minimam* (Fermat, see Tannery [98, pp. 133]) and *Nova methodus pro maximis et minimis …* (Leibniz 1684 [72] in Gerhardt [42]).

When Are Quantities Equal?

Leibniz developed the TLH in order to enable inferences to be made between inassignable and assignable quantities. The TLH governs equations involving differentials. H. Bos interprets it as follows:

> A quantity which is infinitely small with respect to another quantity can be neglected if compared with that quantity. Thus all terms in an equation except those of the highest order of infinity, or the lowest order of infinite smallness, can be discarded. For instance,
>
> $$a + dx = a \qquad (3)$$
>
> $$dx + ddy = dx$$
>
> etc. The resulting equations satisfy this […] requirement of homogeneity (Bos 1974 [18, p. 33] paraphrasing Leibniz 1710 [75, pp. 381–382]).

[19] *See a related discussion at* http://math.stackexchange.com/questions/661999/are-infinitesimals-dangerous.

The title of Leibniz's 1710 text is *Symbolismus memorabilis calculi algebraici et infinitesimalis in comparatione potentiarum et differentiarum, et de lege homogeneorum transcendentali*. The inclusion of the transcendental law of homogeneity (*lex homogeneorum transcendentalis*) in the title of the text attests to the importance Leibniz attached to this law.

The "equality up to an infinitesimal" implied in TLH was explicitly discussed by Leibniz in a 1695 response to Nieuwentijt, in the following terms:

> Caeterum *aequalia* esse puto, non tantum quorum differentia est omnino nulla, sed et quorum differentia est incomparabiliter parva; et licet ea Nihil omnino dici non debeat, non tamen est quantitas comparabilis cum ipsis, quorum est differentia (Leibniz 1695 [73, p. 322]) [emphasis added–authors]

We provide a translation of Leibniz's Latin:

> Besides, I consider to be *equal* not only those things whose difference is entirely nothing, but also those whose difference is incomparably small: and granted that it [i.e., the difference] should not be called entirely Nothing, nevertheless it is not a quantity comparable to those whose difference it is.

Product Rule

How did Leibniz use the TLH in developing the calculus? The issue can be illustrated by Leibniz's justification of the last step in the following calculation:

$$\begin{aligned} d(uv) &= (u+du)(v+dv) - uv \\ &= udv + vdu + du\,dv \\ &= udv + vdu. \end{aligned} \tag{4}$$

The last step in the calculation (4) depends on the following inference:

$$d(uv) = udv+vdu+dudv \implies d(uv) = udv+vdu.$$

Such an inference is an application of Leibniz's TLH. In his 1701 text *Cum Prodiisset* [74, pp. 46–47], Leibniz presents an alternative justification of the product rule (see Bos [18, p. 58]). Here he divides by dx, and argues with differential *quotients* rather than differentials. The role played by the TLH in these calculations is similar to that played by adequality in Fermat's work on maxima and minima. For more details on Leibniz, see Guillaume (2014 [45]); Katz & Sherry (2012 [64]), (2013 [65]); Sherry & Katz [92]; Tho (2012 [101]).

Euler's Principle of Cancellation

Some of the Leibnizian formulas reappear, not surprisingly, in his student's student Euler. Euler's formulas like

$$a + dx = a, \tag{5}$$

where a "is any finite quantity" (see Euler 1755 [35, §§86,87]) are consonant with a Leibnizian tradition as reported by Bos; see formula (3) above. To explain formulas like (5), Euler elaborated two distinct ways (arithmetic and geometric) of comparing quantities, in the following terms:

> Since we are going to show that an infinitely small quantity is really zero, we must meet the objection of why we do not always use the same symbol 0 for infinitely small quantities, rather than some special ones…[S]ince we have two ways to compare them, either *arithmetic* or *geometric*, let us look at the quotients of quantities to be compared in order to see the difference.
>
> If we accept the notation used in the analysis of the infinite, then dx indicates a quantity that is infinitely small, so that both $dx = 0$ and $a\,dx = 0$, where a is any finite quantity. Despite this, the *geometric* ratio $a\,dx : dx$ is finite, namely $a : 1$. For this reason, these two infinitely small quantities, dx and $a\,dx$, both being equal to 0, cannot be confused when we consider their ratio. In a similar way, we will deal with infinitely small quantities dx and dy (ibid., § 86, pp. 51–52) [emphasis added–the authors].

Having defined the arithmetic and geometric comparisons, Euler proceeds to clarify the difference between them as follows:

> Let a be a finite quantity and let dx be infinitely small. The arithmetic ratio of equals is clear: Since $ndx = 0$, we have
>
> $$a \pm ndx - a = 0.$$
>
> On the other hand, the geometric ratio is clearly of equals, since
>
> $$\frac{a \pm ndx}{a} = 1. \tag{6}$$
>
> From this we obtain the well-known rule that *the infinitely small vanishes in comparison with the finite and hence can be neglected [with respect to it]* [35, §87] [emphasis in the original–the authors].

Like Leibniz, Euler considers more than one way of comparing quantities. Euler's formula (6) indicates that his geometric comparison is procedurally identical with the Leibnizian TLH.

To summarize, Euler's geometric comparison of a pair of quantities amounts to their ratio being infinitely close to a finite quantity, as in formula (6); the same is true for TLH. Note that one has $a + dx = a$ in this sense for an appreciable $a \neq 0$, but *not* for $a = 0$ (in which case there is equality only in the *arithmetic* sense). Euler's "geometric" comparison was dubbed "the principle of cancellation" in (Ferraro [40, pp. 47, 48, 54]).

Euler proceeds to present the usual rules of infinitesimal calculus, which go back to Leibniz, l'Hôpital, and the Bernoullis, such as

$$a\,dx^m + b\,dx^n = a\,dx^m \tag{7}$$

provided $m < n$ "since dx^n vanishes compared with dx^m" ([35, § 89]), relying on his "geometric" comparison. Euler introduces a distinction between infinitesimals of different order, and directly *computes*[20] a ratio of the form

$$\frac{dx \pm dx^2}{dx} = 1 \pm dx = 1$$

of two particular infinitesimals, assigning the value 1 to it (ibid., § 88). Euler concludes:

> Although all of them [infinitely small quantities] are equal to 0, still they must be carefully distinguished one from the other if we are to pay attention to their mutual relationships, which has been explained through a geometric ratio (ibid., § 89).

The Eulerian hierarchy of orders of infinitesimals harks back to Leibniz's work (see the section "Leibniz's Transcendental Law of Homogeneity"). Euler's *geometric comparison*, or "principle of cancellation," is yet another incarnation of the idea at the root of Fermat's adequality and Leibniz's Transcendental Law of Homogeneity. For further details on Euler see Bibiloni et al. (2006 [13]); Bair et al. (2013 [6]); Reeder (2013 [86]).

What Did Cauchy Mean by "Limit"?

Laugwitz's detailed study of Cauchy's methodology places it squarely in the B-track (see the section called "Methodological Remarks"). In conclusion, Laugwitz writes:

> The influence of Euler should not be neglected, with regard both to the organization of Cauchy's texts and, in particular, to the fundamental role of infinitesimals (Laugwitz 1987 [71, p. 273]).

Thus, in his 1844 text *Exercices d'analyse et de physique mathématique*, Cauchy wrote:

> …si, les accroissements des variables étant supposés infiniment petits, on néglige, vis-à-vis de ces accroissements considérés comme infiniment petits du premier ordre, les infiniment petits des ordres supérieurs au premier, les nouvelles équations deviendront linéaires par rapport aux accroissements petits des variables. Leibniz et les premiers géomètres qui se sont occupés de l'analyse infinitésimale ont appelé *différentielles* des variables leurs accroissements infiniment petits, … (Cauchy 1844 [25, p. 5]).

Two important points emerge from this passage. First, Cauchy specifically speaks about *neglecting* ("on néglige") higher-order terms, rather than setting them equal to zero. This indicates a similarity of procedure with the Leibnizian TLH (see the section "Leibniz's Transcendental Law of Homogeneity"). Like Leibniz and Fermat before him, Cauchy does not set the higher-order terms equal to zero, but rather "neglects" or discards them. Furthermore, Cauchy's comments on Leibniz deserve special attention.

Cauchy on Leibniz

By speaking matter-of-factly about the infinitesimals of Leibniz specifically, Cauchy reveals that his (Cauchy's) infinitesimals are consonant with Leibniz's. This is unlike the differentials where Cauchy adopts a different approach.

On page 6 of the same text, Cauchy notes that the notion of derivative

> représente en réalité la *limite* du rapport entre les accrossements infiniment petits et simultanés de la fonction et de la variable (ibid., p. 6) [emphasis added–the authors]

The same definition of the derivative is repeated on page 7, this time emphasized by means of italics. Note Cauchy's emphasis on the point that the derivative is not a ratio of infinitesimal increments, but rather the *limit* of the ratio.

Cauchy's use of the term "limit" as applied to a ratio of infinitesimals in this context may be unfamiliar to a modern reader, accustomed to taking limits of *sequences* of real numbers. Its meaning is clarified by Cauchy's discussion of "neglecting" higher order infinitesimals in the previous paragraph on page 5 cited above. Cauchy's use of "limit" is procedurally identical with the Leibnizian TLH, and therefore similarly finds its modern proxy as extracting the standard part out of the ratio of infinitesimals.

On page 11, Cauchy chooses infinitesimal increments Δs and Δt, and writes down the equation

$$\frac{ds}{dt} = \text{lim.}\,\frac{\Delta s}{\Delta t}. \tag{8}$$

Modulo replacing Cauchy's symbol "lim." by the modern one "st" or "sh," Cauchy's formula (8) is identical to the formula appearing in any textbook based on the hyperreal approach, expressing the derivative in terms of the standard part function (shadow).

[20] *Note that Euler does not "prove that the expression is equal to 1;" such* indirect *proofs are a trademark of the* (ϵ, δ) *approach. Rather, Euler* directly *computes (what would today be formalized as the* standard part *of) the expression.*

Cauchy on Continuity

On page 17 of his 1844 text, Cauchy gives a definition of continuity in terms of infinitesimals (an infinitesimal x-increment necessarily produces an infinitesimal y-increment). His definition is nearly identical with the italicized definition that appeared on page 34 in his *Cours d'Analyse* (Cauchy 1821 [24]) 23 years earlier, when he first introduced the modern notion of continuity. We will use the translation by Bradley & Sandifer (2009 [20]). In his Section 2.2 entitled *Continuity of functions*, Cauchy writes:

> If, beginning with a value of x contained between these limits, we add to the variable x an infinitely small increment α, the function itself is incremented by the difference $f(x+\alpha)-f(x)$.

Cauchy goes on to state that

> the function $f(x)$ is a continuous function of x between the assigned limits if, for each value of x between these limits, the numerical value of the difference $f(x+\alpha)-f(x)$ decreases indefinitely with the numerical value of α.

He then proceeds to provide an italicized definition of continuity in the following terms:

> *the function $f(x)$ is continuous with respect to x between the given limits if, between these limits, an infinitely small increment in the variable always produces an infinitely small increment in the function itself.*

In modern notation, Cauchy's definition can be stated as follows. Denote by $\overset{\frown}{x}$ the *halo* of x, i.e., the collection of all points infinitely close to x. Then f is continuous at x if

$$f\left(\overset{\frown}{x}\right) \subset \overset{\frown}{f(x)}. \tag{9}$$

Most scholars hold that Cauchy never worked with a pointwise definition of continuity (as is customary today) but rather required a condition of type (9) to hold in a range ("between the given limits"). It is worth recalling that Cauchy never gave an ϵ, δ *definition* of either limit or continuity (though (ϵ, δ)-type *arguments* occasionally do appear in Cauchy). It is a widespread and deeply rooted misconception among both mathematicians and those interested in the history and philosophy of mathematics that it was Cauchy who invented the modern (ϵ, δ) definitions of limit and continuity; see, e.g., Colyvan & Easwaran (2008 [27, p. 88]) who err in attributing the formal (ϵ, δ) definition of continuity to Cauchy. That this is not the case was argued by Błaszczyk et al. (2013 [15]), Borovik et al. (2012 [17]), Katz & Katz (2011 [58]), Nakane (2014 [80]), Tall et al. (2014 [97]).

Modern Formalizations: A Case Study

To illustrate the use of the standard part in the context of the hyperreal field extension of $\mathbb{R}$, we will consider the following problem on divergent integrals. The problem was recently posed at SE, and is reportedly due to S. Konyagin.[21] The solution exploits the technique of a monotone rearrangement g of a function f, shown by Ryff to admit a measure-preserving map $\phi : [0,1] \to [0,1]$ such that $f = g \circ \phi$. In general there is no "inverse" ψ such that $g = f \circ \psi$; however, a hyperreal enlargement enables one to construct a suitable (internal) proxy for such a ψ, so as to be able to write $g = \mathrm{st}(f \circ \psi)$; see formula (14) below.

Theorem 1. *Let f be a real-valued function continuous on $[0,1]$. Then there exists a number a such that the integral*

$$\int_0^1 \frac{1}{|f(x)-a|}\,dx \tag{10}$$

diverges.

A proof can be given in terms of a monotone rearrangement of the function (see Hardy et al. [46]). We take a decreasing rearrangement $g(x)$ of the function $f(x)$. If f is continuous, then the function $g(x)$ will also be continuous. If f is not constant on any set of positive measure, one can construct g by setting

$$g = m^{-1} \quad \text{where} \quad m(y) = \mathrm{meas}\{x : f(x) > y\}. \tag{11}$$

Ryff (1970 [90]) showed that there exists a measure-preserving transformation[22] $\phi : [0,1] \to [0,1]$ that relates f and g as follows:

$$f(x) = g \circ \phi(x). \tag{12}$$

Finding a map ψ such that $g(x) = f \circ \psi(x)$ is in general impossible (see Bennett & Sharpley [12, p. 85, example 7.7] for a counterexample). This difficulty can be circumvented using a hyperfinite rearrangement (see the section entitled "A Combinatorial Approach to Decreasing Rearrangements"). By measure preservation, we have

$$\int_0^1 |f(x)-a|^{-1}\,dx = \int_0^1 |g(x)-a|^{-1}\,dx$$

(for every a).[23]

To complete the proof of Theorem 1, apply the result that every monotone function is

[21] http://math.stackexchange.com/questions/408311/improper-integral-diverges

[22] *However, see the section "A Combinatorial Approach to Decreasing Rearrangements" for a hyperfinite approach avoiding measure theory altogether.*

[23] *Here one needs to replace the function $|f(x)-a|^{-1}$ by the family of its truncations $\min\left(C, |f(x)-a|^{-1}\right)$, and then let C increase without bound.*

a.e. differentiable.[24] Take a point $p \in [0,1]$ where the function g is differentiable. Then the number $a = g(p)$ yields an infinite integral (10), since the difference $|g(x) - a|$ can be bounded above in terms of a linear expression.[25]

A Combinatorial Approach to Decreasing Rearrangements

The existence of a decreasing rearrangement of a function f continuous on $[0,1]$ admits an elegant proof in the context of its hyperreal extension $^*f$, which we will continue to denote by f.

We present a combinatorial argument showing that the decreasing rearrangement enjoys the same modulus of uniformity as the original function.[26] The argument actually yields an independent construction of the decreasing rearrangement (see Proposition 2) that avoids recourse to measure theory. It also yields an "inverse up to an infinitesimal," ψ (see formula (14)), to the function ϕ such that $f = g \circ \phi$. For a recent application of combinatorial arguments in a hyperreal framework, see Benci et al. (2013 [11]).

In passing from the finite to the continuous case of rearrangements, Bennett and Sharpley [12] note that

> nonnegative sequences $(a_1, a_2, \dots, a_n)$ and $(b_1, b_2, \dots, b_n)$ are equimeasurable if and only if there is a permutation σ of $\{1, 2, \dots, n\}$ such that $b_i = a_{\sigma(i)}$ for $i = 1, 2, \dots, n$. … The notion of permutation is no longer available in this context [of continuous measure spaces] and is replaced by that of a "measure-preserving transformation" (Bennett and Sharpley 1988 [12, p. 79]).

We show that the hyperreal framework allows one to continue working with combinatorial ideas, such as the "inverse" function ψ, in the continuous case as well.

Let $H \in {}^*\mathbb{N} \setminus \mathbb{N}$, let $p_i = \frac{i}{H}$ for $i = 1, 2, \dots, H$. By the Transfer Principle (see e.g., Davis [28], Herzberg [49], Kanovei & Reeken [56]), the nonstandard domain of internal sets satisfies the same basic laws as the usual, "standard" domain of real numbers and related objects. Thus, as for finite sets, there exists a permutation ψ of the hyperfinite grid

$$G_H = \{p_1, \dots, p_H\} \tag{13}$$

by decreasing value of $f(p_i)$ (here $f(\psi(p_1))$ is the maximal value). We assume that equal values are ordered lexicographically so that if $f(p_i) = f(p_j)$ with $i < j$ then $\psi(p_i) < \psi(p_j)$. Hence we obtain an internal function

$$\hat{g}(p_i) = f(\psi(p_i)), \quad i = 1, \dots, H. \tag{14}$$

Here $\hat{g}$ is (perhaps nonstrictly) decreasing on the grid G_H of (13). The internal sequences $(f(p_i))$ and $(\hat{g}(p_i))$, where $i = 1, \dots, H$, are equinumerable in the sense above.

Proposition 2. *Let f be an arbitrary continuous function. Then there is a standard continuous real function $g(x)$ such that $g(\mathrm{st}(p_i)) = \mathrm{st}(\hat{g}(p_i))$ for all i, where $\mathrm{st}(y)$ denotes the standard part of a hyperreal y.*

Proof. Let $g_i = \hat{g}(p_i)$. We claim that $\hat{g}$ is S-continuous (microcontinuous), i.e., for each pair $i, j = 1, \dots, H$, if $p_i - p_j$ is infinitesimal then so is $\hat{g}(p_i) - \hat{g}(p_j)$. To prove the claim, we will prove the following stronger fact:

> for every $i < j$ there are $m < n$ such that $n - m \le j - i$ and $|f(p_m) - f(p_n)| \ge g_i - g_j$.

The sets $A = \{k : f(p_k) \ge g_i\}$ and $B = \{k : f(p_k) \le g_j\}$ are nonempty and there are at most $j - i - 1$ points which are not in $A \cup B$. Let $m \in A$ and $n \in B$ be such that $|m - n|$ is minimal. All integers between m and n are not in $A \cup B$. Hence there are at most $j - i - 1$ such integers, and therefore $|n - m| \le j - i$. By the definition of A and B, we obtain $|f(p_n) - f(p_m)| \ge g_i - g_j$, which proves the claim. Thus $\hat{g}$ is indeed S-continuous.

This allows us to define, for any standard $x \in [0,1]$, the value $g(x)$ to be the standard part of the hyperreal g_i for any hyperinteger i such that p_i is infinitely close to x, and then g is a continuous[27] and (nonstrictly) monotone real function equal to the decreasing rearrangement $g = m^{-1}$ of (11). □

The hyperreal approach makes it possible to solve Konyagin's problem without resorting to standard treatments of decreasing rearrangements which use measure theory. Note that the rearrangement defined by the internal permutation ψ preserves the integral of f (as well as the integrals of the truncations of $|f(x) - a|^{-1}$), in the following sense. The *right-hand* Riemann sums satisfy

$$\sum_{i=1}^{H} f(p_i)\Delta x = \sum_{i=1}^{H} f(\psi(p_i))\Delta x = \sum_{i=1}^{H} \hat{g}(p_i)\Delta x, \tag{15}$$

[24] *In fact, one does not really need to use the result that monotone functions are a.e. differentiable. Consider the convex hull in the plane of the graph of the monotone function $g(x)$, and take a point where the graph touches the boundary of the convex hull (other than the endpoints 0 and 1). Setting a equal to the y-coordinate of the point does the job.*

[25] *Namely, for x near such a point p, we have $|g(x) - a| \le (|g'(p)| + 1)|x - p|$, hence $\frac{1}{|g(x)-a|} \ge \frac{1}{(|g'(p)|+1)|x-a|}$, yielding a lower bound in terms of a divergent integral.*

[26] *A function f on $[0,1]$ is said to satisfy a modulus of uniformity $\mu(n) > 0, n \in \mathbb{N}$, if $\forall n \in \mathbb{N}\ \forall p, q \in [0,1] \left(|p - q| \le \mu(n) \to |f(p) - f(q)| \le \frac{1}{n}\right)$.*

[27] *The argument shows in fact that the modulus of uniformity of g is bounded by that of f; see footnote 26.*

where $\Delta x = \frac{1}{H}$. Thus ψ transforms a hyperfinite Riemann sum of f into a hyperfinite Riemann sum of $\hat{g}$. Since $\int_0^1 f(x)dx = \mathrm{st}\left(\sum_{i=1}^{H} f(p_i)\Delta x\right)$ and $g(\mathrm{st}(p_i)) = \mathrm{st}(\hat{g}(p_i))$, we conclude that f and g have the same integrals, and similarly for the integrals of $|f(x) - a|^{-1}$; see footnote 23.

The first equality in (15) holds automatically by the transfer principle even though ψ is an infinite permutation. (Compare with the standard situation where changing the order of summation in an infinite sum generally requires further justification.) This illustrates one of the advantages of the hyperreal approach.

Conclusion

We have critically reviewed several common misrepresentations of hyperreal number systems, not least in relation to their alleged nonconstructiveness, from a historical, philosophical, and set-theoretic perspective. In particular we have countered some of Easwaran's recent arguments against the use of hyperreals in formal epistemology. A hyperreal framework enables a richer syntax better suited for expressing proxies for procedural moves found in the work of Fermat, Leibniz, Euler, and Cauchy. Such a framework sheds light on the internal coherence of their procedures which have been often misunderstood from a whiggish post-Weierstrassian perspective.

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References

[1] S. Albeverio, R. Høegh-Krohn, J. Fenstad, and T. Lindstrøm, Nonstandard methods in stochastic analysis and mathematical physics, *Pure and Applied Mathematics* **122**, Academic Press, Inc., Orlando, FL, 1986.

[2] A. Alexander, *Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World*, Farrar, Straus and Giroux, 2014.

[3] N. Alling, *Foundations of Analysis over Surreal Number Fields*, North-Holland Mathematical Library, 1987.

[4] R. Anderson, A nonstandard representation for Brownian motion and Itô integration, *Israel Journal of Mathematics* **25** (1976), no. 1-2, 15–46.

[5] R. Arthur, Leibniz's syncategorematic infinitesimals, *Arch. Hist. Exact Sci.* **67** (2013), no. 5, 553–593.

[6] J. Bair, P. Błaszczyk, R. Ely, V. Henry, V. Kanovei, K. Katz, M. Katz, S. Kutateladze, T. McGaffey, D. Schaps, D. Sherry, and S. Shnider, Is mathematical history written by the victors? *Notices of the American Mathematical Society* **60** (2013) no. 7, 886–904. See http://www.ams.org/notices/201307/rnoti-p886.pdf and http://arxiv.org/abs/1306.5973.

[7] T. Bascelli, Galileo's quanti: Understanding infinitesimal magnitudes, *Arch. Hist. Exact Sci.* **68** (2014), no. 2, 121–136.

[8] ———, Infinitesimal issues in Galileo's theory of motion, *Revue Roumaine de Philosophie* **58** (2014), no. 1, 23-41.

[9] J. Bell, *The Continuous and the Infinitesimal in Mathematics and Philosophy*, Polimetrica, 2006.

[10] P. Benacerraf, What numbers could not be, *Philos. Rev.* **74** (1965), 47–73.

[11] V. Benci, E. Bottazzi, and M. Di Nasso, *Elementary numerosity and measures*, preprint (2013).

[12] C. Bennett and R. Sharpley, Interpolation of operators, *Pure and Applied Mathematics* vol. 129, Academic Press, Boston, MA, 1988.

[13] L. Bibiloni, P. Viader, and J. Paradís, On a series of Goldbach and Euler, *Amer. Math. Monthly* **113** (2006), no. 3, 206–220.

[14] E. Bishop, *Mathematics as a numerical language*, 1970 Intuitionism and Proof Theory (Proc. Conf., Buffalo, N.Y., 1968), pp. 53–71, North-Holland, Amsterdam.

[15] P. Błaszczyk, M. Katz, and D. Sherry, Ten misconceptions from the history of analysis and their debunking, *Foundations of Science* **18** (2013), no. 1, 43–74. See http://dx.doi.org/10.1007/s10699-012-9285-8 and http://arxiv.org/abs/1202.4153.

[16] A. Borovik, R. Jin, and M. Katz, An integer construction of infinitesimals: Toward a theory of Eudoxus hyperreals, *Notre Dame Journal of Formal Logic* **53** (2012), no. 4, 557-570. See http://dx.doi.org/10.1215/00294527-1722755 and http://arxiv.org/abs/1210.7475.

[17] A. Borovik and M. Katz, Who gave you the Cauchy–Weierstrass tale? The dual history of rigorous calculus, *Foundations of Science* **17** (2012), no. 3, 245–276. See http://dx.doi.org/10.1007/s10699-011-9235-x and http://arxiv.org/abs/1108.2885.

[18] H. J. M. Bos, Differentials, higher-order differentials and the derivative in the Leibnizian calculus, *Arch. History Exact Sci.* **14** (1974), 1–90.

[19] H. J. M. Bos, R. Bunn, J. Dauben, I. Grattan-Guinness, T. Hawkins, and K. M. Pedersen, *From the calculus to set theory*, 1630–1910, An introductory history, Edited by I. Grattan-Guinness, Gerald Duckworth & Co. Ltd., London, 1980.

[20] R. Bradley and C. Sandifer, Cauchy's *Cours d'analyse*, An annotated translation, Sources and Studies in the History of Mathematics and Physical Sciences, Springer, New York, 2009.

[21] H. Breger, The mysteries of adaequare: A vindication of Fermat, *Arch. Hist. Exact Sci.* **46** (1994), no. 3, 193–219.

[22] Č. Brukner and A. Zeilinger, Quantum physics as a science of information, in Quo vadis quantum mechanics?, 47–61, *Frontiers Collection*, Springer, Berlin, 2005.

[23] M. Carroll, S. Dougherty, and D. Perkins, Indivisibles, infinitesimals and a tale of seventeenth-century

mathematics, *Mathematics Magazine* **86** (2013), no. 4, 239–254.

[24] A. L. Cauchy, *Cours d'Analyse de L'Ecole Royale Polytechnique*, Première Partie, Analyse algébrique, Paris: Imprimérie Royale, 1821, Online at http://books.google.com/books?id=_mYVAAAAQAAJ&dq=cauchy&lr=&source=gbs_navlinks_s.

[25] ———, *Exercices d'analyse et de physique mathématique*, (vol. 3), Paris, Bachelier, 1844.

[26] P. Cohen, *Set Theory and the Continuum Hypothesis* W. A. Benjamin, New York-Amsterdam, 1966.

[27] M. Colyvan and K. Easwaran, Mathematical and physical continuity, *Australas. J. Log.* **6** (2008), 87–93.

[28] M. Davis, *Applied nonstandard analysis*, Pure and Applied Mathematics, Wiley-Interscience [John Wiley & Sons], New York-London-Sydney, 1977. Reprinted: Dover, NY, 2005, see http://store.doverpublications.com/0486442292.html.

[29] G. Dowek, Real numbers, chaos, and the principle of a bounded density of information, Invited paper at International Computer Science Symposium in Russia, 2013. See http://who.rocq.inria.fr/Gilles.Dowek/Publi/csr.pdf.

[30] J. Earman, Infinities, infinitesimals, and indivisibles: The Leibnizian labyrinth, *Studia Leibnitiana* **7** (1975), no. 2, 236–251.

[31] K. Easwaran, Regularity and hyperreal credences, *Philosophical Review* **123** (2014), No. 1, 1–41.

[32] P. Ehrlich, The rise of non-Archimedean mathematics and the roots of a misconception, I, The emergence of non-Archimedean systems of magnitudes, *Arch. Hist. Exact Sci.* **60** (2006), no. 1, 1–121.

[33] A. Elga, Infinitesimal chances and the laws of nature, *Australasian Journal of Philosophy* **82** (2004), no. 1, 67–76.

[34] L. Euler, Institutiones Calculi Differentialis, SPb, 1755.

[35] ———, *Foundations of Differential Calculus*, English translation of Chapters 1–9 of ([34]) by D. Blanton, Springer, New York, 2000.

[36] S. Feferman and A. Levy, Independence results in set theory by Cohen's method II, *Notices Amer. Math. Soc.* **10** (1963), 593.

[37] U. Felgner, Der Begriff der "Angleichung" ($\pi\alpha\rho\iota\sigma\acute{o}\tau\eta\varsigma$, adaequatio) bei Diophant und Fermat (2014), preprint.

[38] P. Fermat, *Méthode pour la recherche du maximum et du minimum*, pp. 121–156 in Tannery's edition [99].

[39] ———, *Letter to Brûlart*, Oeuvres, Vol. 5, pp. 120–125.

[40] G. Ferraro, Differentials and differential coefficients in the Eulerian foundations of the calculus, *Historia Mathematica* **31** (2004), no. 1, 34–61. See http://dx.doi.org/10.1016/S0315-0860(03)00030-2.

[41] C. I. Gerhardt (ed.), *Historia et Origo calculi differentialis a G. G. Leibnitio conscripta*, ed. C. I. Gerhardt, Hannover, 1846.

[42] ———, *Leibnizens mathematische Schriften*, (Berlin and Halle: Eidmann, 1850–1863).

[43] E. Giusti, Les méthodes des maxima et minima de Fermat, *Ann. Fac. Sci. Toulouse Math.* (6) **18** (2009), Fascicule Special, 59–85.

[44] U. Goldenbaum and D. Jesseph (eds.), *Infinitesimal Differences: Controversies between Leibniz and his Contemporaries*, Berlin-New York: Walter de Gruyter, 2008.

[45] M. Guillaume, "Review of M. Katz, D. Sherry, Leibniz's infinitesimals: Their fictionality, their modern implementations, and their foes from Berkeley to Russell and beyond, *Erkenntnis* **78** (2013), no. 3, 571–625." Mathematical Reviews (2014). See http://www.ams.org/mathscinet-getitem?mr=3053644.

[46] G. Hardy, J. Littlewood, and G. Pólya, *Inequalities*, Second edition, Cambridge University Press, 1952.

[47] H. Heaton, Infinity, the infinitesimal, and zero, *American Mathematical Monthly* **5** (1898), no. 10, 224–226.

[48] F. Herzberg, Internal laws of probability, generalized likelihoods and Lewis' infinitesimal chances—a response to Adam Elga. *British Journal for the Philosophy of Science* **58** (2007), no. 1, 25–43.

[49] ———, *Stochastic calculus with infinitesimals*, Lecture Notes in Mathematics, 2067, Springer, Heidelberg, 2013.

[50] E. Hewitt, Rings of real-valued continuous functions, I, *Trans. Amer. Math. Soc.* **64** (1948), 45–99.

[51] A. Heijting, Address to Professor A. Robinson, At the occasion of the Brouwer memorial lecture given by Professor A. Robinson on April 26, 1973, *Nieuw Archief voor Wiskunde (3)* **21** (1973), 134–137.

[52] H. Ishiguro, *Leibniz's Philosophy of Logic and Language*, Second edition, Cambridge University Press, Cambridge, 1990.

[53] G. Jaroszkiewicz, Principles of Discrete Time Mechanics, *Cambridge Monographs on Mathematical Physics*, Cambridge University Press, 2014.

[54] T. Jech, *The axiom of choice*, Studies in Logic and the Foundations of Mathematics, Vol. 75. North-Holland Publishing Co., Amsterdam-London; American Elsevier Publishing Co., Inc., New York, 1973.

[55] V. Kanovei, M. Katz, and T. Mormann, Tools, objects, and chimeras: Connes on the role of hyperreals in mathematics, *Foundations of Science* **18** (2013), no. 2, 259–296. See http://dx.doi.org/10.1007/s10699-012-9316-5 and http://arxiv.org/abs/1211.0244.

[56] V. Kanovei and M. Reeken, *Nonstandard analysis, axiomatically*, Springer Monographs in Mathematics, Berlin: Springer, 2004.

[57] V. Kanovei and S. Shelah, A definable nonstandard model of the reals, *Journal of Symbolic Logic* **69** (2004), no. 1, 159–164.

[58] K. Katz and M. Katz, Cauchy's continuum, *Perspectives on Science* **19** (2011), no. 4, 426–452. See http://arxiv.org/abs/1108.4201 and http://www.mitpressjournals.org/doi/abs/10.1162/POSC_ a_00047.

[59] ———, Meaning in classical mathematics: Is it at odds with intuitionism? *Intellectica* **56** (2011), no. 2, 223–302. See http://arxiv.org/abs/1110.5456.

[60] ———, A Burgessian critique of nominalistic tendencies in contemporary mathematics and its historiography, *Foundations of Science* **17** (2012), no. 1, 51–89. See http://dx.doi.org/10.1007/s10699-011-9223-1 and http://arxiv.org/abs/1104.0375.

[61] K. Katz, M. Katz, and T. Kudryk, Toward a clarity of the extreme value theorem, *Logica Universalis* **8** (2014), no. 2, 193-214. See http://dx.doi.org/10.1007/s11787-014-0102-8 and http://arxiv.org/abs/1404.5658.

[62] M. Katz and E. Leichtnam, Commuting and noncommuting infinitesimals, *American Mathematical Monthly* **120** (2013), no. 7, 631–641. See http://dx.doi.org/10.4169/amer.math.monthly.120.07.631 and http://arxiv.org/abs/1304.0583.

[63] M. Katz, D. Schaps, and S. Shnider, Almost equal: The method of adequality from Diophantus to Fermat and beyond. *Perspectives on Science* **21** (2013), no. 3, 283–324. See http://www.mitpressjournals.org/doi/abs/10.1162/POSC_a_00101 and http://arxiv.org/abs/1210.7750.

[64] M. Katz and D. Sherry, Leibniz's laws of continuity and homogeneity, *Notices of the American Mathematical Society* **59** (2012), no. 11, 1550–1558. See http://www.ams.org/notices/201211/ and http://arxiv.org/abs/1211.7188.

[65] ———, Leibniz's infinitesimals: Their fictionality, their modern implementations, and their foes from Berkeley to Russell and beyond, *Erkenntnis* **78** (2013), no. 3, 571–625. See http://dx.doi.org/10.1007/s10670-012-9370-y and http://arxiv.org/abs/1205.0174.

[66] V. Katz, "Review of Bair et al., Is mathematical history written by the victors? *Notices Amer. Math. Soc.* **60** (2013), no. 7, 886–904." *Mathematical Reviews* (2014). See http://www.ams.org/mathscinet-getitem?mr=3086638.

[67] H. J. Keisler, *Elementary Calculus: An Infinitesimal Approach*, Second Edition, Prindle, Weber & Schimdt, Boston, 1986. Revision from February 2012 online at http://www.math.wisc.edu/~keisler/calc.html.

[68] F. Klein, *Elementary Mathematics from an Advanced Standpoint*, Vol. I, Arithmetic, Algebra, Analysis, Translation by E. R. Hedrick and C. A. Noble [Macmillan, New York, 1932] from the third German edition [Springer, Berlin, 1924]. Originally published as Elementarmathematik vom höheren Standpunkte aus (Leipzig, 1908).

[69] E. Knobloch, *Leibniz's rigorous foundation of infinitesimal geometry by means of Riemannian sums*, Foundations of the formal sciences, 1 (Berlin, 1999), *Synthese* **133** (2002), no. 1–2, 59–73.

[70] ———, "Review of: M. Katz, D. Schaps, and S. Shnider, Almost equal: The method of adequality from Diophantus to Fermat and beyond, *Perspectives on Science* **21** (2013), no. 3, 283–324." *Mathematical Reviews* (2014). See http://www.ams.org/mathscinet-getitem?mr=3114421.

[71] D. Laugwitz, Infinitely small quantities in Cauchy's textbooks, *Historia Mathematica* **14** (1987), no. 3, 258–274.

[72] G. Leibniz, Nova methodus pro maximis et minimis …, in *Acta Erud.*, October 1684. See Gerhardt [42], V, pp. 220–226.

[73] ———, Responsio ad nonnullas difficultates a Dn. Bernardo Niewentiit circa methodum differentialem siu infinitesimalem motas, in Gerhardt [42], V, p. 320–328, 1695.

[74] ———, *Cum Prodiisset*…mss "Cum prodiisset atque increbuisset Analysis mea infinitesimalis…" in Gerhardt [41], pp. 39–50, 1701.

[75] ———, Symbolismus memorabilis calculi algebraici et infinitesimalis in comparatione potentiarum et differentiarum, et de lege homogeneorum transcendentali, in Gerhardt [42, vol. V, pp. 377–382], 1710.

[76] A. Lewis, Bringing modern mathematics to bear on historical research, *Historia Mathematica* **2** (1975), 84–85.

[77] ———, *A subjectivist's guide to objective chance.* In Studies in Inductive Logic and Probability (ed. Richard C. Jeffrey), pp. 263–293, University of California Press, 1980.

[78] J. Łoś, *Quelques remarques, théorèmes et problèmes sur les classes définissables d'algèbres*, in Mathematical interpretation of formal systems, 98–113, North-Holland Publishing Co., Amsterdam, 1955.

[79] T. Mormann and M. Katz, Infinitesimals as an issue of neo-Kantian philosophy of science, *HOPOS: The Journal of the International Society for the History of Philosophy of Science* **3** (2013), no. 2, 236–280. See http://www.jstor.org/stable/10.1086/671348. and http://arxiv.org/abs/1304.1027.

[80] M. Nakane, Did Weierstrass's differential calculus have a limit-avoiding character? His definition of a limit in ϵ-δ style, *BSHM Bulletin: Journal of the British Society for the History of Mathematics* **29** (2014), no. 1, 51–59. See http://dx.doi.org/10.1080/17498430.2013.831241.

[81] E. Nelson, Internal set theory: a new approach to nonstandard analysis. *Bulletin of the American Mathematical Society* **83** (1977), no. 6, 1165–1198.

[82] ———, Radically elementary probability theory, *Annals of Mathematics Studies*, vol. 117, Princeton University Press, 1987.

[83] ———, *Warning signs of a possible collapse of contemporary mathematics*, in Infinity (Michael Heller and W. Hugh Woodin, eds.), pp. 76–85, Cambridge University Press, 2011.

[84] B. Pourciau, Newton and the notion of limit, *Historia Mathematica* **28** (2001), no. 1, 18–30.

[85] C. Reder, Transient behaviour of a Galton-Watson process with a large number of types, *Journal of Applied Probability* **40** (2003), no. 4, 1007–1030.

[86] P. Reeder, Internal Set Theory and Euler's *Introductio in Analysin Infinitorum*, MSc Thesis, Ohio State University, 2013.

[87] A. Robinson, Nonstandard analysis, *Nederl. Akad. Wetensch. Proc. Ser. A* **64**, *Indag. Math.* **23** (1961), 432–440 [reprinted in Selected Works, see item [88], pp. 3-11]

[88] ———, Selected papers of Abraham Robinson, Vol. II, Nonstandard analysis and philosophy, edited and with introductions by W. A. J. Luxemburg and S. Körner, Yale University Press, New Haven, Conn., 1979.

[89] B. Russell, *The Principles of Mathematics*, Routledge, London 1903.

[90] J. Ryff, Measure preserving transformations and rearrangements, *J. Math. Anal. Appl.* **31** (1970), 449–458.

[91] T. Settle, Galilean science: Essays in the mechanics and dynamics of the *Discorsi*, Ph.D. dissertation, Cornell University, 1966, 288 pages.

[92] D. Sherry and M. Katz, Infinitesimals, imaginaries, ideals, and fictions, *Studia Leibnitiana* **44** (2012), no. 2, 166–192. See http://arxiv.org/abs/1304.2137.

[93] T. Skolem, *Peano's axioms and models of arithmetic*, in Mathematical interpretation of formal systems, pp. 1–14. North-Holland Publishing Co., Amsterdam, 1955.

[94] B. Skyrms, *Causal Necessity: A Pragmatic Investigation of the Necessity of Laws*, Yale University Press, 1980.

[95] P. Strømholm, Fermat's methods of maxima and minima and of tangents, A reconstruction, *Arch. History Exact Sci.* **5** (1968), no. 1, 47–69.

[96] K. Sullivan, Mathematical Education: The Teaching of Elementary Calculus Using the Nonstandard Analysis Approach, *Amer. Math. Monthly* **83** (1976), no. 5, 370–375.

[97] D. Tall and M. Katz, A cognitive analysis of Cauchy's conceptions of function, continuity, limit, and infinitesimal, with implications for teaching the calculus, *Educational Studies in Mathematics*, to appear. See http://dx.doi.org/10.1007/s10649-014-9531-9 and http://arxiv.org/abs/1401.1468.

[98] P. Tannery and C. Henry, *Oeuvres de Fermat, Vol. 1*, Gauthier-Villars, 1891.

[99] ———, *Oeuvres de Fermat, Vol. 3*, Gauthier-Villars, 1896.

[100] T. Tao, see the post http://terrytao.wordpress.com/2013/11/16/qualitative-probability-theory-types-and-the-group-chunk-and-group-configuration-theorems/.

[101] T. Tho, Equivocation in the foundations of Leibniz's infinitesimal fictions, *Society and Politics* **6** (2012), no. 2, 70–98.

[102] A. Weil, *Number Theory, An Approach through History, From Hammurapi to Legendre*, Birkhäuser Boston, Inc., Boston, MA, 1984.

[103] J. Wheeler, *At home in the universe*, Masters of Modern Physics, American Institute of Physics, Woodbury, NY, 1994.

[104] N. Wiener, Differential space, *Journal of Mathematical Physics* **2** (1923), no. 1, 131–174.

[105] T. Williamson, How probable is an infinite sequence of heads?, *Analysis* **67** (2007), no. 3, 173–180.

[106] W. Wisan, The new science of motion: A study of Galileo's De motu locali, *Arch. History Exact Sci.* **13** (1974), 103–306.

MOOCs: An Inside View

Rachel McCulloch and Linda Preiss Rothschild

In 2012, as recently retired professors of mathematics (Linda) and economics (Rachel), we were attracted to the newly available—and free—massive open online courses (MOOCs), both for intellectual stimulation and to experience the latest innovation in teaching. Over the next year, we sampled dozens of courses in a variety of fields ranging from biology to cryptography. We completed all the coursework in some of them, earning "certificates" and even notations of distinction for our online efforts. In the process we added significantly to our knowledge in several fields related to our own and also gained perspective on the potential of MOOCs as a mode of instruction.

Discussing our observations with colleagues, we were surprised to learn that almost none of the many professors and administrators now involved in creating MOOCs or deciding on their appropriate role in their institution's curriculum have actually "attended" even a single MOOC. Readers who have yet to discover the world of MOOCs might want to read the excellent Wikipedia article [1]. Then explore `www.coursera.org`, `www.edx.org`, or `www.udacity.com`, currently the most important US platforms for MOOCs, and peek into some courses. But just as peeking into a new textbook reveals only a bit about its value as a learning tool for our students, the same applies to MOOCs. We may be able to eliminate some MOOCs as unsuitable for our needs or those of our students on the basis of a quick peek, but evaluating others requires a larger investment of time.

To begin with the basics, a MOOC is usually an online presentation of all or part of a conventional college or graduate course, including syllabus, lectures, required or recommended reading, problem sets, and exams. Enrollment is free and easy, with no entrance requirements: A prospective student need only establish an account with the relevant platform, e.g., Coursera, and then push the "Enroll" button for any course that is currently running or soon to begin. After agreeing to the honor code, the student can finally see what the course has to offer. Because a student must enroll first, this setup tends to inflate the number of enrollees relative to the number who actually continue in the course, let alone complete it—thus helping to explain the often reported low rate at which students complete courses for which they have enrolled. The instructor of one recent Coursera course reported about 130,000 enrolled, of whom about 15,000 submitted at least one exam and about 9,000 completed the required coursework with an average grade high enough to qualify for a certificate.

Many MOOCs are shorter than most college courses—typically four to ten weeks—and accordingly cover less material. In contrast to the uniform lecture length of conventional courses, MOOCs usually consist of a much larger number of very short lecture segments. (Some research has shown that the average MOOC student finds even these short segments too long to sustain their interest. This is hardly a surprise to those of us with classroom experience.) Although most MOOCs follow a pre-announced schedule, students are free to watch a given week's videos at their convenience during that week or later on. MOOC lecturers are typically research-oriented tenured faculty members at top colleges and universities, sometimes even winners of Nobel prizes or other academic distinctions.

Apart from length, MOOC lectures also vary in format. Most Coursera lectures have been recorded especially for this purpose, often in a way that makes the lecturer seem to be speaking directly to the MOOC student viewer. Lectures on edX are often recorded in front of a class, complete with students walking in front of the camera as they arrive late, coughing, chatting with neighbors, or answering questions posed by the lecturer. (We've noted some editing of these videos lately, perhaps in response to feedback from viewers.) In addition to their relative brevity, the online lectures in many courses contain pauses or mini-quizzes, during

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which the student has an opportunity to apply the most recent material and check for comprehension before proceeding further. Among the courses we have sampled, each week included a computer-graded homework assignment. Some courses also had peer-graded assignments. And courses often have one or more exams, again computer-graded. A final feature common to all the MOOCs we sampled is an online forum, which allows students to ask questions, answer questions posed by others, or simply to comment on their experience.

Examples of "Successful" MOOCs

It is obvious to any experienced teacher that students learn in different ways. For concreteness, we describe here three of our more satisfying adventures in online learning, i.e., MOOCs that were successful for us. (As the small print in advertising for diet aids often cautions, your results may vary.) In the accompanying box, we suggest several other MOOCs that are likely to be of particular interest to mathematicians.

The first, "Financial Accounting," was created by Brian Bushee, a professor at the University of Pennsylvania's Wharton School. This sounded like a boring topic to one of us (the mathematician), but the economist argued that the subject is important in really understanding how corporations (and hence the world) actually operate. The mathematician grudgingly agreed to give it a try—and is glad she did. We already had Coursera accounts from previous courses, so we each logged in and pushed the "Enroll" button, one of us in San Diego and the other in Boston.

The course is noteworthy for several reasons. First, it turned out to be the best course we took, in our view a model of excellence in MOOC education. Second, financial accounting is a standard first-year M.B.A. course, and one of four first-year courses now being offered by Wharton as MOOCs. Third, the course, whether as a MOOC or in a classroom format, has no prerequisite beyond basic arithmetic, not even knowledge of Excel or basic programming. From the forum we knew that some enrolled students had studied accounting in the past and wanted to improve their knowledge, but most were new to the subject. Students lived in many different countries and represented a broad range of ages and prior educational attainments. We were far from the only retirees or Ph.D.'s, but many of our fellow students were undergraduates or even high schoolers in other countries, eager to sample elite US higher education in a physically and financially accessible form. Fourth, the course was indeed massive, with an enrollment of 130,290. Finally, the instructor provided extensive data and observations at the end of the course, so we knew more about this course than any other in which we had enrolled.

Figure 1. Screenshot from Brian Bushee's "Financial Accounting."

According to Bushee, who is a chaired professor of accounting and has received a variety of awards for excellence in teaching, his MOOC is closely modeled on the M.B.A. course he teaches at Wharton. Probably the most important difference is that the classroom version includes discussion of various cases (case analysis is a staple of M.B.A. education). The course ran for ten weeks and actually covered more material than the standard first M.B.A. course in accounting. Each week's topic was covered in up to eight well-organized video segments, as much as three hours in total. The last part of each week's offering applied the most recent material to the financial reports of an actual US company, 3M. The videos were created for the MOOC and show Bushee in his office rather than in a classroom. Students could also download the slides from each lecture or the full transcript—particularly valuable for students whose first language is not English.

There were nine homework assignments and two exams. These were in multiple-choice format but far from easy (at least for us), even though two tries were allowed on each assignment, and three tries on each exam. A very helpful feature was that the machine grading included explanations of the correct answers.

Students could use the online forum to raise and answer questions about the course material—the forum received an amazing 15,694 posts over ten weeks. Although Bushee noted in a "goodbye video" that most student questions to the forum were answered correctly by other students, this course was unusual in the degree to which Bushee himself replied to queries from the class. In other MOOCs, questions were answered more often by teaching assistants or, in many cases, no one except other students. But since both of us were enrolled in the course, we had a second way to interact. Our "bicoastal study group" of two met frequently on Skype to ponder some of the tricky questions on the homework assignments. This was especially important in a subject (like accounting or math) where each topic builds on prior material.

From our own experience in studying an unfamiliar subject, we appreciated that MOOCs are unlikely to be successful for the typical student unless supplemented by a nonmassive way for students to interact with each other and with someone (a professor or teaching assistant) willing and able to provide expert assistance.

One unique feature of this MOOC deserves mention. In lecturing to our own classes, we often raise questions that (we think, based on past experience) may be in the minds of students, and then provide answers. In "Financial Accounting," Professor Bushee created cartoon virtual students who raised questions for him to answer and who also provided some comic relief to enliven what might otherwise have been a very dry presentation.

As academics, we were especially entertained by comments from a virtual dean who worried about alumni reaction to some critical remarks from Bushee about firms' deceptive accounting practices.

A second MOOC on Coursera turned out to be a convenient way for a pure mathematician to learn a bit about machine learning, a heavily mathematical method in computer science that is now influencing our lives, from Netflix video recommendations to self-driving cars. One of us (Linda) pushed the "Enroll" button for the course given by Andrew Ng, a Stanford computer science professor and one of the two founders of Coursera. The topics combined theory and practice, complete with an excellent introduction to MATLAB and its open-source alternative, Octave. In the first week students learned the difference between supervised and unsupervised learning, and the course quickly got into mathematical methods. The weekly assignments included both multiple-choice quizzes on the lecture material and short programming assignments. Of course students could skip the included review of linear algebra, but Linda gained a new respect for matrices as convenient placeholders for manipulation of data. This MOOC


AUGUST 13, 2013

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ASSOCIATE PROFESSOR ANDREW NG
COMPUTER SCIENCE DEPARTMENT
STANFORD UNIVERSITY

PLEASE NOTE: SOME ONLINE COURSES MAY DRAW ON MATERIAL FROM COURSES TAUGHT ON CAMPUS BUT THEY ARE NOT EQUIVALENT TO ON-CAMPUS COURSES. THIS STATEMENT DOES NOT AFFIRM THAT THIS STUDENT WAS ENROLLED AS A STUDENT AT STANFORD UNIVERSITY IN ANY WAY. IT DOES NOT CONFER A STANFORD UNIVERSITY GRADE, COURSE CREDIT OR DEGREE, AND IT DOES NOT VERIFY THE IDENTITY OF THE STUDENT.

Figure 2. Linda's certificate from "Machine Learning."

MOOCs for Mathematicians

For mathematicians interested in expanding their knowledge of subjects using tools from math, there are many other possible MOOCs to consider. For a "nuts and bolts" introduction to practical cryptography, try Coursera's "Cryptography 1" given by Dan Boneh (Stanford). Some programming is required (and it's fun when you finally manage to decode the cipher text), but there is also some interesting basic theory.

Want to know a bit about graph theory and applications to social networks? Try Coursera's "Social and Economic Networks," given by economics professor Matt Jackson (Stanford). That course covers many fascinating topics, including Erdős random networks, game theoretic modeling, and Bayesian learning, as well as special software for network analysis. Networks are currently a hot topic, and edX has now posted their own course, "Networks, Crowds, and Markets," presented by three highly distinguished Cornell professors: theoretical computer scientists Eva Tardos (Fulkerson Prize) and Jon Kleinberg (Nevanlinna Prize), as well as economics professor David Easley. This multidisciplinary course may be less mathematical than others mentioned here, but the promised applications are plentiful.

Udacity's flagship course, "Introduction to Artificial Intelligence" (AI), taught by Peter Norvig (Google) and Udacity co-founder Sebastian Thrun (Stanford), offers lessons in many techniques and their applications to artificial intelligence (robots, anyone?), including a thorough discussion of Bayes's Law with many exercises. Unlike courses at Coursera and edX (and some later courses at Udacity), AI does not run on a set schedule. That is, students can sign up anytime and come back anytime. AI's initial offering by Stanford in 2011 attracted more than 100,000 students from around the world and is often credited with starting the MOOC "revolution."

provided an excellent ratio of knowledge gained to hours spent, as well as a handsome certificate!

How about a course with actual theorems and proofs? Linda tuned into a six-week course on algorithms given by Stanford computer science professor Tim Roughgarden. Corresponding roughly to the first half of a junior-level course for computer science majors, the course introduced some basic algorithms for sorting and searching, with emphasis on estimation of performance time. The weekly multiple-choice quizzes contained clever problems concerning the theory, while the programming assignments required mainly straightforward implementations of the algorithms discussed. For the programming part, students could use any language and were graded on numerical answers rather than on the programs themselves.

"Algorithms" proved very satisfying and relevant for a mathematician who has taught undergraduate courses in probability and applied algebra. Understanding how sophisticated mathematics is used in related areas is certainly helpful in planning lectures that will hold students' interest. Another benefit is in understanding and communicating with colleagues in other departments.

Motivation and Evaluation

Could MOOCs play a direct role for students at a college or university? As retired academics, we were certainly not the target audience for the MOOCs in which we enrolled, though we found we had plenty of company from other older students, many with advanced degrees. Some friends wondered whether we would get academic credit for completing such courses. Our response, with plenty of old-fashioned degrees on our CVs: "Credit toward what?" But the potential to earn credit toward a degree, satisfy a prerequisite, or qualify for employment will be a crucial issue in the future role of MOOCs in higher education. We ourselves were motivated mostly by the opportunity to learn something new in a very convenient way at no cost, and also to see how other departments organize their courses. Although we were not interested in credit (we did like getting those nice certificates), the instant feedback from the quizzes, problem sets, and exams was useful in testing our understanding. While some of the "real" students on the MOOCs were mainly motivated by a desire to learn from world-renowned scholars, many others were eager to obtain a recognized credential. The latter students, much like the ones we have encountered in our classrooms, often seemed at least as interested in the course grade as the knowledge gained in the process of obtaining that grade. And, similar to our own students, they used the course forums to compare homework and exam scores, thus gauging how well they were doing relative to peers.

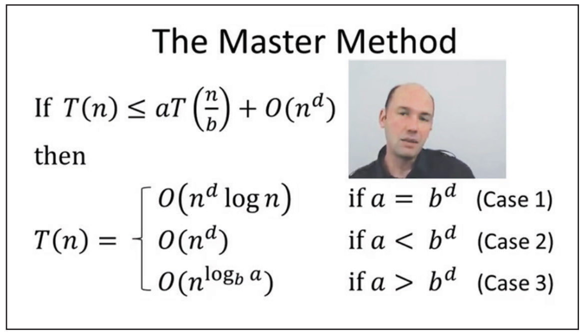


Figure 3. Screenshot from Tim Roughgarden's "Algorithms."

This brings us to the problem of evaluating what has been learned. As professors, we are only too familiar with the issues of evaluation in traditional courses. In large classes where it is easy to copy short answers from a neighbor's exam, much time and effort are expended to prevent cheating, and the electronic age has added new problems to the old ones. For example, students' cell phones may facilitate unauthorized collaboration during an in-class exam, while small computers or calculators can invert a matrix and evaluate a definite integral. So we often choose to ban all electronics from our exams, but thus limit our ability to evaluate how well students can use some important tools.

As MOOC students, we've experienced various ways to evaluate students' work. The first and simplest is with multiple-choice questions, the effectiveness of which is often in question. (In our experience writing exam questions for GRE subject tests, we learned how hard it is to create a meaningful multiple-choice question.) In courses containing computations, another option is to ask for the final numerical result in a calculation. In our MOOC experience, machine grading sometimes rejected correct answers due to round-off errors. Obviously, human grading is also subject to error. For courses in which students must submit computer programs, MOOCs use software to test the submitted programs. A final and, to our minds, least satisfactory solution used in some MOOCs is peer review, in which each student must grade the work (essays or written explanations) of several other students. Of course it is difficult to evaluate the resulting evaluations, and the incentive for and ability of students to do this well is at best questionable. Imagine a complicated proof produced by a top student being graded by a weak student who barely knows what a proof is.

An informal method by which some MOOC students may seek to distinguish themselves and thereby attract positive attention from instructors even in a huge class is through frequent contributions to the MOOC forum, where they answer other students' questions, provide explanations of subtle points, or post solutions to challenges. Some courses recognize the quality and quantity of forum contributions, and a record of exceptional work may later be used to help a student gain entry into a graduate program or be considered for employment.

Regardless of the method by which student work is evaluated, a more basic issue is whose work is being evaluated. The problem is captured succinctly by the caption of Peter Steiner's 1993 cartoon in *The New Yorker*: "On the Internet, nobody knows you're a dog." To separate the dogs from the cats, in 2013 Coursera introduced a system that confirms the identity of the student. According to the announcement of this innovation, a student who opts for the "Signature Track" builds a Signature Profile that links the student's coursework to the student's identity. The profile includes a photo ID and a Signature Phrase, "a biometric profile" of the student's unique typing pattern. Unlike the courses themselves, enrollment in the Signature Track entails a payment for this additional service. A similar identity-verification scheme has also been introduced on edX.

Verifying student identity is a crucial element when coursework can be submitted for academic credit. In 2013, the American Council on Education (ACE) approved five Coursera courses taken on the Signature Track for academic credit, including three math courses. Students would submit their exams through an online monitoring service called ProctorU. However, it is still up to individual colleges to decide whether to accept these courses for credit or even as satisfying the prerequisite for a higher-level course. In recent years, many colleges have backed away from accepting the Educational Testing Service's Advanced Placement exam results for credit. But similar to APs, Coursera course results may be accepted to satisfy the prerequisites for higher-level courses.

MOOCs for Math?

Any discussion of the potential for online learning specifically geared to math needs to begin with the Khan Academy, which describes itself as a "not-for-profit with the goal of changing education for the better by providing a free world-class education for anyone anywhere." It began in 2004 as the modest effort of Salman Khan to assist a young relative who needed help with math. The success of this distinctly nonmassive operation soon generated unmanageable demand from additional relatives and their friends. To extend his services to a much larger audience, Khan began to create very short YouTube tutorials on specific topics (primarily staples of middle-school and high-school math, such as converting fractions to decimals or finding square roots) for which students most often requested help. By now, almost all of these math-help videos have racked up hundreds of thousands of views—probably by math-challenged parents as well as their children—and in some cases more than a million. With financial support from foundations and individual donors, the Khan Academy has been able to expand its staff as well as its subject coverage, though it is still far from achieving its goal of providing world-class education across a broad spectrum of subjects, and the treatment is still mainly geared to secondary school students. And some members of the mathematical community are less than enthusiastic about the Khan Academy math videos, believing that they do not promote real understanding.

It's noteworthy that Khan himself is not a mathematician and previously had no classroom teaching experience in the subject. He did earn a bachelor's degree in math at MIT, but his graduate work was in engineering and computer science; he also earned an M.B.A. at Harvard. Most members of the Khan Academy staff likewise have credentials in computer science rather than math. In this respect the Khan Academy effort is representative of what has happened so far with mathematics MOOCs. At this point only a few math-related MOOCs have been created by members of math departments. Among the few is the successful calculus MOOC created by Robert Ghrist (University of Pennsylvania). Ghrist says he was motivated by the opportunity to present the subject from his own point of view [2]. Likewise, Petra Bonfert-Taylor (Wesleyan) created a course in complex analysis, one of the few upper-level math courses currently offered as a MOOC. Rather than replicating a typical undergraduate course on complex analysis, she minimized course prerequisites and decided to forgo full rigor in order to "spark a lasting interest and curiosity in a beautiful corner of mathematics" [3].

One MOOC entrepreneur told us that many mathematicians react negatively to the idea of creating an online course in their subject. The reason is not clear. Do mathematicians lack the ego to be thrilled by the prospect of reaching 50,000 students in a single class? Or even 10,000? Would higher-level math MOOCs suffer because prerequisites or "mathematical maturity" are required for success? One of Linda's UCSD colleagues suggested that mathematics is too hard to be taught in a MOOC since students have no way to ask questions during the lectures. A similar sentiment was expressed in the "Musings" article by Harvey Diamond [3]. Could this disadvantage be offset by the opportunity for students to replay parts of MOOC lectures or overcome by having a live TA to ask?

In [4], AMS president Eric Friedlander expressed his skepticism about the introduction of MOOCs: "Who knows how that's going to influence mathematics teaching? Maybe one professor who normally teaches computer science will instead teach 500,000 students first-year calculus through a MOOC. Students don't learn that way, and we mathematicians have to say so." We find it interesting that Friedlander assumes the creator of a massive calculus course would be a computer scientist rather than a mathematician. We are less certain than Friedlander about how students learn—surely they vary in how they learn—and we conjecture that MOOCs might be a tool that will help at least some students, whether in conjunction with a traditional course or as a substitute for it.

How Should Math Departments Respond?

How should mathematics departments respond to the challenge posed by this new mode of teaching? As Friedlander's comment implies, mathematicians can't simply ignore MOOCs. What would happen if other departments, e.g., engineering and computer science, are able to prove that they can teach basic courses like calculus, differential equations, and linear algebra more effectively (and efficiently) using MOOCs? How about discrete math and probability?

So far the total MOOC experience for ordinary students in universities has been mixed. MOOCs created by Udacity for San Jose State University to teach remedial math courses and elementary statistics produced a low pass rate [5]. The issue of evaluation, discussed previously, need not be a deal breaker for MOOCs in mathematics, since exams could be written, proctored, and graded by humans, as they are now. However, the real problem may be that most students do not have the discipline and aptitude to go through a difficult course on their own without significant live human intervention. Udacity has subsequently entered into an agreement with Georgia Tech to create a fully accredited online M.S. in Computer Science. The new program will provide enrolled students with additional services, including individual coaching. Students will pay $7,000, a fraction of the cost of the on-campus version of the degree, but will follow the same curriculum and receive the same degree as students in the traditional program. The courses themselves (minus the individual coaching) will be MOOCs, open to any interested student at no charge.

The idea of a flipped class, where students follow MOOC video lectures and take quizzes outside of class and discuss problems and questions in class, has been proposed and tried at a small number of institutions. A Yale math instructor [6] reported success in using a Coursera MOOC in an integral calculus class. Do math faculty really want to teach basic topics such as the techniques of integration over and over? Could it be better to have students watch a few lectures, replay where necessary, and then work on some problems in class? Already some students taking calculus in regular lecture classes report that they are watching "the guy from Penn" to see how he does it. MOOCs may also allow talented students to complete basic courses more speedily instead of being held back by their weaker classmates.

We all know that different mathematicians have different talents: some are problem solvers, some see hidden structures, some are quick to follow an argument or trend. (Of course there are those few who do it all better than anyone else!) It's likely that math students also have different kinds of mathematical talent, and the opportunity to experience a variety of different teaching methods, including (but not exclusively) MOOCs, might enable some to experience greater success than in standard classes, whatever their size.

What MOOCs Can't Do

Many successful "products" of higher education credit a particular teacher for motivation, inspiration, or advice that helped them find the right path to achieving their goals, or perhaps even in determining what their goals might be. It is hard to believe that MOOCs can ever replace those personal encouraging words from professors who praise some students and urge others to think more. Can a MOOC write a letter of recommendation or give career advice? Sadly, today it is not mainly MOOCs but steadily increasing class size and increased use of adjunct faculty that threaten the student-teacher relationship that adds so much value to education.

Even where MOOCs are used simply to fill holes in a student's preparation, problems can arise (as in the San Jose State offerings of remedial math courses). When students are stuck, where can they find the help they need? Last year, Rachel taught a microeconomics course with a calculus prerequisite for entering students in a master's degree program. Students lacking the necessary preparation in calculus had been instructed to complete an online (non-MOOC) calculus course prior to the start of the micro course. But many of these students, all graduates of good colleges and universities in majors like political science or romance languages, got stalled in their efforts and did not complete the calculus course. With no one to ask for help when they got stuck, they were unable to move forward. As Linda's UCSD colleague emphasized, math is hard and students must be able to ask questions. In a MOOC, some questions can be answered via the online forum, but this is a pale substitute for the personal help that is (at least ideally) available to campus students. Can personal help be provided remotely? It will be interesting to see the results of Georgia Tech's approach, which pairs MOOCs with individual coaching.

Finally, what about the learning that comes from interaction among students? Can the online forum in a MOOC with students all around the globe replace the intellectual excitement of in-person discussions with fellow students? Here it is worthwhile to distinguish students by age and situation. An increasing proportion of today's students, both on campus and online, are "nontraditional" students, usually older and more likely to have schedules constrained by family or work obligations. For these nontraditional students, the asynchronous nature of MOOCs is a major advantage, as is their availability from any location with reliable Internet access. No doubt these students would benefit from in-person discussions on campus, but for most that may not even be an option. The same is true for students of any age living far from the educational institutions that provide the MOOCs they "attend." Perhaps this issue exemplifies the most obvious advantage and disadvantage of MOOCs: while online classes are extremely convenient for students to fit into their schedules and can be accessed remotely, this also means that MOOC students will not be in the same place at the same time as other humans, either fellow students or instructors.

In conclusion, we note again that the focus of this article is the potential for MOOCs in delivering instruction, and especially instruction in math and related fields. We have not tried to address the possible impact of MOOCs on university faculty with respect to their research mission. And finally, we should emphasize that the landscape of MOOCs is changing so rapidly that any published article, including this one, is already out of date in some respects.

References

[1] http://en.wikipedia.org/wiki/Massive_open_online_course

[2] R. Ghrist, MOOCs and the future of mathematics, *Notices of the AMS*, www.ams.org/notices/201310/rnoti-p1277.pdf

[3] Musings on MOOCs, *Notices of the AMS*, www.ams.org/notices/201401/rnoti-p69.pdf

[4] Presidential Views, Interview with Eric Friedlander, *Notices of the AMS*, www.ams.org/notices/201302/rnoti-p218.pdf

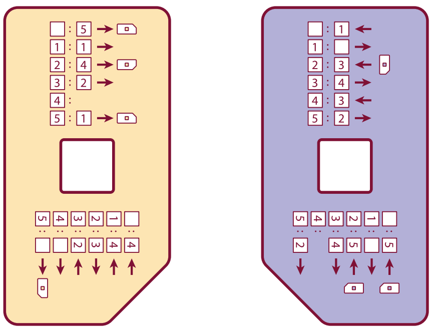
[5] www.insidehighered.com/news/2013/12/18/san-jose-state-u-resurrects-scaled-back-online-course-experiment-mooc-provider#sthash.zLXRkOLG.dpbs

[6] www.insidehighered.com/news/2014/02/21/elite-universities-face-lower-stakes-familiar-concerns-mooc-space

About the cover

Smart Card

This month's cover illustrates a Turing machine discovered by Yuri Rogozhin and implemented by Alvy Ray Smith, the author of the review in this issue of four books about Alan Turing. Rogozhin is responsible for discovering a number of very small universal Turing machines, some time after Marvin Minsky proposed one with 7 states and an alphabet of 4 symbols. The one here has 4 states, corresponding to configurations of the card, with alphabet [0, 5]. The cards on the cover are slightly different from the one illustrated in Smith's review. The commands relevant to a given state are the ones easily readable in that state.



Rogozhin's UTM(4,6) is apparently the smallest UTM so far known.

Smith tells us, "UC Berkeley passed out a copy of the card to each of 8,000 entering freshmen this year, along with a copy of George Dyson's *Turing's Cathedral* and a small pamphlet that could serve as a manual for the card. The computation detailed in the manual and on the *Notices* cover (with initial tape `5155[0]...`) halts, but is otherwise uninteresting. Programming this business card machine to simulate an arbitrary Turing machine—to compute something actually interesting—would be quite difficult. I didn't and won't bother even to try. My goal was simply to show that a universal stored-program computer can be *very* simple. Programming it, on the other hand, is not.

"Programming the little guy goes like this: Implement the algorithm you wish to compute as a Post tag system (known to be equivalent to Turing machines). Encode the tag system as dictated in the Rogozhin paper. That's the program that is then 'stored' on the UTM's tape. The encoding step is quite elaborate (because so few symbols are allotted to the task). Actual programming is just too hard to explain in a page or two."

For help in beginning such a task, Marvin Minsky's classic text *Computation: Finite and Infinite Machines* is still valuable. As a reward for even a few steps in the project, you will certainly acquire an appreciation of the importance of hierarchies of structures.

The manual Smith mentions can be found at http://alvyray.com/CreativeCommons/BizCardUniversalTuringMachine_v1.4.pdf

The design is under a Creative Commons License: http://alvyray.com/CreativeCommons/TuringToysdotcom.htm

—Bill Casselman
Graphics Editor
(notices-covers@ams.org)

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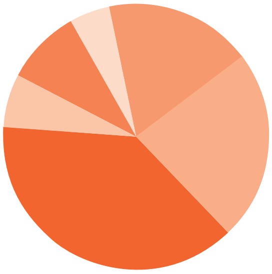


Report on the 2012-2013 New Doctoral Recipients

William Yslas Vélez, James W. Maxwell, and Colleen Rose

This report presents a statistical profile of recipients of doctoral degrees awarded by departments in the mathematical sciences at universities in the United States during the period July 1, 2012, through June 30, 2013. Information in the report was provided by the departments that awarded the degrees with additional information provided by the individual new doctoral recipients. The report includes an analysis of the fall 2013 employment plans of 2012–2013 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, gender, and racial/ethnic group. This report is based on a complete census of the 2012–2013 new doctorates and includes information about 2012-2013 doctoral recipients that were not included in the preliminary report in the June/July 2014 issue of *Notices*.

Detailed information, including tables which traditionally appeared in this report, is available on the AMS website at `www.ams.org/annual-survey/survey-reports.`

Doctoral Degrees Awarded

1,843 Ph.D.'s were awarded by the 315 doctoral-granting departments. We are pleased to report that we had a 100% response rate for this survey, and we thank the departments for their cooperation.

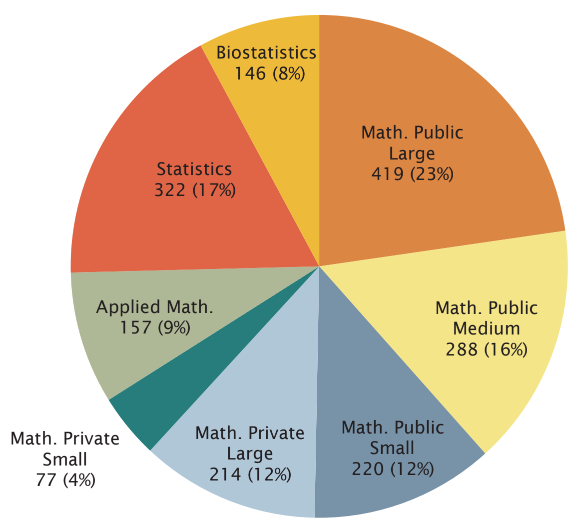
Math. Public Large reported the largest increase in the number of doctoral recipients, up 32 over the total of 387 reported for 2011-2012.

31% (573) of the new Ph.D.'s had a dissertation in statistics/ biostatistics, followed by algebra/number theory with 14% (258) applied mathematics with 12%(214).

Comparing Ph.D.'s awarded this year to last year, the number of Ph.D.'s awarded:

- Increased about 3% from 1,798 to 1,843.
- Increased 24% in Math. Public Small.
- Decreased 15% in Biostatistics.

Figure A.1: Number and Percentage of Degrees Awarded by Department Grouping*



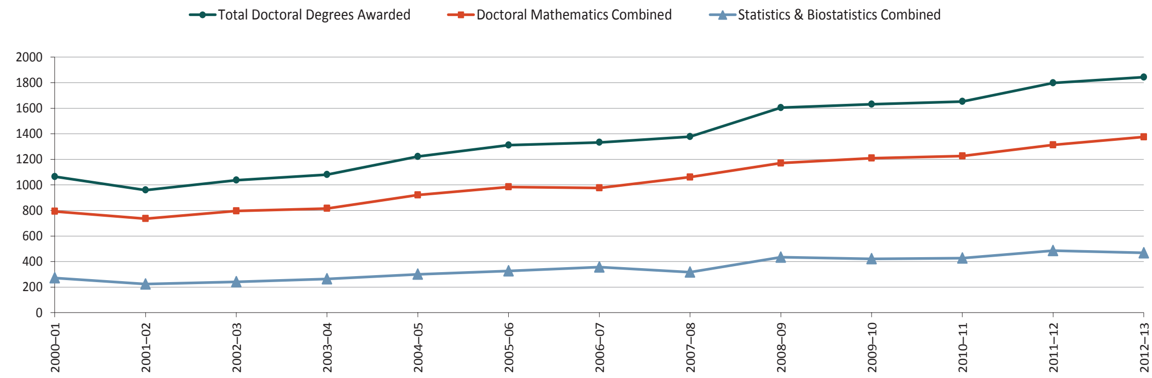
Total Degrees Awarded: 1,843

*See page 884 for a description of the department groupings.

William Yslas Vélez is a professor in the Department of Mathematics at University of Arizona. James W. Maxwell is AMS coordinator of special projects. Colleen A. Rose is AMS survey analyst.

Doctoral Degrees Awarded

Figure A.2: New Ph.D.'s Awarded by Group



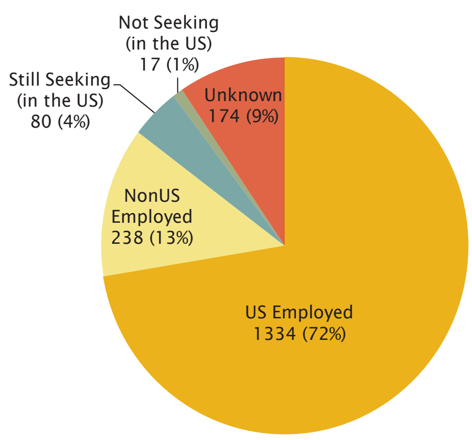
Comparing Ph.D.'s awarded this year with those awarded in 2002–2003:

- Ph.D.'s awarded have increased more than 78% over the last 10 years.
- Degrees awarded by Doctoral Mathematics combined and by Statistics & Biostatistics Combined have increased 73% and 94%, respectively. Some of this latter increase is due to the increase in response rate among the Statistics & Biostatistics departments.

Employment

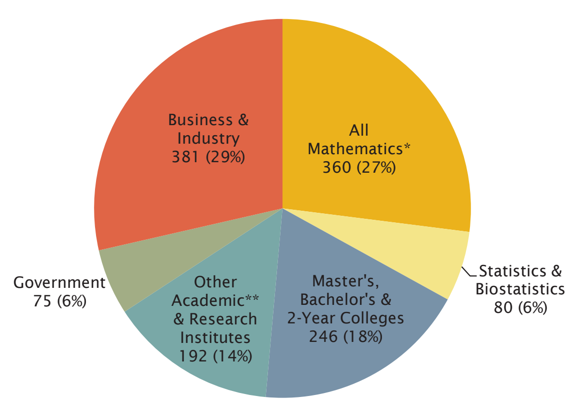
The overall U.S. unemployment rate for the new doctoral recipients is 5.7%, down from 6.9% last year. (Details on the calculations are on page 884.) The employment plans are known for 1,669 of the 1,843 new doctoral recipients. The number of new doctoral recipients employed in the U.S. is 1,334, up 3% from last year's number of 1,300. 69% of Ph.D.'s employed in Doctoral Math. departments are in postdoc positions, up from 68% last year. The number of new Ph.D.'s taking positions in Business & Industry has increased to 381 this year compared to 340 last year. All groups showed an increase in Business & Industry and 56% of the increase was accounted for by the Statistics Group.

Figure E.1: Employment Status



- 52% (692) of those who are employed in the U.S. are U.S. citizens, down slightly from 53% last year.
- 74% (642) of non-U.S. citizens whose employment status is known are employed in the U.S., the remaining 231 non-U.S. citizens are either employed outside of the U.S. or are unemployed.
- 6% (100) of all new Ph.D.'s are working at the institution which granted their degree, down from 13% last year. These individuals constitute 11% of total U.S. academic employed.
- 60% of those still seeking employment in the U.S. are U.S. citizens.

Figure E.2: U.S. Employed by Type of Employer

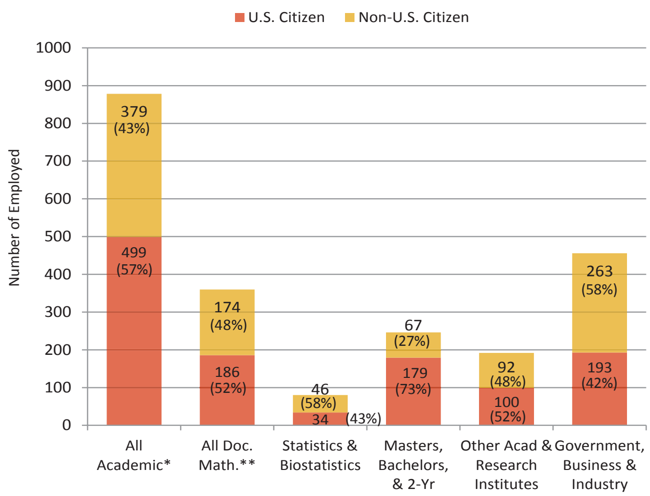


*Includes all Math. Public, Math. Private, and Applied Math. departments.
**Other Academic consists of departments outside the mathematical sciences including numerous medical related units.

- Total U.S. employed: 1,334
- U.S. academic hiring decreased slightly to 878 compared to 894 last year.
- Goverment hiring increased 14% (from 66 to 75); all doctoral-granting groups except Math. Public Medium, Applied Math. and Biostatistics showed an increase in the number of Ph.D.'s taking positions in this sector.

Employment

Figure E.3: Employment in the U.S. by Type of Employer and Citizenship Total: 1,334



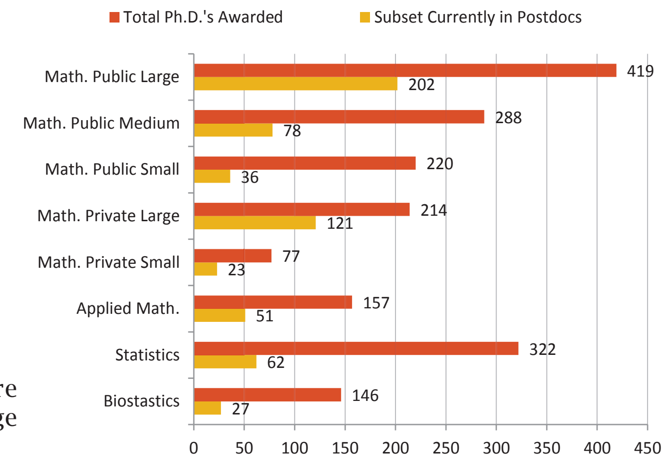
* Includes all math. sciences departments plus other academic and research institutes/nonprofit.
**Includes all Math. Public, Math. Private, and Applied Math. departments.

- Total known to be employed: 1,572
- 38% (600) of the new Ph.D.'s that are employed are reported to be in postdoc positions, the same percentage as last year but up in number from 573.

Of the U.S. citizens whose employment status is known 87% (692) are employed in the U.S. and of these:

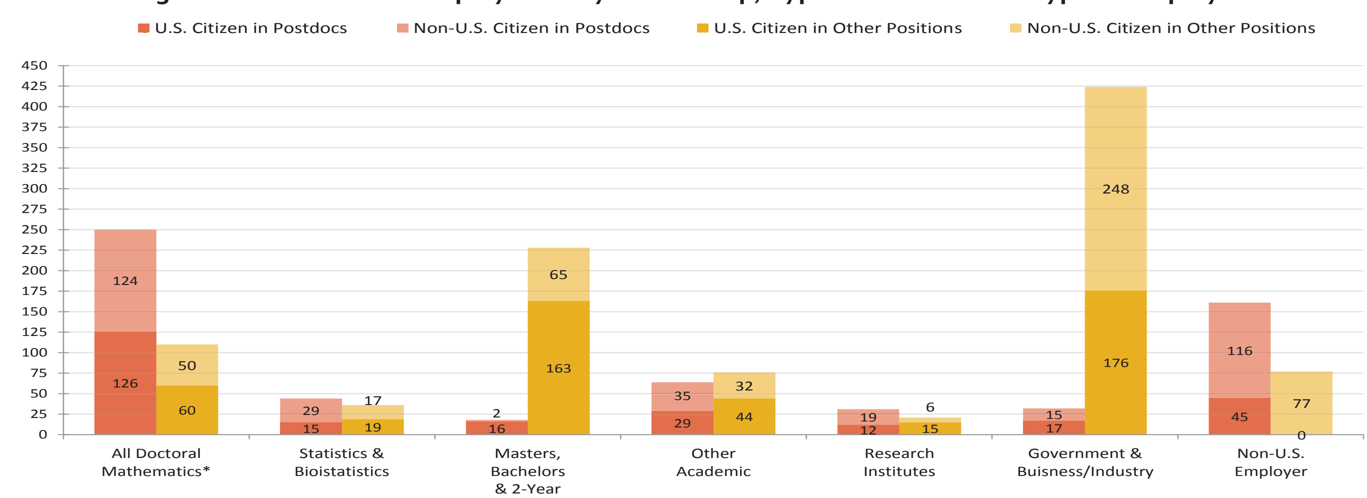
- 32% are employed in Ph.D.-granting departments
- 40% are employed in all other academic categories
- 28% are employed in government, business and industry

Figure E.4: Ph.D.'s Employed in Postdocs by Degree-Granting Department Group



- 57% of the new Ph.D.'s awarded by the Math. Private Large group are employed in postdocs, while only 16% of new Ph.D.'s awarded by the Math. Public Small group are in postdocs.
- 46% of the new Ph.D.'s having U.S. academic employment are in postdocs, the same as last year.

Figure E.5: New Ph.D.'s Employment by Citizenship, Type of Position and Type of Employer



*Includes all Math. Public, Math. Private, and Applied Math. departments.

- 27% of the new Ph.D.'s in postdoc positions are employed outside the U.S.; last year this percentage was 22%.
- 92% of the new Ph.D.'s employed in the Math. Private Large Group are in postdoc positions, up from 85% last year.
- 69% of the new Ph.D.'s employed in Doctoral Math. departments are in postdoc positions, up from 68% last year.

Employment

Figure E.6 displays the U.S. unemployment rate for new doctorates; details on the calculations are on page 884.

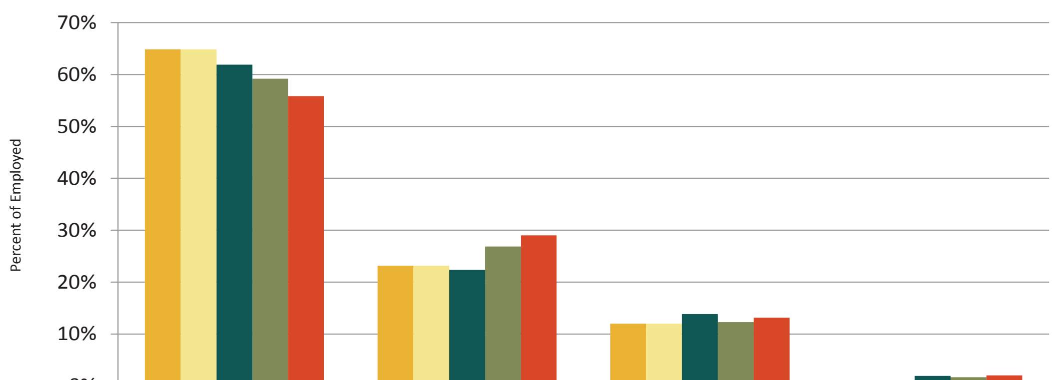
Figure E.6: Percentage of New Doctoral Recipients Unemployed 2004–2013*

*The difficult employment years of the 1990's are not shown here but are located on the AMS website at www.ams.org/annual-survey/2013Survey-NewDoctorates-Report.

Among new doctorates reported to be in the U.S.:

- Unemployment among those whose employment status is known is 5.7%, down from 6.9% for Fall 2012.
- 6.5% of U.S. citizens are unemployed, compared to 7.8% in Fall 2012.
- 4.7% of non-U.S. citizens are unemployed, compared to 6.0% in Fall 2012.
- new doctorates from the Math. Private Small Group reported the highest unemployment rate at 10.9%, down from 13.0% last year.
- new doctorates from the Biostatistics Group reported the lowest unemployment at 1.7%.

Figure E.7: Percentage of Employed New Ph.D.'s by Type of Employer



	U.S. Academic*	U.S. Noncademic	Non-U.S. Academic	Non-U.S. Nonacademic
Fall 2009	65%	23%	12%	1%
Fall 2010	65%	23%	12%	1%
Fall 2011	62%	22%	14%	2%
Fall 2012	59%	27%	12%	2%
Fall 2013	56%	29%	13%	2%

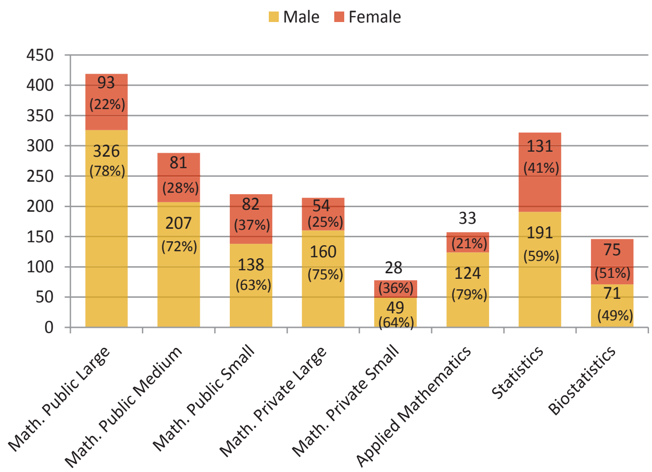
* Includes other academic departments and research institutes/other non-profits.

- U.S. academic hiring has dropped for the third consecutive year to 56% (a five-year low), while U.S. nonacademic hiring has jumped to 29% (a five-year high).
- Detailed information on new Ph.D.'s employed in the U.S. by degree-granting department group is available on the AMS website at www.ams.org/annual-survey/2013Survey-NewDoctorates-Report.

Demographics

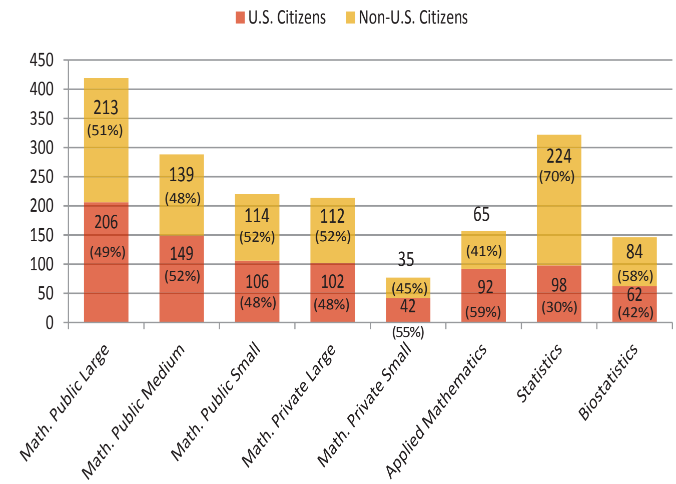
Gender and citizenship was known for all 1,843 new Ph.D.'s reported for 2012–2013. The number of U.S. citizens is 857 (47%) (down slightly from 48% last year). Females accounted for 27% of the U.S. citizen total (down from 28% last year). Non-U.S. citizens receiving a Ph.D. increased to 53% from 52% last year. 13% (81) of the non-U.S. citizens employed in the U.S. have permanent visa status (up from 11% last year).

Figure D.1: Gender of Doctoral Recipients by Degree-Granting Grouping



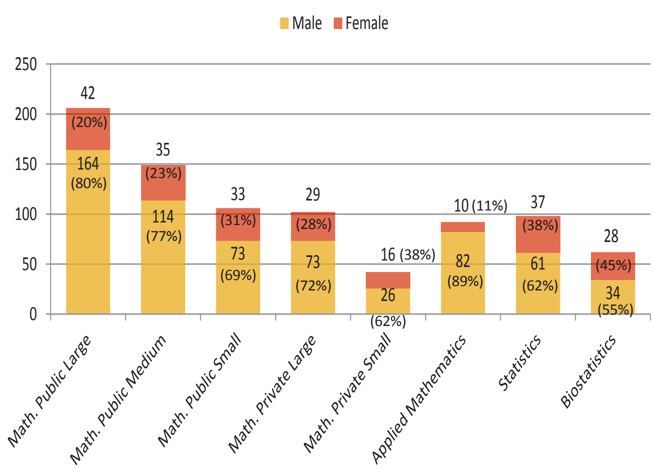
- Females account for 31% (577) of the 1,843 Ph.D.'s, the same percentage as last year.

Figure D.2: Citizenship of Doctoral Recipients by Degree-Granting Grouping



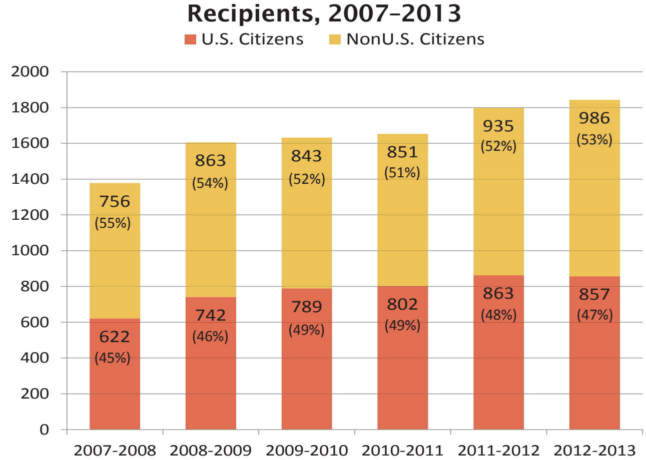
- All groups awarded less degrees to U.S. citizens than Non-U.S. citizens except Math. Public Medium, Math. Private Small, and Applied Math. which awarded 52%, 55% and 59% to U.S. citizens.

Figure D.3: Gender of U.S. Citizen Doctoral Recipients by Degree-Granting Grouping



- 50% of the males and 40% of the females are U.S. citizens.
- Females accounted for 27% of the U.S. citizens.
- Among the U.S. citizens: 1 is American Indian or Alaska Native, 72 are Asian, 24 are Black or African American, 25 are Hispanic or Latino, 1 is Native Hawaiian or Other Pacific Islander, 707 are White, and 27 are of unknown race/ethnicity.

Figure D.4: Citizenship of New Ph.D.* Recipients, 2007–2013



*The increase shown from 2007–2008 to 2008–2009 is due in part to the increase in the response rate for statistics and biostatistics departments.

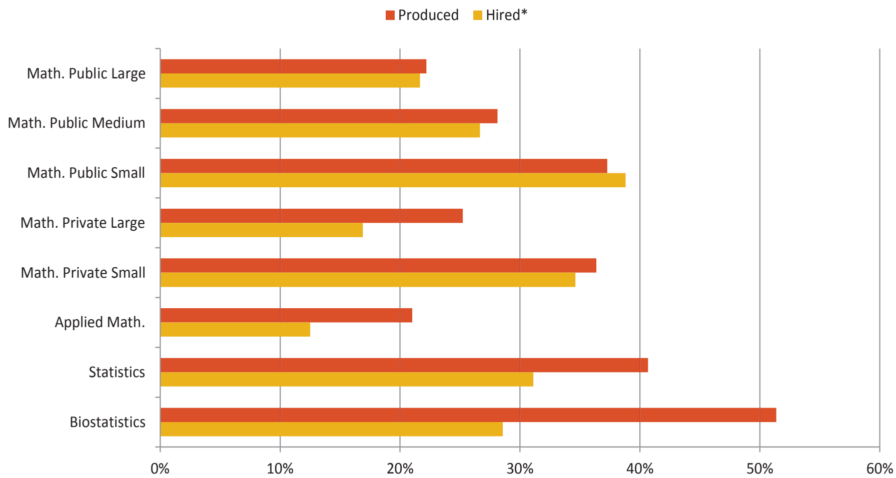
Looking at the last six years we see that:

- U.S. citizen counts which had been increasing steadily, decreased to 857 this year. While this is a slight decrease from last year, it is a 38% increase from Fall 2007–2008.
- Non-U.S. citizen counts have increased for the third consectuive year to 986. While this is a 30% increase from Fall 2007–2008, it represents a 5% increase from last year.

Female New Doctoral Recipients

The proportion of female new doctoral recipients remains unchanged from last year at 31% this year. Of the 878 new Ph.D.'s hired into academic positions 32% (285) were women, up from 31% last year. 24% of those hired into postdoc positions were women, with 39% of the women in postdocs being U.S. citizens, down from 42% last year. The U.S. unemployment rate for females is 5.0%, compared to 5.9% for males and 5.7% overall.

Figure F.1: Females as a Percentage of New Doctoral Recipients Produced by and Hired by Department Grouping



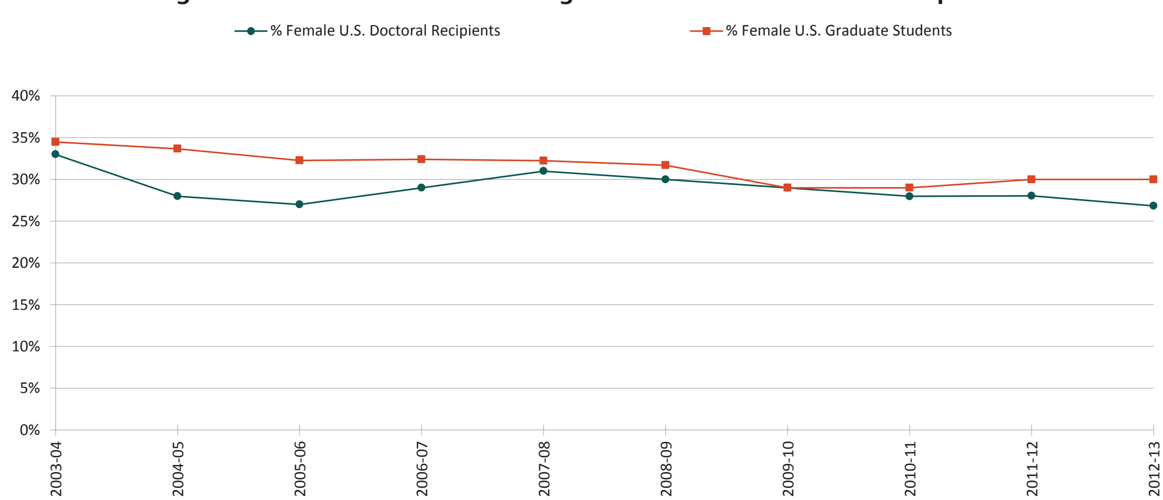
* Females as a percentage of total hires by the department grouping.

Table F.1: Number of Female New Doctoral Recipients Produced by and Hired by Department Groupings

Department Grouping	Females Produced	Females Hired
Math. Public Large	93	26
Math. Public Medium	81	16
Math. Public Small	82	26
Math. Private Large	54	12
Math. Private Small	28	9
Applied Math.	33	2
Statistics	131	14
Biostatistics	75	10

- 36% of those hired by Group B were women (down from 38% last year) and 31% of those hired by Group M were women (up from 29% last year).
- 46% of those hired into Research Institutes/Other non-profit positions were women (up from 37% last year).
- 32% of those hired into Government positions were women (down from 36% last year).
- 53% of the women employed in all doctoral groups are in postdoc positions, compared to 72% of males employed in these groups.

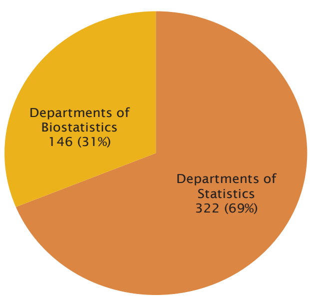
Figure F.2: Females as a Percentage of U.S. Citizen Doctoral Recipients



Ph.D.'s Awarded by Statistics and Biostatistics Departments

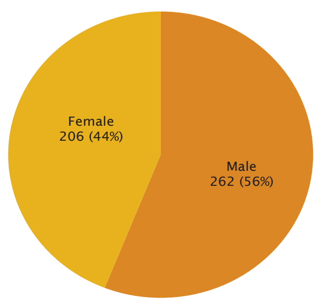
This section contains information about new doctoral recipients in these departments (59 statistics and 44 biostatistics departments). Statistics and Biostatistics departments produced 468 new doctorates, of which all had dissertations in statistics/biostatistics. This is a 4% decrease in the number reported for fall 2012 which was 485. In addition, Math. Public, Math. Private and Applied Math. departments combined had 105 Ph.D. recipients with dissertations in statistics. 34% (160) of the new Ph.D.'s awarded by Statistics and Biostatistics departments are U.S. citizens (while in the other groups combined 51% are U.S. citizens). The U.S. unemployment among this group of new Ph.D.'s is 2.1% up from 4.2%.

Figure S.1: Ph.D.'s Awarded by Statistics/Biostatistics Departments



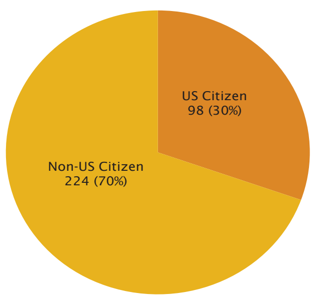
- 25% of all Ph.D.'s awarded were in Statistics/Biostatistics.
- Females account for 41% of statistics and 51% of biostatistics Ph.D.'s awarded.

Figure S.2: Gender of Ph.D. Recipients from Statistics/Biostatistics Departments



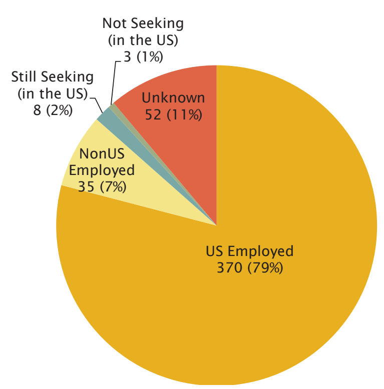
- Females accounted for 44% of the 468 Ph.D.'s in Statistics and Biostatistics, compared to all other groups combined, where 27% are female.

Figure S.3: Citizenship of Ph.D. Recipients from Statistics/Biostatistics Departments



- 41% of Statistics/Biostatistics U.S. citizen Ph.D. recipients are females, while in all other groups combined 24% of the U.S. citizens are females.

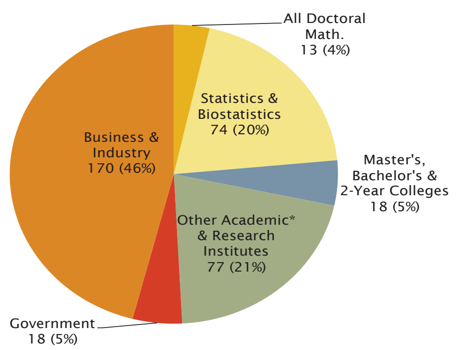
Figure S.4: Employment Status of Ph.D. Recipients from Statistics/Biostatistics Departments



Total Ph.D.'s Awarded: 468

- 2.1% of Statistics/Biostatistics Ph.D.'s are unemployed compared to 6.4% among all other groups. This is down from 4.2% last year.
- Unemployment among new Ph.D.'s with dissertations in statistics/probability is 3.1%, down from 4.0%. Among all other dissertation groupings 5.7% are unemployed.

Figure S.5: U.S.-Employed Ph.D. Recipients from Statistics/Biostatistics Departments by Type of Employer



*Other Academic consists of departments outside the mathematical sciences including numerous medical related units.

Total U.S. Employed: 370

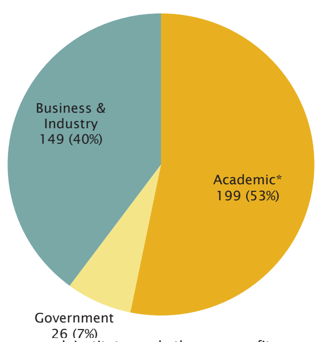
- 46% of Statistics/Biostatistics Ph.D.'s are employed in Business/Industry, compared to 23% in all other groups.
- 30% of those hired by statistics and biostatistics were females, compared to 25% in all other groups.

Information from the Employment Experiences of New Doctorates (EENDR) Survey

This section contains additional information on employment gathered from a subset of the 2012–2013 new Ph.D.'s on the EENDR Survey. It expands on the details of employment which are not available through the departments.

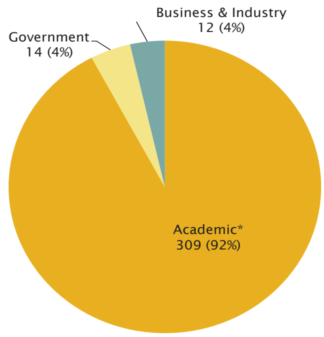
The EENDR survey was sent to the 1,676 new PhD's for which departments provided current contact information by early October of 2013. Of these individuals 861 (51%) responded. The employment status is known for 851 of these individuals, the U.S. unemployment among this group is 2.6%. Of the 822 who reported being employed, 29% indicated they were actively looking for new employment.

Figure EE.1: EENDR Respondents Reporting Permanent U.S. Employment by Sector



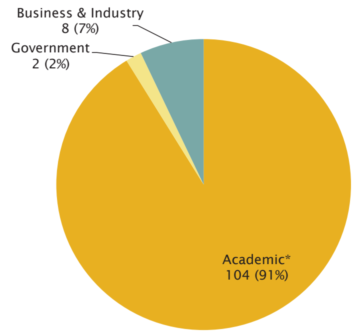
* Includes research institutes and other non-profits.

Figure EE.2: EENDR Respondents Reporting Temporary U.S. Employment by Sector



* Includes research institutes and other non-profits.

Figure EE.3. EENDR Respondents Employed Outside the U.S. by Sector



* Includes research institutes and other non-profits.

Of the 374 permanently employed:

- 36% are women.
- 68% of those reporting academic employment hold tenured/tenure-track positions.

Of the 335 temporarily employed:

- 27% are women.
- 52% were unable to find a suitable permanent position (up from 39% last year).
- 74% are employed in postdocs and 43% of these reported they could not find a suitable permanent position.

Of the 114 employed outside the U.S.:

- 19% are women.
- 19% are U.S. Citizens.
- 75% are employed in postdocs.

Table EE.1: Number and Percentage of EENDR Respondents Employed in the U.S. by Job Status

					Temporary		Temporary Postdocs				
Year	Perm Total	%	Temp Total	%	Perm Not Avail	% of Temp Total	Total	% of Temp Total	Perm Not Avail	% of Temp Postdocs	#(%) Unknown
Fall 2009	318	49%	326	51%	146	45%	234	72%	68	29%	0%
Fall 2010	320	48%	341	52%	140	41%	246	72%	68	28%	0
Fall 2011	251	44%	319	56%	133	42%	225	71%	87	39%	0
Fall 2012	261	44%	328	56%	127	39%	242	74%	108	45%	0
Fall 2013	374	53%	335	47%	173	52%	247	74%	106	43%	0

Comparing the employment status of EENDR respondents employed in the U.S. over the last five years we see that:

- Permanent positions have increased to 53% this year. This is up 4 percentage points from the high reported in 2009 and up in number by 54 (17%) from the high of 320 in 2010.
- Temporary positions decreased to 47% this year, reaching a five-year low.
- 52% of those holding temporary positions were unable to find suitable permanent positions, this is a five-year high and up 13 percentage points from the low in 2012.
- 43% of those holding postdoc positions were unable to find suitable permanent positions.

Information from the Employment Experiences of New Doctorates (EENDR) Survey

Table EE.2: Percentage of EENDR Respondents Employed in the U.S. by Employment Sector within Job Status

Year	Permanent			Temporary		
	Acad	Govn	B/I	Acad	Govn	B/I
Fall 2009	64%	6%	29%	91%	5%	4%
Fall 2010	64%	8%	28%	93%	5%	2%
Fall 2011	61%	8%	31%	94%	5%	1%
Fall 2012	61%	8%	32%	92%	5%	2%
Fall 2013	53%	7%	40%	92%	4%	4%

Looking at at Table EE.2 we see that

- Permanent academic employment has decreased to 53%, while temporary employment in this sector has leveled off at 92%.
- Permanent and temporary government employment has dropped to 7% and 4%, respectively.
- Business/Industry permanent employment has increased to 40% (a five-year high), while temporary positions increased to 4%.

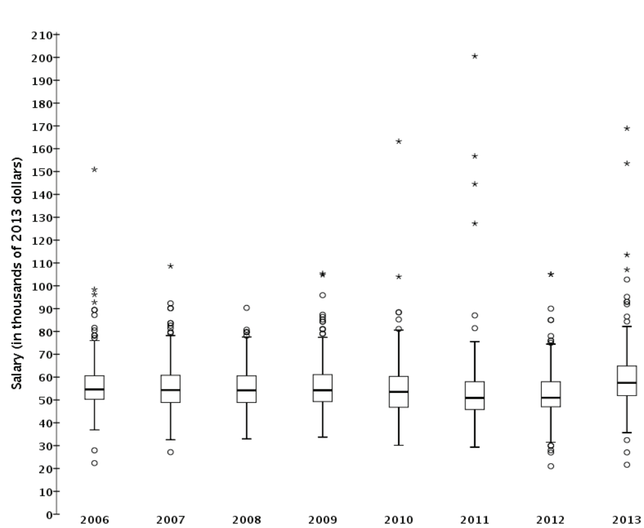
Starting Salaries of the 2012-2013 Doctoral Recipients

The starting salary figures were compiled from information gathered on the EENDR questionnaires sent to 1,676 individuals using addresses provided by the departments granting the degrees; 861 individuals responded between late October and April. Responses with insufficient data or from individuals who indicated they had part-time or non-U.S. employment were excluded. Numbers of usable responses for each salary category are reported in the following tables.

Readers should be warned that the data in this report are obtained from a self-selected sample, and inferences from them may not be representative of the full population. Detailed information, including boxplots which traditionally appeared in this report, is available on the AMS website at www.ams.org/annual-survey/survey-reports.

Academic Teaching/Teaching and Research 9–10-Month Starting Salaries* (in thousands of dollars)

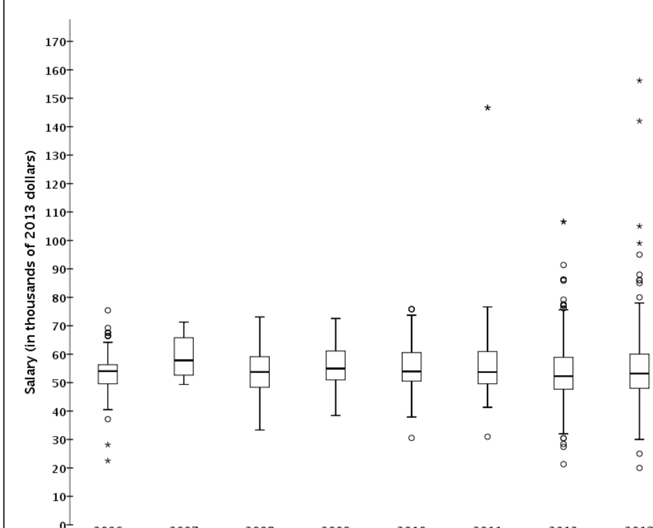
Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (196 male/97 female)					
2013 M	20.0	47.9	53.0	60.0	156.2
2013 F	30.0	50.0	54.9	61.9	105.0
One year or less experience (184 male/88 female)					
2013 M	40.0	48.0	54.0	60.0	156.2
2013 F	20.0	48.5	53.0	60.0	105.0



* Includes postdoctoral salaries.

Academic Postdoctorates Only* 9–10-Month Starting Salaries (in thousands of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (89 male/23 female)					
2013 M	30.0	48.0	53.0	60.0	76.0
2013 F	30.0	49.3	52.0	59.3	70.0
One year or less experience (86 male/23 female)					
2013 M	33.0	48.0	53.1	60.0	73.5
2013 F	30.0	48.9	52.5	59.6	70.0

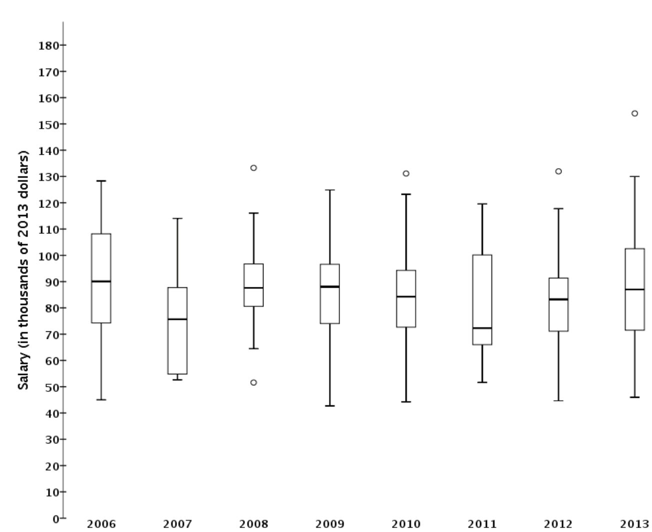


* A postdoctoral appointment is a temporary position primarily intended to provide an opportunity to extend graduate training or to further research experience.

Starting Salaries of the 2012-2013 Doctoral Recipients

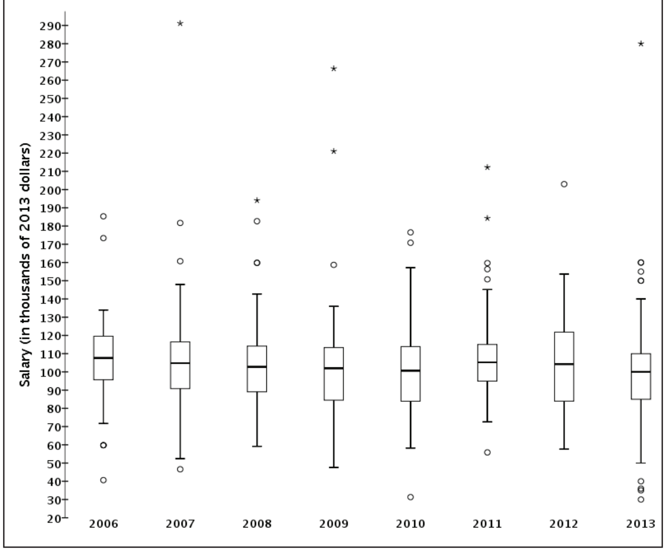
Government
11–12-Month Starting Salaries
(in thousands of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (28 male/11 female)					
2013 M	46.0	63.7	87.0	103.3	154.0
2013 F	70.0	73.5	82.5	93.1	109.0
One year or less experience (23 male/10 female)					
2013 M	46.0	63.2	87.0	102.5	154.0
2013 F	72.0	76.8	84.8	94.7	109.0



Business and Industry
11–12-Month Starting Salaries
(in thousands of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max
Total (113 male/42 female)					
2013 M	30.0	85.0	100.0	115.0	280.0
2013 F	40.0	83.1	95.3	105.0	140.0
One year or less experience (92 male/37 female)					
2013 M	30.0	82.8	100.0	120.0	280.0
2013 F	40.0	82.5	98.0	105.0	135.0



Remarks on Starting Salaries

Key to Tables and Graphs. Salaries are those reported for the fall immediately following the survey cycle. Years listed denote the survey cycle in which the doctorate was received—for example, survey cycle July 1, 2012–June 30, 2013, is designated as 2013. Salaries reported as 9–10 months exclude stipends for summer grants or summer teaching or the equivalent. M and F are male and female respectively. Male and female figures are not provided when the number of salaries available for analysis in a particular category was five or fewer. All categories of "Teaching/Teaching and Research" and "Research Only" contain those recipients employed at academic institutions only.

Graphs. The graphs show standard boxplots summarizing salary distribution information for the years 2006 through 2013. Values plotted for 2006 through 2013 are converted to 2013 dollars using the implicit price deflator prepared annually by the Bureau of Economic Analysis, U.S. Department of Commerce. These categories are based on work activities reported in EENDR. Salaries of postdoctorates are shown separately. They are also included in other academic categories with matching work activities.

For each boxplot the box shows the first quartile (Q1), the median (M), and the third quartile (Q3). The interquartile range (IQR) is defined as Q3–Q1. Think of constructing invisible fences 1.5 IQR below Q1 and 1.5 IQR above Q3. Whiskers are drawn from Q3 to the largest observation that falls below the upper invisible fence and from Q1 to the smallest observation that falls above the lower invisible fence. Think of constructing two more invisible fences, each falling 1.5 IQR above or below the existing invisible fences. Any observation that falls between the fences on each end of the boxplots is called an outlier and is plotted as ○ in the boxplots. Any observation that falls outside of both fences either above or below the box in the boxplot is called an extreme outlier and is marked as ✱ in the boxplot.

Remarks on U.S. Unemployment Rate Calculations

In the unemployment calculations provided in this report the individuals employed outside the U.S. have been removed from the denominator used in the calculation of the rate, in addition to the routine removal of all individuals whose employment status is unknown. This is a change from Annual Survey Reports prior to 2009. As a consequence, the unemployment rate now being reported more accurately reflects the U.S. labor market experienced by the new doctoral recipients. This change tends to increase the rate of unemployment over that reported in prior years.

In a further small change from prior years, those individuals reported as not seeking employment have also been removed from the denominator. The number of individuals so designated is small each year, and the impact of this change is to produce a slight increase in the rate over that reported in prior years.

The unemployment rates for years prior to 2009 shown in this report have been recalculated using this new method. One can view a comparison of the unemployment rates using the traditional method and the new method by visiting the AMS website at `www.ams.org/annual-survey/surveyreports.html`.

Departmental Groupings and Response Rates

Starting with reports on the 2012 AMS-ASA-IMS-MAA-SIAM Annual Survey of the Mathematical Sciences, the Joint Data Committee has implemented a new method for grouping the doctorate-granting mathematics departments. These departments are first grouped into those at public institutions and those at private institutions. These groups are further subdivided based on the size of their doctoral program as reflected in the average annual number of Ph.D.'s awarded between 2000 and 2010, based on their reports to the Annual Survey during this period. Furthermore, doctorate-granting departments which self-classify their Ph.D. program as being in applied mathematics will join with the other applied mathematics departments previously in Group Va to form their own group. The former Group IV will be divided into two groups, one for departments in statistics and one for departments in biostatistics.

For further details on the change in the doctoral department groupings see the article in the October 2012 issue of *Notices of the AMS* at `http://www.ams.org/notices/201209/rtx120901262p.pdf.`

Group Descriptions

Math. Public Large consists of departments with the highest annual rate of production of Ph.D.'s, ranging between 7.0 and 24.2 per year.

Math. Public Medium consists of departments with an annual rate of production of Ph.D.'s, ranging between 3.9 and 6.9 per year.

Math. Public Small consists of departments with an annual rate of production of Ph.D.'s of 3.8 or less per year.

Math. Private Large consists of departments with an annual rate of production of Ph.D.'s, ranging between 3.9 and 19.8 per year.

Math. Private Small consists of departments with an annual rate of production of Ph.D.'s of 3.8 or less per year.

Applied Mathematics consists of doctoral-degree-granting applied mathematics departments.

Statistics consists of doctoral-degree-granting statistics departments.

Biostatistics consists of doctoral-degree-granting biostatistics departments.

Group M contains U.S. departments granting a master's degree as the highest graduate degree.

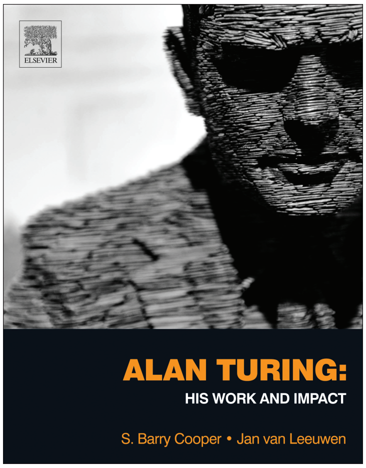
Group B contains U.S. departments granting a baccalaureate degree only.

Listings of the actual departments which compose these groups are available on the AMS website at `www.ams.org/annual-survey/groups.`

Survey Response Rates by New Groupings

Doctorates Granted
Departmental Response Rates*

Math. Public Large	26 of 26 including	0 with no degrees
Math. Public Medium	40 of 40 including	1 with no degrees
Math. Public Small	64 of 64 including	11 with no degrees
Math. Private Large	24 of 24 including	0 with no degrees
Math. Private Small	28 of 28 including	2 with no degrees
Applied Math.	30 of 30 including	3 with no degrees
Statistics	59 of 59 including	3 with no degrees
Biostatistics	44 of 44 including	16 with no degrees
Total	315 of 315 including	36 with no degrees



Alan Turing: His Work and Impact

Reviewed by Jeremy Avigad

Alan Turing: His Work and Impact
S. Barry Cooper and Jan van Leeuwen, eds.
Elsevier Science, 944 pages,
English, US$74.95
ISBN-13: 978-0123869807

The year 2012 marked the centennial of Alan Turing's birth, with conferences, articles, broadcasts, and celebrations in his honor. The popular media has embraced Turing, and even in staid academic circles his status borders on sainthood. In an essay in the collection under review, Jonathan Swinton sums up the state of affairs nicely:

> Propelled by a brilliant biography (Hodges, 1992), the awareness of Turing as an iconic, field-defining figure passed from logicians and philosophers, through gay rights activists, applied mathematicians, cryptographers, artificial lifers, mainstream computer scientists, and into popular scientific culture, where he is now firmly established as a boffin of fiction, stage, and screen.

Some may wonder whether the level of praise that has been lavished on Turing is justified. Yes, the 1936 paper in which he defined what are now known as Turing machines is a landmark in the history of science, but other logicians at the time were involved in the development of formal models of computation, including Herbrand, Gödel, Post, and Church. And, although Turing played an important part in the development of the modern electronic computer, his role should not be overstated: a number of early computing devices were built from the late 1930s to mid-1940s with little or no influence of Turing's early foundational work, and the real history involves a complex mix of theoretical and practical insights, with contributions from a substantial cast of researchers and engineers alongside Turing. Finally, although the hideous abuses that Turing was subjected to as a homosexual in postwar Britain are made even more ironic by the role he played in helping the Allies win the war, those abuses are no more morally offensive than those suffered by countless others whose lives are left uncelebrated. With all this in mind, it is reasonable to ask: Was all the hoopla really called for?

One need only sit down with Turing's work for an hour or two, however, to find such doubts pushed aside. His papers are full of technical detail, but are surprisingly easy to read. His writing is careful and methodical, but even after all these years the work feels creatively fresh and original. He dealt with weighty topics and raised important questions, but relied on technical mastery and a good deal of hard work to back up his answers. When we read his original papers, we get a sense of Turing as an accomplished mathematician and scientist, one whose philosophical disposition, talent, and drive are well worth celebrating.

One of many publications designed to mark the centennial is *Alan Turing: His Work and Impact*, a collection that surrounds some of Turing's most important works with a mixture of scholarly commentary, introductory background, historical and scientific surveys, and personal reflections. These supporting essays are written by notable researchers in mathematics, computer science, logic, biology, cognitive science, and philosophy, as well as a few who knew Turing personally.

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It may be helpful to compare *Work and Impact* to the *Collected Works of A. M. Turing*, the four volumes of which appeared between 1992 and 2001. Whereas the *Collected Works* was more than forty years in the making, *Work and Impact* was completed in less than three. And whereas the *Collected Works* is regimented and carefully edited, *Work and Impact* is a much more heterogeneous sprawl, ranging from expositions of Turing's work itself to personal accounts of the effects that Turing's contributions have had on some of the essayists. According to the introduction, *Work and Impact* encourages "a visceral engagement" with Turing's work, and it reflects "a personal organic involvement" on the part of many of the authors. Reading the work of a seminal and visionary thinker inevitably encourages one to try one's own hand at speculation, and there is no shortage of that, either. For all it offers, the price is quite reasonable: you can have all 944 pages of *Work and Impact* adorning your coffee table, in hardcover, for under $75.00. (It is worth mentioning that there is also a smaller, more focused collection published by Clarendon Press: *The Essential Turing* features a selection of Turing's most important works, edited by B. Jack Copeland with helpful introductory notes.)

Turing is best known for his work on computability, the "Turing test," and his contributions to the British war effort in decrypting messages encoded by the German *Enigma* machine. But his collected works contain contributions to a much broader array of topics, both pure and applied. The *Collected Works* is divided into four volumes:

(1) Mathematical logic
(2) Pure mathematics
(3) Mechanical intelligence
(4) Morphogenesis

The four parts of *Work and Impact* roughly mirror these divisions, but with more colorful and descriptive labels:

(1) How do we compute? What can we prove?
(2) Hiding and unhiding information: cryptography, complexity, and number theory
(3) Building a brain: intelligent machines, practice, and theory
(4) The mathematics of emergence: the mysteries of morphogenesis

In the collection, more than 80 surveys and commentaries supplement two dozen or so of Turing's original works. Space does not allow me to discuss all of the supporting essays, but I will try to convey a sense of the range of topics they address and pass along some of the observations and comments that caught my attention. Some of the more speculative pieces stand in stark contrast to Turing's deliberate, measured style of writing, and I generally preferred the more conservative analyses as well as the essays that help situate Turing's work within our current scientific understanding. But these preferences should not be interpreted as a value judgment: like the seven-season run of *Mad Men*, everyone spending time with *Work and Impact* will have their favorite parts, and it is often more interesting to talk about the general plot lines rather than the individual scenes.

Part I contains Turing's work on logic and computability. It begins with the 1936 classic, "On computable numbers, with an application to the *Entscheidungsproblem*," which introduced what are now known as Turing machines. This is followed by a 1937 paper, "Computability and λ-definability," which demonstrates the equivalence of Turing computability with Church's notion of computability by λ-terms, and the Herbrand–Gödel–Kleene notion of a general recursive function. In the years after World War II, these papers played a key role in laying the foundations for a theory of computation, which was needed to make sense of and to support the technology that has transformed our lives so dramatically. These early works are so iconic that providing informative commentary is no easy task, but a number of essays in the collection rise to the occasion.

It is interesting to note, however, that Turing's early work dealt with the foundations of mathematics as much as with the foundation of computing. In the wake of Gödel's discovery of the incompleteness phenomena, Turing wrote papers on truth and ordinal logics, which provide ways of extending a formal system with stronger axioms. These are helpfully explained in articles by Michael Rathjen, Solomon Feferman, and Philip Welch. Turing was interested not only in logical strength but in the *expressivity* of formal languages, as is made clear in his essays "Practical forms of type theory" and "The reform of mathematical notation and phraseology." The latter begins amusingly as follows:

> It has long been recognised that mathematics and logic are virtually the same and that they may be expected to merge imperceptibly into one another. Actually this merging process has not gone all that far, and mathematics has profited very little from researches in symbolic logic. The chief reasons for this seem to be a lack of liaison between the logician and the mathematician-in-the-street. Symbolic logic is a very alarming mouthful for most mathematicians, and the logicians are not very much interested in making it more palatable. It seems however that symbolic logic has a number of small lessons for the mathematician which may be taught

> without it being necessary for him to learn very much of symbolic logic.

The particular small lessons Turing discusses in this essay involve ways that Church's simple type theory provides a good framework to encode ordinary mathematical assertions and make them precise. In his associated commentary, Stephen Wolfram underscores the importance and difficulty of making sense of informal notation, and he relates the challenge to the design of computer algebra systems.

Part II, which surveys the range of Turing's mathematical contributions outside of logic and the theory of computability, offers more surprises to those only casually familiar with Turing's work. For example, few may be aware that, as an undergraduate, Turing did substantial work in probability. After attending a series of lectures in 1933 in which the astrophysicist Sir Arthur Stanley Eddington noted that repeated experimental measurements are often normally distributed, Turing set himself the task of providing a rigorous explanation. Within a few months, he had proved a general form of the central limit theorem for independent but not necessarily identically distributed variables. What he had discovered was a version of a theorem that the Finnish mathematician Lindeberg had proved twelve years earlier, as well as part of a converse, due to Feller and Lévy, which had not yet been published at the time. These results are now textbook standards, and are fundamental to modern probability. And Turing discovered them as an *undergraduate*.

Others will be pleased to learn that Turing had a longstanding interest in the Riemann hypothesis, an interest he shared with Littlewood's student, Stanley Skewes, a regular rowing partner of his in Cambridge. Turing introduced a number of important ideas, including algorithmic methods for computing the zeros of the zeta function that are now standard in computational branches of analytic number theory. Denis Hejhal and Andrew Odlyzko do a fine job of explaining the intricacies of Turing's methods, but the take-away message is that Turing was no mere dabbler: when he picked up a problem, he threw himself into it, with ingenuity and hard work.

Part II contains excerpts from, and commentaries on, Turing's 1940 paper on the Enigma. It also contains Turing's 1944 notes on the design of a system, "Delilah," for voice encryption. A few years later Turing turned his attention to the burgeoning field of electronic computers, whose early days are colorfully described in an article by Toby Howard. The first digital stored-program computer was designed and built at the University of Manchester, and known as the "Baby." Its first program ran on June 21, 1948, and was designed to take an input, N, and compute the largest proper divisor. Within a few weeks, the program was able to compute the largest factor of $N = 2^{18}$. It took the Baby, however, 52 minutes to complete the task.

Turing had accepted a post in Manchester in May 1948, but he did not arrive until October 1948, having written programs for the Baby in the interim. *Work and Impact* contains a remarkable report written by Turing, "Checking a large routine," which discusses strategies for verifying the correctness of a computer program. As Cliff B. Jones correctly points out in his essay, this foreshadows the study of methods of program verification, an ongoing and active research area in computer science. Part II also devotes seven pages to excerpts from Turing's ninety-page programmer's handbook for a successor to the Baby, known as the Ferranti Mark I. Though the machine code was rudimentary, the excerpt reads much like any contemporary introduction to programming, with advice on how to break a problem down to components and modularize the task through the use of subroutines.

Part II also contains Turing's 1949 paper that shows that the word problem in semi-groups with cancellation is undecidable. Having shown in 1936 that the halting problem is algorithmically unsolvable, here he was concerned with exploring the extent to which unsolvability arises in traditional mathematical questions. The work improves on the prior result, due to Post and Markov independently, that the word problem for semi-groups is unsolvable. The result was later extended to groups by Novikov and Boone independently, in the mid-1950s. There is now, of course, a well-developed theory of undecidability phenomena in mathematics. One of the crowning achievements is the result of Matiyasevich, Robinson, Davis, and Putnam, who showed that there is no algorithm to determine whether a given Diophantine equation has a solution in the integers, thereby providing a negative answer to Hilbert's 10th problem.

The last work by Turing presented in this section is a paper called "Rounding off errors in matrix processes." As Lenore Blum explains, this paper introduces the notion of the *condition number* of a matrix, a quantity which measures the extent to which calculations with linear systems of equations are subject to rounding errors. Both the problem of managing rounding errors and the notion of condition number itself are now central to numeric computation.

Part III turns to Turing's work on mechanized intelligence, with such landmark papers as "Intelligent machinery," "Computing machinery and intelligence," and "Digital computers applied to games." Discussions of the Turing test are now commonplace in undergraduate philosophy classes, but the essays make clear that the idea was not just a passing fancy for Turing. These writings are among his most speculative and most prescient. "Intelligent machinery" in and of itself inaugurated the field of artificial intelligence, distinguished clearly between discrete and continuous models of computation, and even foreshadowed the study of neural networks and machine learning.

The essays are also among his most provocative. "Computing machinery and intelligence," which proposes the Turing test, addresses a wide range of objections to the thesis that machines can exhibit intelligent behavior, including theological, philosophical, and mathematical arguments. Responding to a skeptical 1947 lecture, "The Mind of Mechanical Man," by the British neurologist and neurosurgeon Geoffrey Jefferson, Turing challenges us to imagine how we might react to a machine that could not only compose a sonnet, but also respond to an interrogator's queries about the choice of words and the sentiments expressed. But even when Turing was being provocative, he was making a clear scientific point. Recognizing that questions as to whether machines can think are not only vague but also loaded with social and religious implications, Turing deftly shifted focus to the much more scientifically fruitful question as to whether machines can exhibit intelligent behavior. (The Turing test was designed to frame that question in even more pointed observational terms.) The essays moreover provide a thorough and thoughtful exploration of what it *means* to exhibit intelligent behavior, ranging from carrying out mathematical calculations and playing games to composing sonnets and even engaging in frivolous banter. The first step in developing a new science is to gain clarity as to the phenomena one is trying to model and explain, and Turing did an admirable job in mapping out the landscape.

But Turing went further than that, with concrete proposals as to how various types of intelligent machine behavior might be obtained. For example, "Digital computers applied to games" presents an explicit two-move lookahead algorithm for playing chess and a "run" of this algorithm against a novice player, with Turing playing the role of the computer and simulating the algorithm by hand. In this way, Turing's essays on machine behavior are as scientifically substantive as they are entertaining. As a result, it is fitting that almost two dozen supplementary essays in Section III are devoted to exploring the significance of this work.

The historical data presented in Part II makes the essays in Part III even more poignant. It is one thing for us, today, to take a break from shuttling between Google and Siri to speculate on the nature of machine intelligence. It is yet another thing entirely to spend as much time as Turing did writing machine code to compute basic numeric operations and to come away from the experience with the conviction that computers are capable of exhibiting intelligent behavior.

Part IV deals with Turing's work in biology, centered on the single long paper "The chemical basis of morphogenesis." The paper was published in 1952, just after Turing was tried and convicted for homosexual activities, and it is reproduced in full. It addresses a fundamental question: How do structured and complex organisms, like plants, animals, and humans, develop from a single cell? Somehow, the information and mechanisms stored in the original cell have to govern a reproductive process in which future cells are created and assume radically different roles.

One might speculate about the path that led Turing to this work. Although Crick and Watson did not discover the structure of DNA until 1953, the paradigm of classical genetics—based on the Mendelian notion of a gene—was firmly in place in the early 1950s, when Turing took up the project. What was called for, it would seem, is an analysis of genes as a method of encoding computer programs powerful enough to orchestrate the growth process.

But this is emphatically *not* the approach that Turing took. He was not one to use a tool or method just because it was near to hand. He approached every problem afresh, distilled it down to what he took to be the essentials, and adopted the methods that he felt were most appropriate. In the case at hand, Turing was more interested in the physical and chemical processes that could give rise to such complex behavior, and he found the language of dynamical systems and partial differential equations more appropriate to the analysis.

Turing's approach to the problem is intricate, but his exposition is, as usual, clear and methodical. The supplementary essays in Part IV, especially the surveys by Henri Berestycki and Hans Meinhardt, James D. Murray, Peter Saunders, and Jonathan Swinton do a good job of explaining the scientific substance of Turing's work and its contemporary relevance. We do not often think of Turing as an influential biologist, but, as Saunders points out, the paper has had a tremendous impact, with well over 3,000 citations listed on the ISI Web of Science. And although the general consensus is that the processes that Turing described cannot be the entire story, the mechanisms that underlie morphogenesis are still poorly understood today. Which is to say, more than sixty years later, it is still too early to fully assess the importance of Turing's contributions to biology.

The editors of *Work and Impact*, S. Barry Cooper and Jan van Leeuwen, are right to emphasize the rewards of a personal engagement with Turing's work. The sheer magnitude of Turing's accomplishments is impressive. As Rodney A. Brooks notes in his essay:

> It is humbling to read Alan Turing's papers.
> He thought of it all. First.

But reading Turing is as encouraging as it is humbling. When we spend time with his work, we become keenly aware that Turing was not a comic-book superhero or a demigod; he was a pure and applied mathematician, practicing his craft, like the rest of us. He was exceedingly clever and talented, but he was also careful, methodical, thoughtful, and hard working. He sought out questions and problems that he felt were interesting and important, and he pursued answers with energy, focus, creativity, and élan. He was not afraid to entertain big ideas, but big ideas by themselves are light and airy things, and Turing did the work that was needed to make them substantial. There is a lot to be learned from his outlook and temperament, and *Alan Turing: His Work and Impact* can serve as both an instructional and an inspirational text.

Acknowledgments

I am grateful to Thomas Hales and Robert Lewis for very helpful comments.

His Just Deserts: A Review of Four Books

Reviewed by Alvy Ray Smith

Alan Turing: The Enigma: The Centenary Edition
Andrew Hodges
Princeton University Press, May 2012
US$24.95, 632 pages
ISBN-13: 0691155647

Alan M. Turing: Centenary Edition
Sara Turing
Cambridge University Press, April 2012
US$31.99, 193 pages
ISBN-13: 978-1107020580

Alan Turing's Electronic Brain: The Struggle to Build the ACE, the World's Fastest Computer
B. Jack Copeland and others
Oxford University Press, May 2012
US$33.97, 592 pages
ISBN-13: 978-0199609154

Turing: Pioneer of the Information Age
Jack Copeland
Oxford University Press, January 2013
US$21.95, 224 pages
ISBN-13: 978-0199639793

A computer is an existential conundrum masked as an appliance. While appliances aren't transcendent, a computer is doubly so. First, it's the most malleable tool ever invented by mankind. It allows us to do many more things than we can possibly envision. Second, it's the most powerful amplifier that the human mind has ever had. It increases our power to do those things to unimaginable levels. Malleability and Amplification are the twin glories of computation.

St. Turing

Alan Mathison Turing was born in London on June 23, 1912—a century ago, which is the point, of course. Turing was a fellow at King's College of Cambridge by age twenty-two, received an Order of the British Empire by age thirty-four, became a Fellow of the Royal Society by age thirty-eight, and was dead of cyanide poisoning by age forty-one, on June 7, 1954. The four books we review are part of the centenary celebration of this remarkable man. Three are new editions of earlier works, and the fourth is brand new.

Turing was a mystery to us first-generation computer science students in the 1960s. Of course they taught us his great idea of computation but he himself remained a cipher. Rising out of the mist that otherwise obscured his person was the persistent rumor that he had committed suicide. Then suddenly, in 1983, Andrew Hodges published his biography, *Alan Turing: The Enigma*, which told it all. It finally brought Turing the man into sharp focus. It explained the mystery: Turing had been classified top secret in the War, and much of the information about him had been impounded for decades by Britain's Official Secrets Act—especially the fact that he had played a significant role in cracking Nazi Germany's Enigma code at Bletchley Park.

Topping that revelation was another. Turing had been openly, even recklessly, gay when homosexuality was still a crime. The suicide rumor was officially true. When he was arrested for "indecent acts" in 1952, he couldn't use the fact that he had saved England to save himself. The indecent acts trumped the Secrets Act. Given the choice of

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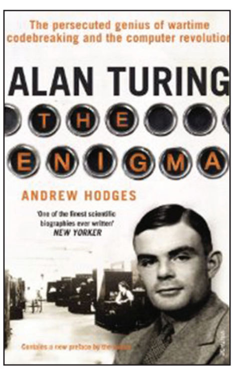
prison or chemical castration, he chose castration. His marathon runner's body fattened from the hormones, and he grew breasts. It was the humiliation, perhaps, that drove him to eat a poisoned apple—in a death scene that almost certainly was lifted straight out of Disney's Snow White.

Biographer Hodges, a King's College theoretical physicist and a member of Britain's gay liberation movement, finally parted the veils of secrecy and embarrassment in Turing's life. He got the full story and told it carefully, intimately, and well. And he brings it up-to-date in the Centenary Edition. It's still the Bible of Turing biography.

The government relaxed its hypocritical anti-gay laws in 1967, and England finally apologized publicly in 2009 for its appalling mistake. But both events came too late to forestall the martyrdom of "St. Turing". The 2012 worldwide celebrations of the centenary of his birth were his vindication—capped off finally by the Queen's pardon on Christmas Eve, 2013. And then there's the fact that his invention is the ubiquitous key to the modern world.

He's Got Algorithm



Intuitively, being careful or systematic about a process means to break it down into a sequence of smaller steps, each of which is simple, unambiguous, and obvious. But what happens when the number of steps in a systematic process gets large, the number of loops through the steps multiplies, and the branches of their possible execution ramify vastly? By asking questions about systematic processes at the turn of the twentieth century, mathematicians started to feel their way toward the notion of computation. They would discover that this new mathematical animal was full of surprises.

Starting in 1900 David Hilbert leveraged his international prestige to focus attention on hard problems. Famously, Hilbert's Second Problem concerned the very foundations of mathematics. His 1928 question did too. He posed it as a question about simple first-order logic.

Hilbert asked if there was a systematic way—an algorithm we would now say—to decide if a statement expressed in the logic is true or not. He did not ask that the algorithm actually generate a derivation of the statement from the axioms of the logic—only that it accurately decide whether one was possible or not. This is curious. If you can decide that a statement is true, why is it important to show the actual derivation of it from the axioms? It's an important distinction.

In the scholarly genealogy of families, for example, it's possible to know that Joseph from the seventeenth century, say, was the direct ancestor of James alive today without formally establishing a father-to-son path, a generation-by-generation descent, between them. If they share the same DNA on the Y chromosome—a straightforward lab test establishes this—then they must be related by a male line. But knowing that a path exists is nothing at all like knowing the actual series of males who passed the particular DNA down the male line—often quite difficult to establish.

Hilbert asked if first-order logic had a trick—like the DNA test—that would decide in a systematic way if a statement was true without actually doing the derivation from the obviously true axioms. This was Hilbert's Entscheidungsproblem, which means decision problem. But while decision problem sounds like a business school topic, *Entscheidungsproblem* suggests a Gotterdämmerung to shake and renew the world. And it did. I'll call it the eProblem since it led to email.

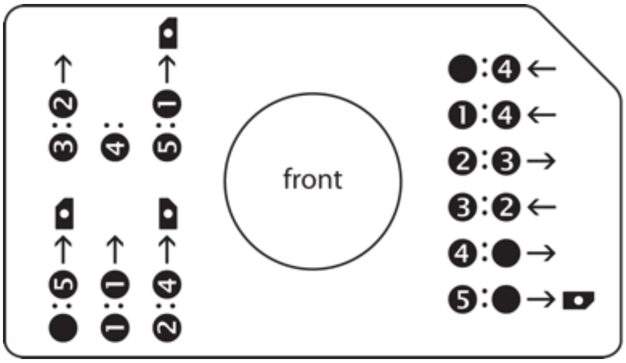
In England in 1934, topologist Max Newman presented the eProblem in a lecture at Cambridge. Student Alan Turing was in attendance. Newman spoke about systematic process—"mechanical process" was the term he actually used. Newman's choice of the words was key. There were no precise words for the concept yet. That was exactly the problem.[1]

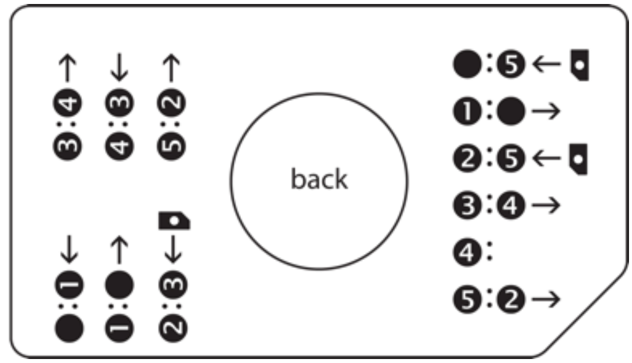
The exceedingly literal-minded Turing proceeded to formalize Newman's "mechanical process" with a paper "machine." Then he solved the eProblem with it—in a mighty intellectual leap. Turing used his machine—now called a Turing machine, of course—to show that first-order logic is undecidable. If he had done nothing else—like save Britain or invent computation—this would have put him in the scientific pantheon. He had solved one of the hard problems. But it was his machine—not his solution—that made him famous to the larger world. The modern computer is a direct conceptual descendant of Turing's machine. The path from concept to realization, however, was convoluted, and it was along this path that Turing was to meet perhaps his only failure.

As Turing was solving the eProblem, Alonzo Church at Princeton University was too. In fact, Church beat Turing by several months. By the rules of academia Church had won and the honor would've normally been all his. But Turing's solution technique was strikingly different from Church's, and Newman thought that the mathematical world should know about it.

He urged Church to acknowledge Turing's contribution, and Church did. They both went public, Church slightly before Turing, with printed papers in 1936. This was a big step because it was Turing's intuitive, industrial, even folksy, machine that inspired the birth of the computer, not Church's

[1] *David Anderson, "Historical reflections: Max Newman: Forgotten man of early British computing",* Communications of the Association for Computing Machinery **56** *(May 2013), 29–31.*





abstruse formalization (lambda definability). They were equivalent concepts, of course—Turing proved it so—but Turing's choice of words had profoundly different consequences.

Church wasn't the only other claimant. Emil Post and Stephen Kleene both had equivalent ideas.[2] But Turing's version influenced the modern notion so strongly that, to nonmathematicians, the others pale in comparison. His word computation is the one that stuck. Today we still use the concepts that he introduced. For starters, he gave us programming. That makes him the first programmer. Also, alas, he was the first to write buggy software, as first pointed out by Post.[3]

Martin Davis studied under both Post and Church and wrote influential books explaining Turing to generations of computer scientists.[4] So it's no surprise to find him here as author of the Centenary foreword to Sara Turing's little book in which she attempts, uncomprehendingly, to salvage her son's reputation. Alan's brother John, in the book's unkindest chapter, savages Joan Clarke, Alan's short-term fianceé. Davis's biting analysis of this brotherly betrayal is worth the price of admission alone.

And Turing was the first of another computer tradition. His quirky personality—intense literal-mindedness, honesty to a fault, social awkwardness, and disregard of dress—qualified him as the first geek, too.[5] Newman was afraid that Turing was fast becoming a "confirmed solitary" and told Church so. He asked Church to accept Turing as a graduate student at Princeton, and Church obliged again. Turing would earn his Ph.D. under Church in America.

[2]*Jacques Herbrand and Kurt Gödel are sometimes co-credited with Kleene.*

[3]*Emil Post, "Recursive unsolvability of a problem of Thue",* Journal of Symbolic Logic **12** *(1947), 7.*

[4]*Martin Davis,* The Universal Computer: The Road from Leibniz to Turing, *W. W. Norton & Co., New York, 2000.*

[5]*David Leavitt,* The Man Who Knew Too Much: Alan Turing and the Invention of the Computer, *W. W. Norton & Co., New York, 2006.*

Not a Toy

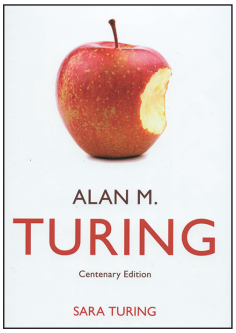
To get a handle on Turing's great idea, consider this business card (above). It has one corner cut off and a round hole in the center. Both the front and the back are inscribed as shown.

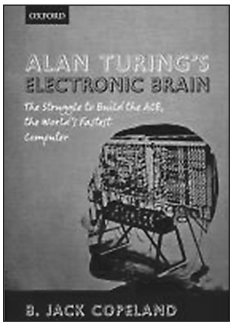
Imagine that there's a paper tape running from left to right behind the card. It's divided into squares, and you can see one square through the hole in the card. The tape is mostly blank, but there are typically one or more squares with symbols on them. I chose the nonblank symbols to be the numerals 1, 2, 3, 4, and 5, but they could just as well be #, !, $, %, and &. The point is that they're distinct marks, without meaning. In particular, they're not numbers. We call them symbols, but they symbolize nothing. Simply replace a 1 with #, a 2 with a !, etc., everywhere in the description of this business card device, and nothing changes—except, of course, the marks.

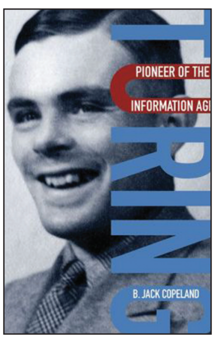
The business card device works like this. Suppose the symbol in the hole is a 5, in front orientation. The rule for 5 is at the lower right in this case. (Pay no attention to rules written sideways.) It says to replace the 5 with a blank then move the card right one square. The little glyph at the right of the rule represents the business card itself. It means that you should rotate the card to match the glyph's orientation. (No glyph means don't rotate.) Now repeat these steps for each new hole position. A rule with no right side means halt.

This isn't an idle game. The business card device is a Turing machine.[6] It's a hardware implementation of Turing's most famous invention. But a modern computer can execute any computation, by simply changing its program. Surely our simple business card device can't execute any computation, can it? Yes, it can. Pixar could compute "Toy Story" with it! They wouldn't want to, however. It's so tediously slow that it might take the lifetime

[6]*Designed 2013 by Alvy Ray Smith, protected by a Creative Commons Attribution-NonCommercial-ShareAlike license. See* `alvyray.com/CreativeCommons/TuringToysdotcom.htm`. *Based on UTM(4, 6) proved universal by Yurii Rogozhin, "Small universal Turing machines",* Theoretical Computer Science ***168*** *(1996), 215–240.*







of the universe—but speed is a separable issue. The point is that this device isn't just any ordinary Turing machine. The business card machine is a universal Turing machine.

Turing's first great idea is that what we mean by a systematic process is embodied exactly in a Turing machine. That idea—the Church-Turing Thesis—is a good one in itself. But Turing's master stroke was to show that there's a single Turing machine that can do what any other Turing machine can. It can perform all systematic processes. It's one machine that can compute anything that's computable. The modern computer is a descendant of this, the universal Turing machine.

Turing did it by encoding the description of an arbitrary Turing machine—an arbitrary algorithm—into a string of symbols. He placed this coded description on the tape of his universal machine. We call that a program today, and programmers call it code. He also similarly placed the data of the arbitrary machine somewhere else on the universal machine's tape. That machine then had enough information to simulate the arbitrary machine on arbitrary data. The simulation is a systematic process, so not surprisingly Turing could design a Turing machine to do it—namely the universal machine. To change what it does, just change the program. So Turing also invented the key notion of the stored-program computer. What we now mean by the single word computer is a universal stored-program machine. We drop it into hardware only to make it go fast.

How many programs can a computer compute? Well, there're so many that you can't count them. It's like asking, how many pieces of music can a piano play? The computer is the most malleable tool ever invented by mankind.

Nexus

Turing proceeded to Princeton for his Ph.D. studies in the late 1930s. His mentor, Newman, soon came for a six-month visit to the neighboring Institute for Advanced Study—sometimes called the Princetitute to distinguish it from the university. John von Neumann—another major player in the story—was already there. Earlier in the decade he had taken a stab at Hilbert's Second with an improvement to Kurt Gödel's as yet unpublished incompleteness result, but Gödel had beat him to it. Hardly missing a beat, von Neumann attempted to recruit Turing to the Princetitute. Astonishingly, Turing rejected this plum offer.[7]

Turing's and von Neumann's personalities were diametrically opposed, however. Von Neumann was a bon vivant, wore ridiculous party hats, and loved the good salacious limerick.[8] A team of the geek and the bon vivant might not have worked. There was to be no telling, however, because Turing, true to character, struck out on his own. He returned to England, where he was almost immediately recruited into Bletchley Park. It was 1939, and England was frightened for her life.

Bletchley Park

Turing famously helped crack the encryption scheme that the Nazis used for war communications. They employed a devilishly complex encryption machine called Enigma—its actual trade name. It recursively scrambled a text message several layers deep. Descrambling was tedious, superhuman work. The Bletchley Park people built large machines, called Bombes, to aid the humans and increase the speed of decryption. They weren't computers yet, but they were certainly on the path.

Turing needed a partner, not a leader. He was too much the loner. That's where Newman—already his mentor and promoter—would figure again. Like Turing, Newman returned to England from Princeton and joined Bletchley Park.

Turing had led the first-wave attack there. Newman led the second-wave attack, against a newer German encryption machine—nicknamed Tunny. This attack employed giant electronic machines, each called Colossus, the first one built in 1943.[9] These almost-computers were functional years before the almost-computer Eniac in America, on which von Neumann would cut his teeth. But none of these machines was stored-program. They were programmable, but only with hardware cables and toggles.[10]

Turing came up with a mathematical insight, known in Bletchley-speak as Turingismus, that was key to cracking Tunny. Despite his student-teacher relationship with Newman and his own Bletchley Park machine experience with the Bombes, he and Newman didn't team up there—and wouldn't for a while longer—because decoding texts no longer excited Turing. His new interest was encoding voices. The British government sent him back to America on a special mission.

He was to analyze the X System used for secret voice communications between Churchill and Roo-

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[7] *George Dyson,* Turing's Cathedral: The Origins of the Digital Universe, *Pantheon Books, New York, 2012.*

[8] *Marina von Neumann Whitman,* The Martian's Daughter: A Memoir, *University of Michigan Press, Ann Arbor, 2013.*

[9] *B. Jack Copeland and others,* Colossus: The Secrets of Bletchley Park's Codebreaking Computers, *Oxford University Press, Oxford, 2006.*

[10] *I promote all machine acronyms to real names—Eniac, Ace, Edvac—since that's how we know them and the acronyms are long forgotten.*

sevelt (later Truman). His American counterpart was Claude Shannon. They couldn't talk Enigma secrets but they could talk all they wanted about the possibilities of using computers for an exciting possibility now called artificial intelligence. Computation is about patterns of symbols, not just numbers.

Unknowability

Turing's solution to the eProblem was that there is no decision algorithm. Not surprisingly, considering their common origin with Turing, there is a similar consequence in computation—a certain unknowability—the famous printing problem. You generally cannot know whether a computation will ever print a 1, say. Turing proved there's no algorithm that, given a program and a blank tape, can discover whether the program will eventually print a 1 on its tape. That's a surprising mystery that comes with Malleability.[11]

So a computer is completely determined but not predetermined. It might not be so unsuited to modeling the human brain or mind as many think. Turing certainly thought it was a rich model.

Architecture

It's not farfetched to claim that essentially all computers in use today are descendants of the universal stored-program concept invented by Turing and the architecture for realizing it invented by von Neumann. The von Neumann architecture carries only his name because it appeared alone on the influential report of 1945 which launched it.[12]

Turing had an architecture, too, but it didn't fare so well. He created it for the early computer, Pilot Ace, and its progeny. His machine by all rights should've been the first in the world. Why it wasn't is a tale of bureaucratic bungling and Turing's personal faults, and finally his disillusionment. The Ace book, edited by Copeland, carefully documents the rise and fall of Turing architecture.

The machine that was the first computer was Baby at the University of Manchester, built by Frederic Williams and Tom Kilburn, with first cry in 1948.[13] It used a von Neumann architecture. Pilot Ace, with Turing's architecture, wasn't birthed until 1950. Von Neumann's own machine wasn't first because there was a failure to develop a fast memory device in America. The winning design came from Williams and Kilburn at Manchester—hence Baby. America's first machines eventually used Baby's memory technology too. And Turing, who finally joined Newman at Manchester, wrote programs for Baby and a programming manual for its progeny. Copeland's well-written, and fresh, Turing biography is particularly strong on the Manchester machines—and the Ace machines, of course.

Suicide?

Then there's that suicide—or was it? The official finding was a deliberate act of cyanide poisoning, but the nibbled apple wasn't tested, leaving plenty of wiggle room for alternative theories. The authors reviewed cover the gamut. Hodges is convinced that Turing died by suicide, even though those hormones had worn off by then. But Alan's mother, Sara, never believed it. Neither did Lyn (Irvine) Newman—Max's wife and Alan's dear friend—who wrote the original foreword to Sara's book. Perhaps it was a chemistry experiment gone bad or Alan being sloppy. That's Sara's version. Copeland's is murder. That story of Snow White's poisoned apple is just too precious. He suggests that the British government might have taken Turing out in a fit of McCarthy era insanity.

Amplification

Baby was 10,000 times faster than a human, and Turing's Pilot Ace was even faster. But it was only briefly the "world's fastest computer". The invention of the integrated circuit chip and the announcement in 1965 of "Moore's Law" changed everything. Not the fundamentals, of course—computation would remain Turing's computation, regardless of speed. But Moore's Law told us to expect an order-of-magnitude increase in speed of those computations every five years! Amplification of humans went supernova. It's now reached a quadrillionfold—unimaginable in Turing's time. And it's headed for a quintillionfold by 2025—unimaginable by us even today. That's because we can't see beyond even one order of magnitude, much less three. Those order-of-magnitude barriers are Amplification's unknowability. We just have to get there to see what it means—determined but not predetermined.

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[11] *The more famous halting problem wasn't Turing's. Martin Davis,* Computability & Unsolvability*, New York: McGraw-Hill, New York, 1958, p. 70, named and proved it.*

[12] *John von Neumann, "First draft of a report on the EDVAC", Moore School of Electrical Engineering, University of Pennsylvania, 30 June 1945. Unnamed team members included Herman Goldstine, Arthur Burks, Presper Eckert, and John Mauchly.*

[13] *Baby was officially the Small-Scale Experimental Machine.*

WHAT IS...

a Period?

Stefan Müller-Stach

Mathematical constants such as π, e, and γ arise frequently in number theory and other areas of mathematics and physics. Mathematicians have long wondered whether such numbers are irrational or perhaps even transcendental, that is, not algebraic. Because they are solutions of polynomial equations with rational coefficients, algebraic numbers form a countable subset of the complex numbers. Therefore, most complex numbers are transcendental, although, for any given number, it is usually difficult to figure out whether it is transcendental.

This essay is about the arithmetic notion of *periods*, a countable subalgebra $\mathcal{P}$ of the complex numbers defined around 1999 by Maxim Kontsevich and Don Zagier; see [4]. Periods contain all algebraic numbers but also many other transcendental numbers important for number theory. This notion of periods generalizes in algebraic geometry and yields the theory of periods and period domains for algebraic varieties; see [2].

Kontsevich and Zagier define periods as those complex numbers whose real and imaginary parts are values of absolutely convergent integrals

$$p = \int_\Delta \frac{f(x_1,\dots,x_n)}{g(x_1,\dots,x_n)} dx_1 \cdots dx_n.$$

Here f and g are polynomials with coefficients in $\mathbb{Q}$, and the integration domain $\Delta \subset \mathbb{R}^n$ is given by polynomial inequalities with rational coefficients.

Some initial examples of periods are

$$\log(n) = \int_1^n \frac{dx}{x} \text{ and } \pi = \int_{x^2+y^2\le 1} dxdy.$$

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The representation of a period by an integral is not unique, in the sense that there are many different integrals representing that period.

The values $\zeta(s) = \sum_n n^{-s}$ of the Riemann zeta function at positive integers $s \ge 2$, and their natural generalizations, the *multiple zeta values*

$$\zeta(s_1,\dots,s_k) = \sum_{n_1>\cdots>n_k>0} n_1^{-s_1} n_2^{-s_2} \cdots n_k^{-s_k},$$

for integers $s_i \ge 1$ with $s_1 \ge 2$, are very interesting periods. Even for the odd zeta-values $\zeta(3), \zeta(5), \dots$ only a few results about their irrationality are known. By work of Apéry, $\zeta(3)$ is irrational. Like all multiple zeta values, it can be represented as an *iterated integral*

$$\zeta(3) = \iiint_{0<x<y<z<1} \frac{dxdydz}{(1-x)yz}.$$

Using notions from algebraic geometry, one can also define periods in a different form as follows. Let X be a smooth algebraic variety over $\mathbb{Q}$ of dimension d. Take a regular algebraic d-form ω on X and a normal crossing divisor D in X; both ω and D are also defined over $\mathbb{Q}$. Then let γ be a singular chain on the underlying topological manifold $X(\mathbb{C})$ with boundary in $D(\mathbb{C})$. The integral

$$p = \int_\gamma \omega$$

is the period of the quadruple (X, D, ω, γ).

From an even higher viewpoint, periods are matrix coefficients of the *period isomorphism*

$$H^*_{\mathrm{dR}}(X,D) \otimes_{\mathbb{Q}} \mathbb{C} \xrightarrow{\cong} H^*_{\mathrm{sing}}(X,D) \otimes_{\mathbb{Q}} \mathbb{C}$$

between algebraic de Rham cohomology and singular cohomology after choosing $\mathbb{Q}$-bases in both groups. In this case, X need not be smooth and forms need not be of top degree. Sophisticated arguments show that all three given definitions of periods agree.

In this setting, we find $2\pi i$ as the period of $H^1(X)$ with $X = \mathbb{P}^1 \setminus \{0, \infty\}$, $D = \emptyset$, $\omega = \frac{dx}{x}$, and γ the unit circle. In a similar way, $\log(n)$ is one of the periods of $H^1(X, D)$, where $X = \mathbb{P}^1 \setminus \{0, \infty\}$, $D = \{1, n\}$, $\omega = \frac{dx}{x}$, and $\gamma = [1, n]$. Certain special Γ-values occur in the *Chowla–Selberg formula* for periods of abelian varieties with complex multiplication. The *Beilinson conjectures*, which extend Dirchlet's class number formula in algebraic number theory, would imply that leading terms in the Taylor series of *L-functions* of motives are periods in the extended period ring $\hat{\mathcal{P}} = \mathcal{P}[\frac{1}{\pi}]$, where π is inverted. A completely different example comes from quantum field theory, where periods arise as values of regularized *Feynman amplitudes*. Periods of *homotopy groups* are another source of examples.

In addition to the additivity in the integrand and the integration domain, periods inherit from calculus some well-known relations: a change of variables formula $\int_\gamma f^*\omega = \int_{f_*\gamma} \omega$, and Stokes's formula $\int_\gamma \delta\omega = \int_{\partial\gamma} \omega$. Fubini's theorem gives $\mathcal{P}$ a multiplication, hence it becomes a $\mathbb{Q}$-algebra.

At the time Kontsevich and Zagier formulated their idea, not a single explicit nonperiod number was known. In 2008, Masahiko Yoshinaga (arXiv:0805.0349) wrote down a computable nonperiod, using a variant of Cantor's diagonal argument. Moreover, he showed that all periods are elementary computable, i.e., they lie in a certain proper subset of all computable complex numbers so that there are computable nonperiods.

It is still unknown whether e or $1/\pi$ are periods. Presumably they are not. The notion of *exponential periods* was invented to extend periods to a larger set containing e; see [4].

Let us now turn to deeper properties of periods, so that we find out more about the structure of $\mathcal{P}$. It turns out that the very abstract viewpoint of *mixed motives* provides insights and brings into the game a big symmetry group G—the *motivic Galois group*.

Pure and mixed motives were envisioned by Alexander Grothendieck in order to formalize properties of algebraic varieties. In the 1990s, Madhav Nori defined an abelian category $MM(\mathbb{Q})$ of mixed motives over $\mathbb{Q}$. In Nori's construction, one starts with a directed graph, where the vertices are pairs of algebraic varieties (X, D) defined over $\mathbb{Q}$, and the edges between them are deduced from morphisms of pairs $(X, D) \to (X', D')$ ("change of variables") and chains of inclusions $Z \subset D \subset X$ ("Stokes's formula"). The edges thus immediately resemble relations among periods, and this is what makes the idea so helpful. These arrows are not closed under composition. However, if one fixes a representation T with values in vector spaces over $\mathbb{Q}$ (e.g., singular or de Rham cohomology), then there is a universal diagram category $C(T)$ and an extension of T as a functor. After formally inverting the Tate motive $\mathbb{Z}(-1) = (\mathbb{P}^1 \setminus \{0, \infty\}, \{1\})$ in $C(T)$, one obtains a $\mathbb{Q}$-linear Tannakian, hence abelian, category $MM(\mathbb{Q})$ without any further assumptions; see [3]. The motivic Galois group is the pro-algebraic fundamental group $G = \mathrm{Aut}^{\otimes}(T)$ of $MM(\mathbb{Q})$ in the Tannaka sense. We call G a Galois group, as the viewpoint gives a far-ranging extension of the Galois theory of zero-dimensional varieties. In $MM(\mathbb{Q})$ cohomology groups of algebraic pairs (X, D) are immediately mixed motives, i.e., finite-dimensional $\mathbb{Q}$-representations of G or, equivalently, comodules over the associated Hopf algebra A. Both singular and de Rham cohomology provide fiber functors T_{sing}, T_{dR} from $MM(\mathbb{Q})$ to $\mathbb{Q}$-vector spaces. The pro-algebraic torsor $\mathrm{Isom}^{\otimes}(T_{\mathrm{dR}}, T_{\mathrm{sing}})$ is given by $\mathrm{Spec}(\hat{\mathcal{P}}_{\mathrm{formal}})$, where $\hat{\mathcal{P}}_{\mathrm{formal}}$ is the algebra of formal periods (i.e., generated by quadruples (X, D, ω, γ)), and subject only to the relations of linearity, change of variables, and Stokes; see [3, 4].

In this setting, $\hat{\mathcal{P}}$ is the set of periods of all mixed motives over $\mathbb{Q}$. Multiple zeta values form the subset of periods of mixed Tate motives over $\mathbb{Z}$. The motivic Galois group restricted to mixed Tate motives over $\mathbb{Z}$ gives much control over multiple zeta values and implies relations among multiple zeta values $\zeta(s_1, \ldots, s_k)$ of a fixed weight $s_1 + \cdots + s_k$. The work of Francis Brown on multiple zeta values and the fundamental group of $\mathbb{P}^1 \setminus \{0, 1, \infty\}$ demonstrates again the value of the philosophy of motives; see [1]. Also in other parts of number theory (for example in the area of rational points) motivic arguments can be applied in finiteness proofs.

Grothendieck formulated the famous and difficult *period conjecture*, stating that any relation among periods is coming from algebraic geometry, in particular through algebraic cycles on products of varieties. In the setting of Nori, this is essentially equivalent to saying that the evaluation map $\mathrm{ev} : \hat{\mathcal{P}}_{\mathrm{formal}} \to \hat{\mathcal{P}}$ is injective. This conjecture would have strong consequences for the transcendence degree of the space of all periods of a given algebraic variety X via the action of G.

Further Reading:

[1] F. Brown, Mixed Tate motives over $\mathbb{Z}$, *Annals of Math.* **175**(2), 2012, 949–976.

[2] J. Carlson and Ph. Griffiths, What is a period domain?, *Notices*, AMS, **55**(11), 2008, 1418–1419.

[3] A. Huber and S. Müller-Stach, *On the relation between Nori motives and Kontsevich periods*, arXiv:1105.0865v5 (2011).

[4] M. Kontsevich and D. Zagier, *Periods*, in Engquist, Björn (ed.) et al., Mathematics Unlimited–2001 and Beyond, Springer Verlag, 771–808 (2001).

Hopkins Awarded Nemmers Prize

Photo courtesy of Harvard Mathematics Department.

Michael J. Hopkins

Northwestern University has announced that Michael J. Hopkins of Harvard University has been awarded the 2014 Frederic Esser Nemmers Prize in Mathematics. The Nemmers Prize, one of the largest monetary awards in the United States, honors outstanding achievements in mathematics. Awarded to scholars who have made major contributions to new knowledge or to the development of significant new modes of analysis, the prize carries a cash award of US$200,000.

Hopkins was honored "for his fundamental contributions to algebraic topology, stable homotopy theory, and derived algebraic geometry."

The prize citation reads: "Hopkins's work has revolutionized the field of algebraic topology, a field of mathematics which studies topological or geometric structures using the methods of algebra. He has pioneered the application of homotopy theory to a range of areas in mathematics, collaborating with geometers, number theorists, and mathematical physicists.

"Working with Michael Hill and Douglas Ravenel, Hopkins recently solved the long-standing Kervaire invariant problem. While this question first arose in the 1940s, it has a long history at Northwestern, particularly in the work of Mark Mahowald."

Michael J. Hopkins received his Ph.D. in 1984 from Northwestern University under the direction of Mark Mahowald. Also in 1984 he earned a D.Phil. (doctor of philosophy) in mathematics from the University of Oxford as a result of his work there as a Rhodes Scholar. He held professorships at the Massachusetts Institute of Technology and the University of Chicago before joining Harvard in 2005. His honors include the Oswald Veblen Prize in Geometry of the AMS (2001) and the National Academy of Sciences Award in Mathematics (2012). He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences and a foreign member of the Royal Danish Academy of Sciences and Letters.

In connection with the Nemmers Prize, Hopkins will deliver a public lecture and participate in other scholarly activities at Northwestern during the 2014–2015 and 2015–2016 academic years.

Northwestern University also announced that Jean Tirole of the Toulouse School of Economics was awarded the 2014 Erwin Plein Nemmers Prize in Economics, which also carries a cash prize of US$200,000.

The Nemmers Prizes are made possible through bequests from the late Erwin E. Nemmers, a former member of the Northwestern University faculty, and his brother, the late Frederic E. Nemmers, both of Milwaukee. The prizes are awarded every other year. Previous Nemmers Prize recipients are Yuri I. Manin (1994), Joseph B. Keller (1996), John H. Conway (1998), Edward Witten (2000), Yakov G. Sinai (2002), Mikhael Gromov (2004), Robert P. Langlands (2006), Simon Donaldon (2008), Terence Tao (2010), and Ingrid Daubechies (2012).

Consistent with the terms of the Nemmers bequests, the Erwin Plein Nemmers Prize in Economics (named in honor of the Nemmers' father) and the Frederic Esser Nemmers Prize in Mathematics (named by Erwin in honor of his brother) are designed to recognize "work of lasting significance" in the respective disciplines.

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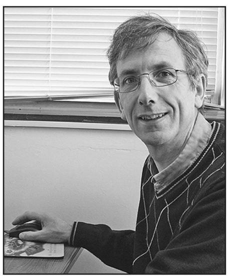
Inaugural Breakthrough Prize in Mathematics Awarded

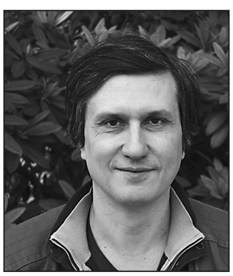
Five mathematicians have been selected as recipients of the first Breakthrough Prize in Mathematics by the Breakthrough Prize Foundation.

SIMON DONALDSON of Stony Brook University and Imperial College London was honored "for the new revolutionary invariants of 4-dimensional manifolds and for the study of the relation between stability in algebraic geometry and in global differential geometry, both for bundles and for Fano varieties."



Simon Donaldson

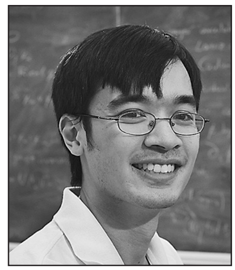
MAXIM KONTSEVICH of the Institut des Hautes Études Scientifiques was recognized "for work making a deep impact in a vast variety of mathematical disciplines, including algebraic geometry, deformation theory, symplectic topology, homological algebra, and dynamical systems."



Maxim Kontsevich

JACOB LURIE of Harvard University was selected "for his work on the foundations of higher category theory and derived algebraic geometry; for the classification of fully extended topological quantum field theories; and for providing a moduli-theoretic interpretation of elliptic cohomology."

Jacob Lurie



Terence Tao

TERENCE TAO of the University of California Los Angeles, was honored "for numerous breakthrough contributions to harmonic analysis, combinatorics, partial differential equations, and analytic number theory."

RICHARD TAYLOR of the Institute for Advanced Study was recognized "for numerous breakthrough results in the theory of automorphic forms, including the Taniyama-Weil conjecture, the local Langlands conjecture for general linear groups, and the Sato-Tate conjecture."

Richard Taylor

The Breakthrough Prize in Mathematics was created by Mark Zuckerberg and Yuri Milner in 2013. It aims to recognize major advances in the field, to honor the world's best mathematicians, to support their future endeavors, and to communicate the excitement of mathematics to the general public. The Breakthrough Prize carries a cash award of US$3 million.

The prizewinners will serve on the selection committee responsible for choosing subsequent winners of the prize from the pool of contenders nominated by the mathematics community. From 2015 on, one Breakthrough Prize in Mathematics will be awarded every year.

Photo credits: Simon Donaldson–Imperial College, London; Maxim Kontsevich–MCV/IHES; Jacob Lurie–Harvard University Department of Mathematics; Terence Tao–Photo by Kyle Alexander; Richard Taylor–Photo by Cliff Moore.

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Mathematicians Discuss the Snowden Revelations

This article is the latest installment in the *Notices* discussion of the National Security Agency (NSA). The previous installment, by Richard George, appeared in the August 2014 issue. A list of earlier articles appears there.

The author of the present article, William Binney, worked at the NSA for thirty years and left in October 2001 out of concern that the NSA was undertaking activities that were unconstitutional. Since then, he has become a prominent critic of the NSA. In July 2014, he appeared before the committee of the German Bundestag that is investigating the NSA. Further background can be found in, for example, "Bill Binney, the 'original' NSA whistleblower, on Snowden, 9/11 and illegal surveillance," by Fiona O'Cleirigh, *Computer Weekly*, June 2014, `http://www.computerweekly.com/feature/Interview-the-original-NSA-whistleblower`.

— *Allyn Jackson*
Notices *Deputy Editor*
`axj@ams.org`

The Danger of Success

William Binney

When I joined the Army Security Agency in the mid-1960s and later the NSA (National Security Agency) in 1970, I did so with the understanding that I would be working to defend the Constitution and help maintain the security of the US and the free world. For the first thirty years working in communications intelligence (COMINT), my job was to solve data systems, codes, and ciphers as well as analyze data used in communications of the Soviet Union and the Warsaw Pact. During this period, we had clear directions within NSA not to spy on Americans. These rules were documented in USSID-18 (United States Signals Intelligence Directive number 18), which we religiously followed.

In the 1990s, in addition to being the co-founder of the Signals Intelligence Automation Research Center (SARC), I became technical director of the NSA's World Geopolitical & Military Analysis and Reporting Group, which employed around 6,000 people. In this position, I had to focus on issues dealing with public communication. I had to help resolve the problems of dealing with the vast amount and verity of communications. The problem, simply put, was: How can one smartly select relevant data from the huge flow going across the fiber optic lines around the world? These communications were primarily in two networks: the Public Switched Telephone Network (PSTN) and the World Wide Web (WWW).

The PSTN system is uniquely numbered (that's how caller ID works) and much easier to deal with compared to the WWW. In the WWW, we had to first solve the problem of reconstructing the data going across the fiber lines. This meant we had to process data at 155mbs—the rate of one fiber. We achieved that in 1998. From then on, it was possible to acquire all the data on a fiber. Space and computing power determined how many fibers we could collect. Once all that data is captured it was, and still is, extremely important to smartly select relevant information for analysts to review. This was a major problem for analysis back in the 1990s, and, from all indications, today it is even more of a problem. My small team developed arguments that selected material based on a defined zone of suspicion around known and targeted entities, plus some other target-specific properties.

Building relationships between entities was at the foundation of the analysis process that made it possible to smartly select data. We could select a rich set of data for analysts to look at and then let the rest of the data go without collecting it. This would give privacy to most of the people in the world. In this process, we could capture

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communications of Americans. So I designed a logic that would encrypt the attributes of any US citizen pulled into the collection. These protected attributes would not be decrypted until "probable cause" was developed and presented to a court for a warrant. A warrant had to be requested within seventy-two hours of starting to examine a US entity; otherwise, the collection had to be stopped and the data purged from the database. This process, we believed, was constitutionally acceptable, legal according to FISA (Foreign Intelligence Surveillance Act of 1978), and consistent with Executive Order 12333 (which dates from the 1980s and deals with surveillance outside the purview of FISA).

There are other benefits from smart selection of data. Since only a fragment of the data flow would be captured, there would be no need to build storage facilities like the one NSA completed in 2013 in Bluffdale, Utah. Nowhere near the number of contractors or contracts would be necessary to maintain the data and programs associated for tasks like query and information distribution. Plus, of course, analysts would not be buried in data from daily pulls for target information, which means they would have a much higher probability of finding actionable intelligence.

Unfortunately, all this power to capture data, graph social networks, and index collected data to the relationships in the graph was directed initially inward, toward US citizens. This automatically produced a profile of the activity of everyone. This profile was available on request from analysts. Also, in the process, the NSA removed the privacy protections for US citizens and decided to collect and store as much data as it could ingest. No one had privacy from the government anymore. I of course objected, as in my mind these actions were, at a minimum, a violation of the First, Fourth, and Fifth Amendments to our Constitution.

The First Amendment was violated because the graphing of social networks (enhanced by other knowledge bases—for example, a reverse lookup of the phone book) would show the people you are associated with. The First Amendment says you have the right to peaceably assemble, and the Supreme Court has held (e.g., in NAACP v. Alabama) that the government does not have a right to know with whom you are assembling. The collection of your email, chatter, and phone calls (recorded or transcribed) is a violation of the Fourth Amendment right to be secure in your affairs. And using content data in order to search for criminal activity can be a violation of the Fifth Amendment, which gives the right not to be a witness against yourself. An example of this is the "parallel construction" techniques used by the FBI and the DEA's Special Operations Division, to find evidence to submit in court proceedings when they use data collected by the NSA (see "Exclusive: U.S. directs agents to cover up program used to investigate Americans," by John Shiffman and Kristina Cooke, *Reuters*, August 3, 2014). The procedure, as outlined in the *Reuters* article, instructs agents not to let the court or lawyers involved in the case know about the NSA data. So, they perjure themselves. This I call a planned programmed perjury policy run by the Department of Justice.

Some have claimed that the NSA collection is innocuous, because, for those who are not terrorist suspects or associates, the NSA collects only metadata, such as telephone numbers, the date, time, and duration of telephone calls. Evidence that this claim is untrue can be found, for example, in the testimony of two NSA transcribers who worked at Fort Gordon in Georgia—Adrienne Kinne and David Murfee Faulk. They have testified that after the invasion of Iraq they transcribed, in full, calls made by US citizens in the Green Zone—members of the military, employees of NGOs, journalists, etc.—to their families back in the US. Kinne and Faulk both were disturbed at having to transcribe these intimate, personal conversations between family members who were separated because of the war. This transcribing was done without a warrant and thereby violated both USSID-18 and FISA—plus of course the Constitution.

So you see what happens when a technical advancement is made. Politicians and bureaucrats, when given the power the advancement provides, use it. Herein lies the danger that seems to be a failing of humankind, as it has happened over and over again down through history. We just don't seem to learn from it. Even with the exposure of the Snowden material detailing the extent of bulk data acquisition, our Congress and the Administration still don't appear to have the stomach to ensure that the activity of NSA and the other intelligence community agencies is verified. In other words, they prefer to trust and not verify. Unless we strongly object to our representatives in Washington, we don't stand a chance of recovering our Constitutional rights.

The *Journal de l'École polytechnique*, A Revival

Claude Sabbah

Let's just do it.
Robert Rosebrugh
Scripta Manent, *Notices of the AMS,* January 2013

Let us start with an observation. At each stage of a mathematician's academic career, the weight of the publication list in his or her CV continues to increase, as it does for any scientist. With a steady increase in the number of mathematicians, so too is there a rapidly growing number of mathematics publications; in particular, a growing number of publications of high scientific quality. Why complain that the number of mathematical papers is growing? We can be glad for the increase in papers of a very high scientific interest. This phenomenon will continue to develop, whatever good practices are implemented to control it, for the very reason that the financial support of mathematics departments or individual research projects, through grants or promotions, depends so much on the publication list. It is not a matter here of the nature of the assessment, but only of the fact that this assessment is fundamental in the decision process for funding.

Big commercial publishers, who publish a large number of mathematical journals, therefore play an essential, while implicit, role in the decision processes for funding, by providing a concrete basis for the assessment of the publication lists.

The Gold Open Access model with author processing charges (APC) generates small business structures, many of them being considered as "predatory publishers," which absorb part of the mathematics literature. They promise quick publication and low APC but they do not, for the most part, ensure long-term archiving. Such structures develop purely commercial techniques to attract authors and to increase their income. In such a model, the author publishes his/her article as if he/she were publishing a classified ad.

The development of electronic academic journals comes as a possible answer to the problems raised by this new publishing environment. They can offer at once a high-quality editorial process, assessed by the sponsorship of scientific institutions, and solutions for long-term archiving. Universities will benefit from supporting academic journals through the higher visibility of the mathematical research they develop, in the same way that they may benefit from the massive open online courses they produce. Moreover, the growing acceptance of electronic journals by mathematicians, as readers and more importantly as authors, allows one to forget about the management of subscriptions and printing, a problem which has led many print university journals to entrust their future to commercial publishers. As noted by Ingrid Daubechies [1], president of the International Mathematical Union: "Electronic publishing is potentially a great game changer."

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The university journals may find it advantageous to join together, while remaining independent from each other, by forming small structures supported by renowned academic institutions (learned societies, research agencies, national or international research institutions) in order to share effective tools for the management of the editorial and publishing process and the dissemination and archiving of electronic articles. A few such structures have already been developed in the US (Project Euclid, IMS, MSP), but this model is not developed enough in Europe, possibly because of the strength of commercial publishers and the existence of many learned societies of various sizes. Developing small production-dissemination-archiving structures, supported by academic institutions, will provide electronic university journals with a secure environment without profitability constraints. For example, ensuring quick publication cannot be emphasized as a quality feature, if it compromises a rigorous refereeing process. Increasing the number of pages published by existing academic journals or creating new electronic academic journals may thus offset the rapid expansion of low-cost and low-quality journals.

Let me quote Ingrid Daubechies once more: "Emancipation of our journals: Set our journals free!" Support by academic institutions will provide for most of the funding needs of an electronic journal through hosting a website with editorial management and electronic edition, and possibly copyediting of the articles. In such a way, the APC may be approached differently. Institutions may sponsor small publishing structures by funding part of their needs. The example of arXiv shows that this is possible. Various institutions were concerned with the question of permanent electronic archiving. They may as well be concerned with supporting structures which foster the development of productive academic journals.

At the École Polytechnique, fondly known as "l'X" by the cognoscenti for the two crossed swords of its insignia, the more favorable conditions offered by the growing acceptance of electronic publications in the mathematical community, allowing the elimination of most of the flow of money, together with the increasing cost of the mathematical literature, urged us to add our modest contribution to the strategy of developing academic publications: The new electronic mathematical journal entitled *Journal de l'École polytechnique—Mathématiques* (JEPM) [5] has been launched recently on the basis of "diamond" open access (free access and no APC). A Creative Commons license is proposed to authors.

The *Journal de l'École polytechnique*, a scientific journal launched in 1795 during the French Revolution just after the creation of the École Polytechnique, was published more or less regularly until 1939, and the memory of its existence is now safely kept by Gallica [4], at the French National Library. Most of the important French mathematicians of the nineteenth century have been authors of articles in this journal, which also published articles of other scientists. Primarily aimed at promoting research results obtained by professors and students of the École Polytechnique, it also published series of lectures provided there by teachers like Monge and Prony, and lectures provided by Lagrange and Laplace at the École Normale Supérieure, created around the same time. The celebrated article *Analysis situs* by Poincaré was published in the centenary issue (1895). But a narrow editorial policy led to its extinction at the beginning of World War II.

Our principal strengths to convince mathematicians that we focus on a high quality for all aspects of the publication are:

- the prestigious history of the *Journal de l'École polytechnique*,
- the sponsorship and support of various French research institutions.

The composition of the Editorial Board reflects our choice to cover a wide spectrum from applied to fundamental mathematics, in the continuation of the *Journal de l'École polytechnique*. Let me emphasize that we feel it important to continue creating general mathematical journals where various mathematical communities can find common interest for publication.

How does it work? The Centre national de la recherche scientifique (CNRS) (the big French research agency composed of various thematic institutes), through its institute dedicated to mathematics (National Institute for Mathematical Sciences [6]), provides support to various academic journals, among which is the JEPM, in two complementary ways:

- The "Centre de diffusion de revues académiques mathématiques" (`cedram`) [2] provides the journals with complete support concerning electronic production and dissemination, and archiving in the `numdam` database [8].
- The "Mathrice" network [7] offers an implementation of the *Open Journal System* provided by the *Public Knowledge Project* [9] dedicated to online submission to journals and article management.

This support reduces the financial needs for copyediting and typesetting, and is efficiently complemented with the support of École Polytechnique through its staff and its publishing house, which will provide a few printed volumes of the JEPM. These volumes will serve for archiving the journal in a printed form and will be sold to libraries at a reasonable cost.

Our editorial project aims at contributing to the strategy of developing academic electronic mathematical journals. We feel it to be important that these journals can join together in relatively small institutional entities that furnish common technical support for the editorial and archiving aspects, as opposed to academic journals managed by big commercial publishers. Alternatives to fee-based Open Access are possible for mathematical publications, and will not lead to increasing the commercial aspects of scientific publications.

References

[1] Ingrid Daubechies, IMU Blog on mathematics, Oct. 25, 2012, `http://blog.mathunion.org/rating/`
[2] `cedram`: `http://www.cedram.org`
[3] Ecole Polytechnique: `http://www.polytechnique.edu/`
[4] *Journal de l'École polytechnique*: `http://gallica.bnf.fr/ark:/12148/cb34378280v/date`
[5] *Journal de l'École polytechnique—Mathématiques*: `http://jep.cedram.org`
[6] INSMI: `http://www.cnrs.fr/insmi/`
[7] Mathrice: network of computer engineers in the mathematics laboratories of the CNRS, `http://www.mathrice.org/`
[8] `numdam`: a repository for publications in mathematics, `http://www.numdam.org`
[9] PKP: "The Public Knowledge Project is a research and development initiative directed toward improving the scholarly and public quality of academic research through the development of innovative online publishing and knowledge-sharing environments. It is located at the University of British Columbia, Simon Fraser University, Stanford University, and Arizona State University," `http://pkp.sfu.ca`

Mathematics People

Eelbode Awarded Clifford Prize

David Eelbode of the University of Antwerp has been selected as the recipient of the second W. K. Clifford Prize "for his outstanding mathematical research achievements in the fields of harmonic and Clifford analysis with applications in theoretical physics." According to the prize citation, he has "a beautiful and remarkable publishing record with papers in pure mathematics and theoretical physics journals. Often cooperating with mathematics centers of excellence around the world, he is a real ambassador for mathematics through Clifford algebra, Clifford analysis and group representation theory. His chief contribution has to be situated within the subject of higher spin operators: these are generalizations of the classical Dirac operator from quantum mechanics, which can be used to model the equations describing higher spin elementary particles. The use of Clifford analysis techniques hereby has the advantage that the resulting function theory can be studied in orthogonal spaces of any dimension and any signature. This topic is also intimately connected to the representation theory for both the conformal Lie algebra and certain transvector algebras." Eelbode received his Ph.D. from Ghent University with a thesis titled "Clifford analysis on the hyperbolic unit ball." He will deliver the W. K. Clifford Prize Lecture at the University College London in November 2014.

The International Conference on Clifford Algebras and Their Applications in Mathematical Physics (ICCA) awards the Clifford Prize for excellence in research in theoretical and applied Clifford algebras and their analysis and geometry. The ICCA international conferences, organized alternately in Europe and the Americas, are intended to bring together the leading scientists and young researchers in the field of Clifford algebras and their various applications in mathematics, physics, engineering, and other applied sciences. W. K. Clifford is best remembered for what is now termed geometric algebra, a special case of the Clifford algebras named in his honor, but he also contributed significantly to other branches of mathematics, especially geometry. The prize is intended for young researchers up to age thirty-five and carries a cash award of 1,000 euros (approximately US$1,450). The first Clifford Prize was awarded to Hendrik De Bie, Ghent University.

The international W. K. Clifford Prize Committee included V. Abramov (Estonia), P. Anglès (France), E. Bayro-Corrochano (Mexico), R. Da Rocha (Brazil), H. De Bie (Belgium), K. Gürlebeck (Germany), D. Hildenbrand (Germany), T. Qian (China), I. Sabadini (Italy), V. Soucek (Czech Republic), S. Staples (United States), and F. Brackx (Belgium, nonvoting secretary).

—Fred Brackx, Ghent University, Belgium

Spohn Awarded Cantor Medal

Herbert Spohn of the Technical University of Munich (TUM) has been awarded the 2014 Cantor Medal of the German Mathematical Society (DMV). According to the prize citation, Spohn's insights have had a decisive impact on the development of stochastic analysis and the theory of kinetic equations and on mathematical physics. He received his Ph.D. in 1975 from the University of Munich and is currently professor of applied probability theory at TUM. He was awarded the Dannie Heineman Prize for Mathematical Physics in 2011. The Cantor Medal is awarded at most every two years and carries a cash award of 4,000 euros (approximately US$5,400).

—From a DMV announcement

2014 Gödel Prize Awarded

Three researchers in computer science have been awarded the 2014 Gödel Prize of the Association for Computing Machinery (ACM) Special Interest Group on Algorithms and Computation Theory (SIGACT), together with the European Association for Theoretical Computer Science (EATCS). Ronald Fagin of IBM Research, Amnon Lotem, an algorithms and technologies expert in the Israeli high-tech industry, and Moni Naor of the Weizmann Institute of Science were honored for their paper "Optimal aggregation algorithms for middleware", which introduced the powerful "threshold algorithm" that is widely used in applications and systems that demand optimal results for gathering multisourced information. The prize citation reads: "Their paper provides a framework to design and analyze algorithms where aggregation of information from multiple data sources is needed, such as in information retrieval and machine learning. The threshold algorithm's elegant mathematical properties and simplicity are particularly suitable for use in middleware, software that is often used to augment computer operating systems that support complex, distributed applications. The authors also introduced the notion of instance optimality, an extremely strong guarantee of performance, and showed that the threshold algorithm is instance optimal. The paper's groundbreaking results have built a foundation for much follow-on research."

The Gödel Prize includes an award of US$5,000 and is named in honor of Kurt Gödel, who was born in Austria-

Hungary (now the Czech Republic) in 1906. Gödel's work has had immense impact upon scientific and philosophical thinking in the twentieth century. The award recognizes his major contributions to mathematical logic and the foundations of computer science.

—From an ACM announcement

Mkrtchyan Awarded Emil Artin Junior Prize

Sevak Mkrtchyan of Carnegie Mellon University has been awarded the 2014 Emil Artin Junior Prize in Mathematics. Mkrtchyan was chosen for his paper "Entropy of Schur–Weyl measures," *Annales de l'Institut Henri Poincaré, Probabilités et Statistiques* **50** (2014), 678–713. Established in 2001, the Emil Artin Junior Prize in Mathematics carries a cash award of US$1,000 and is presented usually every year to a student or former student of an Armenian educational institution under the age of thirty-five for outstanding contributions to algebra, geometry, topology, and number theory—the fields in which Emil Artin made major contributions. The prize committee consisted of A. Basmajian, Y. Movsisyan, and V. Pambuccian.

—Victor Pambuccian, New College, Arizona State University

EMS Monograph Award Announced

The European Mathematical Society (EMS) has instituted the EMS Monograph Award, to be given every two years to the author(s) of a monograph in any area of mathematics that is judged by the selection committee to be an outstanding contribution to its field. In the inaugural year of 2014, the recipients of the EMS Monograph Awards are Patrick Dehornoy (Université de Caen), François Digne (Université de Picardie Jules-Verne), Eddy Godelle (Université de Caen), Daan Krammer (University of Warwick), and Jean Michel (Université Denis Diderot, Paris 7) for their joint work "Foundations of Garside Theory" and to Augusto C. Ponce (Université Catholique de Louvain) for his work "Elliptic PDEs, Measures and Capacities: From the Poisson Equation to Nonlinear Thomas–Fermi Problems." The prize carries a cash award of 10,000 euros (approximately US$13,600). The winning monographs will be published by the EMS Publishing House in the series "EMS Tracts in Mathematics."

—From an EMS announcement

AMS Menger Awards at the 2014 ISEF

The 2014 Intel International Science and Engineering Fair was held May 11–16 in Los Angeles, California. This year more than 1,700 high school students in grades nine through twelve from more than seventy countries, regions, and territories participated in the world's largest precollege science research competition. The first fair was held in Philadelphia in 1950. In 1958, the fair became international when Japan, Canada, and Germany joined the competition.

Student finalists who competed at this year's ISEF went through a multistep process to qualify and won all-expenses-paid trips to the fair. They qualify by winning local, regional, and state fairs in the United States or national science fairs abroad. In addition to numerous grand awards presented by the ISEF, more than sixty federal agencies and professional and educational organizations, including the American Mathematical Society (AMS), participated by giving special awards. Prizes given by the AMS included cash, certificates, AMS tote bags, and a booklet about Karl Menger given to each award winner.

For the AMS this was the twenty-sixth year of participation, and it was the twenty-fourth year of the presentation of the Karl Menger Awards. The Menger Awards Committee consisted of Mihai Stoiciu, Williams College (Chair), John Milton, The Claremont Colleges, and Daniel Dugger, University of Oregon. The judges initially reviewed all projects in mathematics, as well as a number of mathematically oriented projects in computer science, physics, and engineering. From these entries they selected a subset of students who were interviewed for further consideration for Menger Prizes. The AMS gave awards to one first-place winner, two second-place winners, four third-place winners, and honorable mentions to five others.

The Karl Menger Memorial Prize winners for 2014 are listed below, along with each student's high school and project title.

First Place Award (US$1,000): Nitya Mani, Harker School, San Jose, California, "Characterizing the n-division points of genus–0 curves through straightedge and compass constructions."

Second Place Awards (US$500): Kevin K. Lee, University High School, Irvine, California, "Strongly coupling the electrical and mechanical dynamics of the heartbeat in a diffuse interface model"; Sarah L. Shader, Laramie High School, Laramie, Wyoming, "Weighted Catalan numbers and their divisibility properties."

Third Place Awards (US$250): Shahar Silberstein, Makif Alef, Be'er Sheva, Israel, "Hidden secrets in Cevian triangles"; Ritesh N. Ragavender, South Brunswick High School, Monmouth Junction, New Jersey, "Odd Dunkl operators and nilHecke algebras"; Rayna D. Gadzheva, Mathematical High School "Konstantin Velichkov", Pazardzhik, Bulgaria, "Covering squares of side length $n + e$ with unit squares"; Paul Clarke, St. Paul's College, Raheny, Dublin, Ireland, "On the Hamiltonicity of cubic, polyhedral, bipartite graphs."

Honorable Mention Awards: Bertrand A. Stone, Nicolet High School, Glendale, Wisconsin, "Characterization of the line complexity of cellular automata generated by polynomial transition rules"; Katherine M. Webb, Tabb High School, Yorktown, Virginia, "A new statistical measure of effect size: Rate-adjusted standardized mean difference (RASMD)"; Rishi S. Mirchandani, Fox Chapel Area Senior

Photo: IML Photography/Society for Science & the Public.

2014 Menger Award winners: Back row, left to right: Rayna Gadzheva, Nitya Mani, Paul Clarke, Mihai Stoiciu (chair, Menger Committee). Front row, left to right: Sarah Shader, Ritesh Ragavender, Kevin Lee, Shahar Silberstein.

High School, Pittsburgh, Pennsylvania, "The impact of demand elasticity on the Downs-Thomson and Braess paradoxes"; Nikolai Mostovskii, Laboratory for Continuous Mathematical Education, St. Petersburg, Russian Federation, "Cohomology of finite groups without homological algebra"; Ata A. Uslu and Hamdi G. Ozmenekse, Edirne Suleyman Demirel Fen Lisesi, Edirne, Turkey, "Bracelet problem with identical beads."

The Society for Science and the Public (`http://www.societyforscience.org/`), a nonprofit organization based in Washington, DC, owns and has administered the ISEF since 1950. It was first sponsored by Westinghouse and then, since 1998, by Intel.

The AMS's participation in ISEF is supported in part by income from the Karl Menger Fund, which was established by the family of the late Karl Menger (`http://www.ams.org/profession/prizes-awards/ams-awards/menger-award`). The income from the donation by the Menger family covers less than the amount of the awards. The balance, including the travel expenses of the judges, comes from the AMS's general fund. For more information about this program or to make contributions to this fund, contact the AMS Development Office, 201 Charles Street, Providence RI, 02904-2294, send email to `development@ams.org`, or phone 401-455-4103.

—AMS announcement

Mathematical Sciences Awards at ISEF

The 2014 Intel International Science and Engineering Fair was held May 11–16 in Los Angeles, California. The Society for Science and the Public, in partnership with the Intel Foundation, selects a Best-in-Category contestant, who receives a cash award of US$5,000. The student chosen this year in the Mathematical Sciences category was Lennart J. Kleinwort, fifteen, of Friedrich-Koenig-Gyumnasium, Wurzburg, Germany, for his project "Dynamic mathematics on smartphones and tablets." Kleinwort also received a First Award, which carries a cash prize of US$3,000. He was also chosen as a recipient of the Intel Foundation Young Scientist Award of US$50,000. His school was awarded a grant of US$1,000. More award winners and the titles of their projects follow.

First Award (US$3,000): Ritesh N. Ragavender, South Brunswick High School, Monmouth Junction, New Jersey, "Odd Dunkl operators and nilHecke algebras"; Lennart J. Kleinwort, Friedrich-Koenig-Gyumnasium, Wurzburg, Germany, "Dynamic mathematics on smartphones and tablets."

Second Award (US$1,500): Aranka Hruskova, Gymnazium Christiana Dopplera, Prague, Czech Republic, "Continued fractions of quadratic numbers"; Jesse M. Michel, Massachusetts Academy of Math and Science at Worcester Polytechnic Institute, Worcester, Massachusetts, "Base 1.5: Analysis of properties and relation to the Collatz conjecture"; Rumen R. Dangovski, Sofia High School of Mathematics, Sofia, Bulgaria, "On the lower central series of PI-algebras."

Third Award (US$1,000): Oleksandr Tytov, School-Lyceum #3 named after A. S. Makarenko, Simferopol, Ukraine, "Facility location problems and non-Leibniz analysis on complex plane"; Rayna D. Gadzheva, Mathematical High School "Konstantin Velichkov", Pazardzhik, Bulgaria, "Covering squares of side length $n + e$ with unit squares"; Rishi S. Mirchandani, Fox Chapel Area Senior High School, Pittsburgh, Pennsylvania, "The impact of demand elasticity on the Downs-Thomson and Braess paradoxes"; Joshua A. Rhodes, Saginaw Arts and Sciences Academy, Saginaw, Michigan, "Functional equations: Rational functions and their matrix isomorphism"; Nikolai Mostovskii, Laboratory for Continuous Mathematical Education, St. Petersburg, Russian Federation, "Cohomology of finite groups without homological algebra."

Fourth Award ($500): Kuan-Yu Wang, San Min Junior High School, Kaohsiung, Chinese Taipei, "A rational story of pi: From asymmetrical cut to weighted average"; Shreya Mathur, Oxford High School, Oxford, Mississippi, "Identification of the impact of obesity treatments on gene expression using a novel statistical test"; Niranjan Balachandar, Texas Academy of Mathematics and Science, Denton, Texas, "A Monte Carlo protein folding simulation using energy optimization with novel applications to Alzheimer's disease research"; Prem M. Talwai, Mira Loma High School, Sacramento, California, "An investigation of the p53 ubiquitin-proteasome system using a novel non-steady-state enzyme kinetic model"; Nitya Mani, Harker School, San Jose, California, "Characterizing the n-division points of genus-0 curves through straightedge and compass constructions"; Adilsultan Lepes, Republican Physics and Mathematics School named after O. Zhautikov, Almaty, Kazakhstan, "Alternative proof of 100 inequalities: Method of separating tangents"; and Krishan S. Kumar, Terre Haute South Vigo High School, Terre Haute, Indiana, "Explaining the map and the matrix of the discrete Lambert exponentiation."

—From an ISEF announcement

Mathematics Opportunities

American Mathematical Society Centennial Fellowship

Invitation for Applications for Awards for 2015–2016. Deadline December 1, 2014

Description: The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The Society supplements contributions as needed. At least one fellowship will be awarded for the 2015–2016 academic year. A list of previous fellowship winners can be found at http://www.ams.org/profession/prizes-awards/ams-awards/centennial-fellow.

Eligibility: The eligibility rules are as follows. The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. Preference will be given to candidates who have not had extensive fellowship support in the past. Recipients may not hold the Centennial Fellowship concurrently with another research fellowship such as a Sloan or NSF Postdoctoral fellowship. Under normal circumstances, the fellowship cannot be deferred. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award (that is, received between September 1, 2003, and September 1, 2012). Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America. Applications should include a cogent plan indicating how the fellowship will be used. The plan should include travel to at least one other institution and should demonstrate that the fellowship will be used for more than reduction of teaching at the candidate's home institution. The selection committee will consider the plan, in addition to the quality of the candidate's research, and will try to award the fellowship to those for whom the award would make a real difference in the development of their research careers. Work in all areas of mathematics, including interdisciplinary work, is eligible.

Deadline: The deadline for receipt of applications is **December 1, 2014**. The award recipient will be announced in February 2015 or earlier if possible.

Application information: Find Centennial information and the application form via the Internet at http://www.ams.org/ams-fellowships/. For paper copies of the form, write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; prof-serv@ams.org; 401-455-4105.

—AMS announcement

Call for Nominations for the Award for Impact on the Teaching and Learning of Mathematics

This award is given annually to a mathematician or group of mathematicians who have made significant contributions of lasting value to mathematics education. Priorities of the award include recognition of (a) accomplished mathematicians who have worked directly with precollege teachers to enhance teachers' impact on mathematics achievement for all students, or (b) sustainable and replicable contributions by mathematicians to improving the mathematics education of students in the first two years of college. The US$1,000 annual award is provided through an endowment fund established by a contribution from Kenneth I. and Mary Lou Gross in honor of their daughters, Laura and Karen. The AMS Committee on Education selects the recipient. The deadline for nominations for the 2015 award is **September 15, 2014**. For more information, see the nomination webpage at http://www.ams.org/profession/prizes-awards/ams-awards/impact.

—AMS Washington office

AWM Travel Grants for Women

The National Science Foundation (NSF) and the Association for Women in Mathematics (AWM) sponsor travel grant programs for women mathematicians.

AWM Travel Grants for Women Researchers enable women to attend research conferences in their fields, thereby providing scholars valuable opportunities to advance their research activities and their visibility in the research community. A Mathematics Travel Grant provides full or partial support for travel and subsistence for a meeting or conference in the grantee's field of specialization, awarding funds of up to US$1,750 for domestic travel and of US$2,300 for foreign travel.

The Mathematics Education Research Travel Grants provide full or partial support for travel and subsistence in math/math education research for mathematicians attending a math education research conference or math education researchers attending a math conference. The grants provide up to US$1,750 for domestic travel and of US$2,300 for foreign travel.

AWM Mathematics Mentoring Travel Grants are designed to help junior women develop long-term working and mentoring relationships with senior mathematicians. A mentoring travel grant funds travel, subsistence, and other expenses for an untenured woman mathematician to travel to an institute or a department to do research with a specified individual for one month. Up to seven grants will be awarded in amounts up to US$5,000 each.

Mathematics Education Research Mentoring Travel Grants encourage collaboration between mathematicians and researchers in education and related fields in order to improve the education of teachers and students. Women mathematicians who wish to collaborate with an educational researcher or to learn about educational research may use the mentoring grants to travel to collaborate with or be mentored by a mathematics education researcher. Up to seven grants will be awarded in amounts up to US$5,000 each.

The final deadline for the Travel Grants program for 2014 is **October 1, 2014**. The deadlines for 2015 are **February 1, 2015**; **May 1, 2015**; and **October 1, 2015**. For the Mathematics Education Research Travel Grant program, the deadlines are **October 1, 2014**; **February 1, 2015**; **May 1, 2015**; and **October 1, 2015**. For the Mathematics Mentoring Travel Grants program, the deadline is **February 1, 2015**. For the Mathematics Education Research Mentoring Travel Grants program, the deadline is **February 1, 2015**. For further information and details on applying, see the website `https://sites.google.com/site/awmmath/programs/travel-grants`; telephone: 703-934-0163; email: `awm@awm-math.org`; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

—From an AWM announcement

Call for Nominations for Clay Research Fellowships

The Clay Mathematics Institute (CMI) solicits nominations for its competition for the 2015 Clay Research Fellowships. Fellows are appointed for a period of two to five years. They may conduct their research at whatever institution or combination of institutions best suits their research. In addition to a generous salary, the fellows receive support for travel, collaboration, and other research expenses.

The selection criteria are the quality of the candidate's research and promise to become a mathematical leader. All those selected are recent Ph.D.'s, and most are selected as they complete their thesis work. Selection decisions are made by CMI's Scientific Advisory Board.

To nominate a candidate, please send the following items by **November 16, 2014**: (1) letter of nomination; (2) names and contact information of two other references; (3) curriculum vitae for the nominee; and (4) publication list for the nominee. Nominations should be sent to the attention of Nick Woodhouse, Clay Mathematics Institute, 10 Memorial Boulevard, Suite 902, Providence, RI 02903. Electronic submissions are also accepted at `nominations@claymath.org`.

Information about the Clay Research Fellows is available on the CMI website at `http://www.claymath.org/research_fellows`.

—From a Clay Mathematics Institute announcement

NRC-Ford Foundation Fellowships

Through its Fellowship Programs, the Ford Foundation seeks to increase the diversity of the nation's college and university faculties by increasing their ethnic and racial diversity, to maximize the educational benefits of diversity, and to increase the number of professors who can and will use diversity as a resource for enriching the education of all students. The fellowships are administered by the Fellowships Office of the National Research Council.

All citizens or nationals of the United States are eligible, regardless of race, national origin, religion, gender, age, disability, or sexual orientation. The fellowships are awarded to individuals who demonstrate superior academic achievement (such as grade point average, class rank, honors, or other designations) and who are committed to a career in teaching and research at the college or university level.

Sixty Predoctoral Fellowships will be awarded. These fellowships provide three years of support for individuals engaged in graduate study leading to a Doctor of Philosophy (Ph.D.) or Doctor of Science (Sc.D.) degree. The online application deadline is **November 19, 2014**.

Approximately thirty Dissertation Fellowships will be awarded. These fellowships provide one year of support for individuals working to complete a dissertation leading to a Ph.D. or Sc.D. degree. The online application deadline is **November 14, 2014**.

Approximately eighteen Postdoctoral Fellowships will be awarded. These fellowships provide one year of support for individuals engaged in postdoctoral study after the attainment of the Ph.D. or Sc.D. degree. The online application deadline is **November 14, 2014**.

For further information, visit the website `http://sites.nationalacademies.org/pga/fordfellowships/`, or contact: Fellowships Office, Keck 576, National Research Council, 500 Fifth Street, NW, Washington, DC 20001; tel: 202-334-2872; fax: 202-334-3419; email: `infofell@nas.edu`.

—From the Ford Foundation Fellowships website

News from AIM

The American Institute of Mathematics (AIM) is accepting applications for its scientific programs: focused workshops and SQuaREs.

Focused Workshop Program: AIM invites proposals for its focused workshop program. AIM's week-long workshops are distinguished by their specific mathematical goals. This may involve making progress on a significant unsolved problem or examining the convergence of two distinct areas of mathematics. Workshops are small in size—up to twenty-eight people—to allow for close collaboration among the participants. The deadline for proposals is **November 1, 2014**.

Researchers may apply to attend an upcoming AIM workshop. Each workshop supports several participants through an open application process. A list of upcoming workshops is available at www.aimath.org/workshops/upcoming/.

SQuaREs Program: AIM also invites proposals for the Structured Quartet Research Ensembles (SQuaREs) program. This program brings together groups of four to six researchers for a week of focused work on a specific research problem, returning for up to three consecutive years.

More information is available on the AIM website at www.aimath.org. Applications are submitted online; the deadline for submissions is **November 1, 2014**.

—AIM announcement

News from CIRM

The Centro Internazionale per la Ricerca Matematica (CIRM), located in Trento, Italy, announces the following activities in mathematics research in 2015.

Conferences. A series of conferences will be supported in 2015. Proposals must be submitted before **September 30, 2014**, by mail to Fondazione Bruno Kessler, Centro Internazionale per la Ricerca Matematica, Via Sommarive n. 14–Povo, 38123 Trento, Italy, or by electronic mail to micheletti@fbk.eu. For more information see http://cirm.fbk.eu/call-applications-2015-conferences.

Postdoctoral Fellowships. CIRM is accepting applications for both an annual and a trienniel postdoctoral research position in the year 2014–2015. The deadline for applications is **September 30, 2014**, sent by postal mail to Fondazione Bruno Kessler, Centro Internazionale per la Ricerca Matematica, Via Sommarive n. 14–Povo, 38123 Trento, Italy, or by electronic mail to micheletti@fbk.eu. For further information, see http://cirm.fbk.eu/postdoc-fellowships.

Visiting Professorships, Scholarships, Research in Pairs. CIRM Visiting Scholars will perform mathematical research in cooperation with scientists and researchers at Trento University or, more generally, in the Trento area, holding some research seminars; CIRM Visiting Professors will hold short Ph.D. courses, summer courses, or series of seminars. The Research in Pairs program supports two or three partners from universities located in different towns who intend to work together at CIRM on a definite research project for a period of time ranging from one to six weeks. Applications for these programs must be sent by postal mail to Fondazione Bruno Kessler, Centro Internazionale per la Ricerca Matematica, Via Sommarive n. 14–Povo, 38123 Trento, Italy, or by electronic mail to micheletti@fbk.eu. Applications can be submitted at any time and must contain a specific indication of the proposed dates for the visit and a list of publications for each applicant. For more information see http://cirm.fbk.eu/cirm-visiting-professors and http://cirm.fbk.eu/research-pairs.

—Marco Andreatta, Director, CIRM

News from MSRI

The Mathematical Sciences Research Institute invites the submission of preproposals for full- or half-year programs to be held at MSRI. Planning of such programs is generally done about three years ahead. Except in extraordinary cases, a subject is the focus of a program not more than once in ten years.

Proposals for other scientific activities, such as workshops and conferences outside the scope of the long-term programs, are also welcome. In particular, note the possibility of proposing a "Hot Topic Workshop" before November to take place in the spring. In proposals of an activity outside a long-term program (such as a workshop or other special event), please include estimated date(s) of the activity, noting alternate dates to allow coordination with other MSRI events.

A scientific program at MSRI generally consists of up to one year (10 months) of concentrated activity in a specific area of current research interest in the mathematical sciences. MSRI usually runs two programs simultaneously, each with about thirty mathematicians in residence at any given time. The most common program lengths are one year and five months (typically in the form of a Fall or Spring semester program). Each program begins with a Connections for Women workshop, followed by an introductory workshop. The purpose of both is to introduce the subject to the broader mathematical community. The programs receive administrative and financial support from the Institute, allowing organizers to focus on the scientific aspects of the activities.

How to submit a program preproposal:

The Scientific Advisory Committee (SAC) of the Institute meets in January and November each year to consider preproposals for programs. Proposals for special events or conferences outside the programs are considered in a much shorter time frame. Proposals for such events may be submitted at any time.

Successful proposals are usually developed from the preproposal in a collaborative process between the proposers, the Directorate and the SAC, and may be considered at more than one meeting of the SAC before selection.

The scientific planning and organization of each program is the responsibility of a committee of organizers (aided in some cases by a liaison of the Directorate and the SAC). The organizers recommend participants in the program; they also plan workshops and lecture series within the program, which many more participants may attend. Each program is allocated a budget for subsistence and travel expenses.

Please see our website for specific preproposal requirements and further information: https://www.msri.org/web/msri/scientific/request-for-proposals/propose-a-program.

—From an MSRI announcement

Inside the AMS

AMS Congressional Fellow Chosen

The American Mathematical Society is pleased to announce the selection of Boris Granovskiy as its Congressional Fellow for 2014–2015.

Boris Granovskiy

The fellowship provides a unique 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.

Granovskiy earned his Ph.D. in mathematics last year from Uppsala University in Sweden. Prior to accepting the fellowship, he worked at the Institute for Futures Studies in Stockholm as a postdoctoral researcher in collaboration with the Swedish Association of Local Governments. The AMS will sponsor his fellowship through the Congressional Fellowship program administered by the American Association for the Advancement of Science (AAAS).

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 seminar series on issues involving science, technology, and public policy. For more information on the AMS-AAAS Congressional Fellowship go to `http://bit.ly/AMSCongressionalFellowship`.

—*AMS Washington Office*

AMS Sponsors Exhibit on Capitol Hill

The AMS sponsored an exhibit at the twentieth annual Coalition for National Science Funding (CNSF) exhibition and reception on Capitol Hill on May 7, 2014. Robert Ghrist, Andrea Mitchell University Professor of Mathematics and Electrical/Systems Engineering at the University of Pennsylvania, presented work on "Topological Sensor Networks." The exhibition drew more than 280 attendees, including eight members of Congress, to view thirty-seven research and education projects supported by the National Science Foundation.

Ghrist and his collaborators have worked for nearly a decade on applications of algebraic topology to problems of data over networks. The problem of detecting global robust features from networked local data matches perfectly the mathematical tools of algebraic topology developed over the past century. Ghrist's work, initially funded by the NSF, uses homology, cohomology, and sheaves to address problems in sensor networks ranging from coverage (whether there are any gaps in the network) to data aggregation (how to merge redundant data over the network) and target tracking (how to infer from detections over a network). These novel applications, combined with emerging ideas from computational topology, allow for efficient algorithms with performance guarantees.

The Coalition for National Science Funding (CNSF) is an alliance of more than 135 scientific and professional societies and universities united by a concern for the future vitality of the national science, mathematics, and engineering enterprise. The coalition is chaired by Samuel M. Rankin III, associate executive director of the AMS and the director of its Washington office.

—*AMS Washington Office*

From the AMS Public Awareness Office

Communicating Mathematics in the Media: A Guide. Mathematical scientists can play a crucial role in communicating mathematics and issues in education and research funding to the general public. The goals include conveying enthusiasm for mathematics, giving examples of mathematical concepts or applications, showing the beauty of mathematics, offering opinions about issues in mathematics education, advocating for funding basic research, or correcting inaccuracies or misperceptions. Find guidelines for writing and submitting op-eds, letters to the editor, and more. `http://www.ams.org/news/media-info/communicate-math`.

On Teaching and Learning Mathematics—a new AMS Blog. The goal for this blog is to stimulate reflection and dialogue by providing mathematicians with high-quality commentary and resources regarding teaching and learning. Because there is no simple solution to the challenges facing mathematics education, this blog will serve as a big tent, giving voice to multiple contributors representing a wide range of ideas. Contributions will include practical "teaching tips," commentary on current mathematics education research, discussions of social/curricular educational policy, and more. Our focus will include

Benjamin Braun

both postsecondary and PreK–12 education, because mathematics education does not abruptly stop and start anew as students make institutional transitions. Issues that affect both high- and low-achieving students will be addressed, as well as issues that affect students who are minoritized in their mathematical communities. We welcome ideas for posts and pointers to interesting materials or events; please feel free to add your contributions in the comments."

—Benjamin Braun, Editor-in-Chief
University of Kentucky
Contributors are *Priscilla Bremser (Middlebury College), Art Duval (University of Texas at El Paso), Elise Lockwood (Oregon State University)* and *Diana White (University of Colorado Denver).*
http://blogs.ams.org/matheducation/

More on AMS Blogs. There is a lot of interesting advice and opinions on eMentoring Network in the Mathematical Sciences, Blog on Math Blogs, PhD + epsilon, AMS Graduate Student, On Teaching and Learning Mathematics, and Visual Insight blogs. The AMS invites members and the mathematics community to follow the blogs and comment on the postings. http://blogs.ams.org/

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

Deaths of AMS Members

Philip M. Anselone, of Depoe Bay, Oregon, died on December 13, 2013. Born on February 8, 1926, he was a member of the Society for 56 years.

G. U. Brauer, professor, University of Minnesota, died on July 31, 2013. Born on March 18, 1927, he was a member of the Society for 60 years.

Robert Goodell Brown, of Jefferson, Maryland, died on October 3, 2013. Born on April 14, 1923, he was a member of the Society for 65 years.

Billy F. Bryant, of Nashville, Tennessee, died on April 25, 2014. Born on November 29, 1922, he was a member of the Society for 61 years.

F. Eugene Clark, of Falmouth, Maine, died on February 28, 2014. Born on September 16, 1919, he was a member of the Society for 67 years.

Robert Coleman, professor, University of California Berkeley, died on March 24, 2014. Born on November 22, 1954, he was a member of the Society for 28 years.

Brian Conolly, of Cambridge, United Kingdom, died on July 7, 2013. Born on May 28, 1923, he was a member of the Society for 43 years.

Louis J. Cote, of West Lafayette, Indiana, died on March 14, 2014. Born on July 18, 1921, he was a member of the Society for 60 years.

Taen-Yu Dai, professor, York College (CUNY), died on March 25, 2014. Born on April 1, 1942, he was a member of the Society for 44 years.

William Brian DeFacio, of Laredo, Texas, died on March 25, 2014. Born on December 14, 1936, he was a member of the Society for 42 years.

David Litton Foreman, professor, Samford University, died on May 1, 2014. Born on February 26, 1953, he was a member of the Society for 35 years.

Hans-Bjørn Foxby, of Copenhagen, Denmark, died on April 9, 2014. Born on February 12, 1947, he was a member of the Society for 40 years.

Richard D. Geckler, of La Jolla California, died on September 1, 2013. Born on November 4, 1918, he was a member of the Society for 70 years.

James A. Green, of the United Kingdom, died on April 7, 2014. Born on February 26, 1926, he was a member of the Society for 53 years.

Eugene Gutkin, of Torun, Poland, died on June 22, 2013. Born on November 6, 1946, he was a member of the Society for 16 years.

Theodore Hailperin, of Nazareth, Pennsylvania, died on February 5, 2014. Born on March 28, 1915, he was a member of the Society for 72 years.

Keith A. Hardie, professor, University of Cape Town, died on May 19, 2014. Born on September 21, 1929, he was a member of the Society for 52 years.

A. Murray Macbeath, of Wellesbourne, United Kingdom, died on May 14, 2014. Born on June 30, 1923, he was a member of the Society for 39 years.

Walter E. Mientka, of Lincoln, Nebraska, died on June 1, 2014. Born on October 1, 1925, he was a member of the Society for 62 years.

F. Lockwood Morris, professor, Syracuse University, died on March 12, 2014. Born on July 2, 1943, he was a member of the Society for 12 years.

John D. O'Neill, of Clarkston, Michigan, died on October 28, 2012. Born on July 9, 1929, he was a member of the Society for 46 years.

Lesley M. Sibner, of New York, New York, died on September 11, 2013. Born on August 13, 1934, she was a member of the Society for 50 years and a former AMS associate secretary.

Herbert R. Stahl, of Berlin, Germany, died on April 22, 2013. Born on August 3, 1942, he was a member of the Society for 21 years.

Robert Steinberg, of Pacific Palisades, California, died on May 25, 2014. Born on May 25, 1922, he was a member of the Society for 69 years.

James H. Stoddard, of Chatham, Massachusetts, died on April 16, 2014. Born on June 17, 1930, he was a member of the Society for 55 years.

Beauregard Stubblefield, of Smyrna, Georgia, died on January 17, 2013. Born on July 31, 1923, he was a member of the Society for 54 years.

Marvin C. Wunderlich, of Silver Spring, Maryland, died on September 27, 2013. Born on May 8, 1937, he was a member of the Society for 50 years.

Reference and Book List

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

Contacting the *Notices*

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

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

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

Upcoming Deadlines

August 27, 2014: Proposals for National Science Foundation (NSF) Research Experiences for Undergraduates (REU) sites. See the website http://www.nsf.gov/pubs/2009/nsf09598/nsf09598.htm

September 15, 2014: Nominations for Award for Impact on the Teaching and Learning of Mathematics. See "Mathematics Opportunities" in this issue.

September 15, 2014: Nominations for Alfred P. Sloan Foundation Research Fellowships. See http://www.sloan.org/fellowships.

September 15, 2014: Applications for Blackwell-Tapia Conference at IPAM. See www.ipam.ucla.edu.

September 15, 2014 (spring), April 15, 2015 (fall): Applications for spring and fall 2015 semesters of Math in Moscow. See http://www.mccme.ru/mathinmoscow, or contact: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; email: mim@mccme.ru. Information and application forms for the AMS scholarships are available on the AMS website at http://www.ams.org/programs/travel-grants/mimoscow, or contact: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email student-serv@ams.org.

September 19, 2014: Full proposals for National Science Foundation (NSF) Focused Research Groups (FRG). See http://www.nsf.gov/pubs/2012/nsf12566/nsf12566.htm.

September 30, 2014: Proposals for conferences and for postdoctoral fellowships at CIRM. See "Mathematics Opportunities" in this issue.

October 1, 2014: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; telephone: 703-934-0163; or email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

October 15, 2014: Proposals for National Security Agency (NSA) Grants for Research in Mathematics. See http://www.nsa.gov/

Where to Find It

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

research/math_research/index.shtml.

October 15, 2014: Proposals for NSF Postdoctoral Research Fellowships. See http://www.nsf.gov/pubs/2012/nsf12496/nsf12496.htm.

October 31, 2014: Applications for the 2014–2015 Adams Prize in Algebraic Geometry. See http://www.maths.cam.ac.uk/news/4.html.

November 1, 2014: Proposals for AIM focused workshop program and for SQuaREs program. See "Mathematics Opportunities" in this issue.

November 1, 2014: Applications for November review for National Academies Research Associateship Programs. See the website http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email rap@nas.edu.

November 14, 2014: Applications for NRC-Ford Foundation Dissertation Fellowships and Postdoctoral Fellowships. See "Mathematics Opportunities" in this issue.

November 16, 2014: Nominations for Clay Research Fellowships. See "Mathematics Opportunities" in this issue.

December 1, 2014: Applications for AMS Centennial Fellowship. See "Mathematics Opportunities" in this issue.

December 1, 2014: Applications for Pacific Institute for the Mathematical Sciences (PIMS) postdoctoral fellowships. See http://www.pims.math.ca/scientific/postdoctoral or contact assistant.director@pims.math.ca.

February 1, 2015: Applications for AWM Travel Grants, Mathematics Education Research Travel Grants, Mathematics Mentoring Travel Grants, and Mathematics Education Research Mentoring Travel Grants. See "Mathematics Opportunities" in this issue.

May 1, October 15, 2015: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See "Mathematics Opportunities" in this issue.

Conference Board of the Mathematical Sciences

1529 Eighteenth Street, NW
Washington, DC 20036
202-293-1170
http://www.cbmsweb.org/

Ronald C. Rosier
Director
202-293-1170
410-730-1426 (home—try this first)
rosier@georgetown.edu
Lisa R. Kolbe
Administrative Coordinator
202-293-1170
301-601-9449 (home)
kolbe.lisa@gmail.com

Member Societies:

American Mathematical Association of Two-Year Colleges (AMATYC)
American Mathematical Society (AMS)
Association of Mathematics Teacher Educators (AMTE)
American Statistical Association (ASA)
Association for Symbolic Logic (ASL)
Association for Women in Mathematics (AWM)
Association of State Supervisors of Mathematics (ASSM)
Benjamin Banneker Association (BBA)
Institute of Mathematical Statistics (IMS)
Mathematical Association of America (MAA)
National Association of Mathematicians (NAM)
National Council of Supervisors of Mathematics (NCSM)
National Council of Teachers of Mathematics (NCTM)
Society for Industrial and Applied Mathematics (SIAM)
Society of Actuaries (SOA)
TODOS: Mathematics for ALL

Book List

The Book List highlights recent books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. Suggestions for books to include on the list may be sent to notices-booklist@ams.org.

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

Alan M. Turing: Centenary Edition, by Sara Turing. Cambridge University Press, April 2012. ISBN-13: 978-11070-205-80. (Reviewed in this issue.)

Alan Turing: The Enigma, The Centenary Edition, by Andrew Hodges. Princeton University Press, May 2012. ISBN-13: 978-06911-556-47. (Reviewed in this issue.)

Alan Turing: His Work and Impact, edited by S. Barry Cooper and J. van Leeuwen. Elsevier, May 2013. ISBN-13: 978-01238-698-07. (Reviewed in this issue.)

Alan Turing's Electronic Brain: The Struggle to Build the ACE, the World's Fastest Computer, by B. Jack Copeland et al. Oxford University Press, May 2012. ISBN-13: 978-0-19-960915-4. (Reviewed in this issue.)

André-Louis Cholesky: Mathematician, Topographer and Army Officer, by Claude Brezinski and Dominique Tournès. Birkhäuser, August 2014. ISBN: 978-33190-813-42.

**Beyond Banneker: Black Mathematicians and the Paths to Excellence,* by Erica N. Walker. State University of New York Press, June 2014. ISBN-13: 978-14384-521-59.

Computability: Turing, Gödel, Church, and Beyond, edited by B. Jack Copeland, Carl J. Posy, and Oron Shagrir. MIT Press, June 2013. ISBN-13: 978-02620-189-99.

Enlightening Symbols: A Short History of Mathematical Notation and Its Hidden Powers, by Joseph Mazur. Princeton University Press, March 2014. ISBN-13: 978-06911-546-33.

Four Lives: A Celebration of Raymond Smullyan, edited by Jason Rosenhouse. Dover Publications, February 2014. ISBN-13: 978-04864-906-70.

Fractals: A Very Short Introduction, by Kenneth Falconer. Oxford University Press, December 2013. ISBN-13: 978-01996-759-82.

Good Math: A Geek's Guide to the Beauty of Numbers, Logic, and Computation, by Mark C. Chu-Carroll. Pragmatic Bookshelf, July 2013. ISBN-13: 978-19377-853-38.

The Grapes of Math: How Life Reflects Numbers and Numbers Reflect Life, by Alex Bellos. Simon and Schuster, June 2014. ISBN: 978-14516-400-90.

A History in Sum: 150 Years of Mathematics at Harvard (1825–1975), by Steve Nadis and Shing-Tung Yau. Harvard University Press, October 2013. ISBN-13: 978-06747-250-03. (Reviewed June/July 2014.)

The Improbability Principle: Why Coincidences, Miracles, and Rare Events Happen Every Day, by David J. Hand. Scientific American/Farrar, Straus and Giroux, February 2014. ISBN-13: *978-03741-753-44.*

Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World, by Amir Alexander. Scientific American/Farrar, Straus and Giroux, April 2014. ISBN-13: 978-03741-768-15.

L. E. J. Brouwer—Topologist, Intuitionist, Philosopher: How Mathematics Is Rooted in Life, by Dirk van Dalen. Springer (2013 edition), December 2012. ISBN-13: 978-14471-461-55. (Reviewed June/July 2014.)

Jane Austen, Game Theorist, by Michael Suk-Young Chwe. Princeton University Press, April 2013. ISBN-13: 978-06911-557-60.

Levels of Infinity: Selected Writings on Mathematics and Philosophy, by Hermann Weyl (edited and with an introduction by Peter Pesic). Dover Publications, January 2013. ISBN: 978-04864-890-32.

The Logic of Infinity, by Barnaby Sheppard. Cambridge University Press, May 2014. ISBN-13: 978-11076-786-68.

Love and Math: The Heart of Hidden Reality, by Edward Frenkel. Basic Books, October 2013. ISBN-13: 978-04650-507-41.

Magnificent Mistakes in Mathematics, by Alfred S. Posamentier and Ingmar Lehmann. Prometheus Books, August 2013. ISBN-13: 978-16161-474-71.

Mathematics in Nineteenth-Century America: The Bowditch Generation, by Todd Timmons. Docent Press, July 2013. ISBN-13: 978-0-9887449-3-6.

Mathematics of the Transcendental, by Alain Badiou (translated by A. J. Bartlett and Alex Ling). Bloomsbury Academic, March 2014. ISBN-13: 978-14411-892-40.

Math Bytes: Google Bombs, Chocolate-Covered Pi, and Other Cool Bits in Computing, by Tim Chartier. Princeton University Press, April 2014. ISBN-13: 978-06911-606-03.

Math in Minutes: 200 Key Concepts Explained in an Instant, by Paul Glendinning. Quercus, September 2013. ISBN-13: 978-16236-500-87.

Math in 100 Key Breakthroughs, by Richard Elwes. Quercus, December 2013. ISBN-13: 978-16236-505-44.

Math Is Murder, by Robert C. Brigham. iUniverse, March, 2012. ISBN-13 978-14697-972-81.

My Brief History, by Stephen Hawking. Bantam Dell, September 2013. ISBN-13: 978-03455-352-83.

Naming Infinity: A True Story of Religious Mysticism and Mathematical Creativity, by Loren Graham and Jean-Michel Kantor. Belknap Press of Harvard University Press, March 2009. ISBN-13: 978-06740-329-34. (Reviewed January 2014.)

The New York Times Book of Mathematics: More Than 100 Years of Writing by the Numbers, edited by Gina Kolata. Sterling, June 2013. ISBN-13: 978-14027-932-26. (Reviewed May 2014.)

Numbers Are Forever, by Liz Strachan. Constable, March 2014. ISBN-13: 978-14721-110-43.

Our Mathematical Universe: My Quest for the Ultimate Nature of Reality, by Max Tegmark. Knopf, January 2014. ISBN-13: 978-03075-998-03.

The Outer Limits of Reason: What Science, Mathematics, and Logic Cannot Tell Us, by Noson S. Yanofsky. MIT Press, August 2013. ISBN-13: 978-02620-193-54.

Perfect Mechanics: Instrument Makers at the Royal Society of London in the Eighteenth Century, by Richard Sorrenson. Docent Press, September 2013. ISBN-13: 978-0-9887449-2-9.

The Perfect Theory: A Century of Geniuses and the Battle over General Relativity, by Pedro G. Ferreira. Houghton Mifflin Harcourt, February 2014. ISBN-13: 978-05475-548-91.

Philosophy of Mathematics in the Twentieth Century, by Charles Parsons. Harvard University Press, March 2014. ISBN-13: 978-06747-280-66.

Probably Approximately Correct: Nature's Algorithms for Learning and Prospering in a Complex World, by Leslie Valiant. Basic Books, June 2013. ISBN-13: 978-04650-327-16.

Quantum Computing since Democritus, by Scott Aaronson. Cambridge University Press, March 2013. ISBN-13: 978-05211-995-68.

Ramanujan's Place in the World of Mathematics: Essays Providing a Comparative Study, by Krishnaswami Alladi. Springer, 2013. ISBN: 978-81322-076-65.

Mathematical Expeditions: Exploring Word Problems Across the Ages, by Frank J. Swetz. Johns Hopkins University Press, June 2012. ISBN: 978-14214-043-87.

The Simpsons and Their Mathematical Secrets, by Simon Singh. Bloomsbury, October 2013. ISBN-13: 978-14088-353-02.

Strange Attractors (comic book), by Charles Soule, Greg Scott, and Robert Saywitz. Archaia Entertainment, May 2013. ISBN-13: 978-19363-936-26.

**Struck by Genius: How a Brain Injury Made Me a Mathematical Marvel*, by Jason Padgett and Maureen Ann Seaberg. Houghton Mifflin Harcourt, April 2014. ISBN-13: 978-05440-456-06.

Symmetry: A Very Short Introduction, by Ian Stewart. Oxford University Press, July 2013. ISBN-13: 978-01996-519-86.

A Tale of Two Fractals, by A. A. Kirillov. Birkhäuser, May 2013. ISBN-13: 978-08176-838-18.

Théorème vivant, by Cédric Villani (in French). Grasset et Fasquelle, August 2012. ISBN-13: 978-2246798828. (Reviewed February 2014.)

Turing: Pioneer of the Information Age, by Jack Copeland. Oxford University Press, January 2013. ISBN-13: 978-01996-397-93. (Reviewed in this issue.)

Turing's Cathedral: The Origins of the Digital Universe, by George Dyson. Pantheon/Vintage, December 2012. ISBN-13: 978-14000-759-97. (Reviewed August 2014.)

Undiluted Hocus-Pocus: The Autobiography of Martin Gardner. Princeton University Press, September 2013. ISBN-13: 978-06911-599-11. (Reviewed March 2014.)

Why Is There Philosophy of Mathematics At All?, by Ian Hacking. Cambridge University Press, April 2014. ISBN-13: 978-11070-501-74.

SPECIAL SECTION

2014 American Mathematical Society Elections

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2014 AMS Elections

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Hee Oh

Ballots

AMS members will receive email with instructions for voting online by August 18, or a paper ballot by September 18. If you do not receive this information by that date, please contact the AMS (preferably before October 1) to request a ballot. Send email to ballot@ams.org or call the AMS at 800-321-4267 (within the U.S. or Canada) or 401-455-4000 (worldwide) and ask to speak with Member Services. The deadline for receipt of ballots is November 7, 2014.

Write-in Votes

It is suggested that names for write-in votes be given in exactly the form that the name occurs in the *Combined Membership List* (www.ams.org/cml). Otherwise the identity of the individual for whom the vote is cast may be in doubt and the vote may not be properly credited.

Replacement Ballots

For a paper ballot, the following replacement procedure has been devised: A member who has not received a ballot by September 18, 2014, or who has received a ballot but has accidentally spoiled it, may write to ballot@ams.org or Secretary of the AMS, 201 Charles Street, Providence, RI 02904-2294, USA, asking for a second ballot. The request should include the individual's member code and the address to which the replacement ballot should be sent. Immediately upon receipt of the request in the Providence office, a second ballot, which will be indistinguishable from the original, will be sent by first class or airmail. Although a second ballot will be supplied on request and will be sent by first class or airmail, the deadline for receipt of ballots cannot be extended to accommodate these special cases.

Biographies of Candidates

The next several pages contain biographical information about all candidates. All candidates were given the opportunity to provide a statement of not more than 200 words to appear at the end of their biographical information.

Description of Offices

The **vice president** and the **members at large of the AMS Council** serve for three years on the Council. That body determines all scientific policy of the Society, creates and oversees numerous committees, appoints the treasurers and members of the Secretariat, makes nominations of candidates for future elections, and determines the chief editors of several key editorial boards. Typically, each of these new members of the Council also will serve on one of the Society's five policy committees. Current members of the Council may be found here: www.ams.org/council.

The **Board of Trustees**, of whom you will be electing one member for a five-year term, has complete fiduciary responsibility for the Society. Among other activities, the trustees determine the annual budget of the Society, prices of journals, salaries of employees, dues (in cooperation with the Council), registration fees for meetings, and investment policy for the Society's reserves. The person you select will serve as chair of the Board of Trustees during the fourth year of the term. Current members of the Board may be found here: www.ams.org/bt.

The candidates for **vice president**, **members at large**, and **trustee** were suggested to the Council either by the Nominating Committee or by petition from members. While the Council has the final nominating responsibility, the groundwork is laid by the **Nominating Committee**. The candidates for election to the Nominating Committee were nominated by the current president, David A. Vogan Jr. The three elected will serve three-year terms. The main work of the Nominating Committee takes place during the annual meeting of the Society, during which it has four sessions of face-to-face meetings, each lasting about three hours. The Committee then reports its suggestions to the spring Council, which makes the final nominations. Current members of the Nominating Committee may be found here: www.ams.org/nomcom.

The **Editorial Boards Committee** is responsible for the staffing of the editorial boards of the Society. Members are elected for three-year terms from a list of candidates named by the president. The Editorial Boards Committee makes recommendations for almost all editorial boards of the Society. Managing editors of *Journal of the AMS*, *Mathematics of Computation*, *Proceedings of the AMS*, and *Transactions of the AMS*; and Chairs of the *Colloquium*, *Mathematical Surveys and Monographs*, and *Mathematical Reviews* editorial committees are officially appointed by the Council upon recommendation by the Editorial Boards Committee. In virtually all other cases, the editors are appointed by the president, again upon recommendation by the Editorial Boards Committee. Current members of the Editorial Boards Committee may be found here: www.ams.org/ebc.

Elections to the **Nominating Committee** and the **Editorial Boards Committee** are conducted by the method of approval voting. In the approval voting method, you can vote for as many or as few of the candidates as you wish. The candidates with the greatest number of the votes win the election.

A Note from AMS Secretary Carla D. Savage

The choices you make in these elections directly affect the direction the Society takes. The other officers and Council members join me in urging you to take a few minutes to review the election material, fill out your ballot, and submit it. The Society really does belong to its members. You can influence its policies and direction by voting.

Also, let me urge you to consider other ways of participating in Society activities. The Nominating Committee, the Editorial Boards Committee, and the Committee on Committees are always interested in learning of members who are willing to serve the Society in various capacities. Names are always welcome, particularly when accompanied by a few words detailing the person's background and interests. Self-nominations are probably the most useful. Recommendations can be transmitted through an online form (www.ams.org/committee-nominate) or sent directly to the secretary (secretary@ams.org) or Office of the Secretary, American Mathematical Society, Department of Computer Science, Box 8206, North Carolina State University, Raleigh, NC 27695-8206 USA.

PLEASE VOTE.

Biographies of Candidates 2014

Biographical information about the candidates has been supplied and verified by the candidates.

Candidates have had the opportunity to make a statement of not more than 200 words (400 words for presidential candidates) on any subject matter without restriction and to list up to five of their research papers.

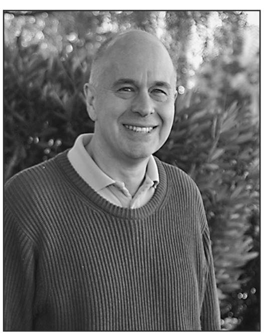
Candidates have had the opportunity to supply a photograph to accompany their biographical information.

Candidates with an asterisk (*) beside their names were nominated in response to a petition.

Abbreviations: American Association for the Advancement of Science (AAAS); American Mathematical Society (AMS); American Statistical Association (ASA); Association for Computing Machinery (ACM); Association for Symbolic Logic (ASL); Association for Women in Mathematics (AWM); Canadian Mathematical Society, Société Mathématique du Canada (CMS); Conference Board of the Mathematical Sciences (CBMS); Institute for Advanced Study (IAS), Institute of Mathematical Statistics (IMS); International Mathematical Union (IMU); London Mathematical Society (LMS); Mathematical Association of America (MAA); Mathematical Sciences Research Institute (MSRI); National Academy of Sciences (NAS); National Academy of Sciences/National Research Council (NAS/NRC); National Aeronautics and Space Administration (NASA); National Council of Teachers of Mathematics (NCTM); National Science Foundation (NSF); Society for Industrial and Applied Mathematics (SIAM).

Vice President

Robert Calderbank



Professor of Mathematics, Director of the Information Initiative, Duke University (iiD).

Born: December 28, 1954, Bridgwater, Somerset, UK.

Ph.D.: California Institute of Technology, 1980.

AMS Committees: AMS Centennial Fellowship Committee, 1995–1998 (Chair, 1996–1998); Committee to Select Speakers at NE Regional Meetings, 2003–2006; Chair, Organizing Committee, von Neumann Symposium, 2006; Committee to Select Speakers at National Meetings, 2006–2009; Committee to Select the Gibbs Lecturer, 2009–2012; AAAS Section A Representative, 2010–present.

Selected Addresses: Principal Lecturer and Organizer, Different Aspects of Coding Theory, AMS Symposium in Applied Mathematics, 1995; AMS Invited Address, Hoboken, 2001; Plenary Lecture, International Symposium on Information Theory, Toronto, 2009; Special Session on New Directions in Applied Mathematics, AAAS Meeting, Vancouver, 2012; R. T. Chien Distinguished Lecture, Coordinated Science Lab, University of Illinois, 2013.

Additional Information: *Positions*: Bell Labs and AT&T, from Member of Technical Staff in 1980 to VP for Research in 2003; Director, Program in Applied and Computational Mathematics, Princeton, 2004–2010; Dean of Natural Sciences, Duke, 2010–2012; Director, Information Initiative, Duke, 2012–present. *Boards*: Institute for Mathematics and Applications, Board of Governors, 1996–1999; NSF Committee of Visitors, Division of Mathematical Sciences, 2001; American Institute of Mathematics, Scientific Advisory Board, 2006–present; Institute for Pure and Applied Mathematics, Scientific Advisory Board, 2013–present. *Selected Editorships*: *IEEE Transactions on Information Theory*, 1995–1998; Editor in Chief, *Information and Inference*, 2011–present. *Selected Honors*: IEEE Fellow, 1995; AT&T Fellow, 2000; National Academy of Engineering, elected 2005; Honorary Doctorate, Warwick University, 2013; IEEE Hamming Medal, 2013; AAAS Fellow, 2013; AMS Fellow, 2013.

Selected Publications: 1. A personal perspective on mathematics research in industry, *Notices Amer. Math. Soc.*, 569–571, May 1996; 2. with P. W. Shor, Good quantum error correcting codes exist, *Phys. Rev.* A, **54** (1996), no. 2, 1098–1105; 3. with P. J. Cameron, W. M. Kantor and J. J. Seidel, Z_4-Kerdock codes, orthogonal spreads and extremal Euclidean line-sets, *Proc. London Math. Soc.* (3), **75** (1997), 436–480. **MR1455862 (98i:94039)**; 4. with I. Daubechies, W. Sweldens, and B. L. Yeo, Wavelet transforms that map integers to integers, *Appl. Comput. Harmon. Anal.*, **5** (1998), 332–369. **MR1632537 (99h:94012)**; 5. with S. Jafarpour, Finding needles in compressed haystacks, *Compressed Sensing: Theory and Applications*, Y. Eldar and G. Kutyniok, eds., Cambridge University Press, Cambridge, UK, 2012, 439–485. **MR2963575**.

Statement by Candidate: It is an honor to be asked to stand as a candidate for Vice President. The role of the AMS in creating a vibrant mathematics community through meetings, publications and outreach activities is vital. AMS initiatives make a huge difference to both the development of individual research mathematicians and to national perceptions of the return on investing in mathematics.

These are interesting times. The rise of the information economy has reduced the distance between mathematics and the value it creates, and there has never been a greater diversity of opportunity for mathematicians. Ours is a global activity and as access to the Internet grows so too does the opportunity to make a difference to mathematicians across the world. However we also face serious challenges, from the future of scholarly publication to the implications of online learning for university instruction.

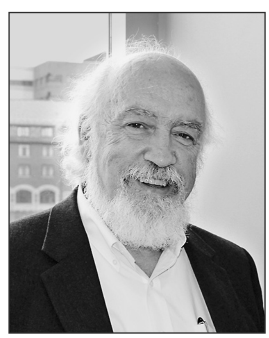
As a mathematician with experience leading an industrial research laboratory, an interdisciplinary mathematics program, and a college of sciences, I have thought deeply about these issues. If elected it would be my privilege to help AMS sustain federal funding for mathematics research and teaching, also to work for AMS programs that expand access to mathematical publications.

Carlos E. Kenig

Professor, Department of Mathematics, University of Chicago.
Born: November 25, 1953, Buenos Aires, Argentina.
Ph.D.: University of Chicago, 1978.
AMS Offices: Council, 1985–1988; Managing Editor, *JAMS*, 2000–2002.
AMS Committees: Editorial Boards Committee, 1989–1992; Committee on Mathematicians with Disabilities (AMS-MAA-SIAM), 1994–2000 (chair, 1997–2000); Committee on Committees, 1999–2000; Editorial Boards: *Bulletin of the AMS*, 1994–1997; *JAMS*, 1998–2002; *Electronic Research Announcements of the AMS*, 2004–2009; Bergman Prize Committee, 2010–2012.
Selected Addresses: Invited address, AMS meeting, Columbia, MO, 1985; Invited speaker, ICM, 1986; Invited address, AMS meeting, Detroit, MI, 1997; Invited speaker, ICM, 2002; Plenary speaker, ICM, 2010.
Additional Information: Sloan Fellow, 1981–1983; Salem Prize, 1984; Guggenheim Fellow, 1986; Fellow, American Academy of Arts and Sciences, 2002; Member, Committee of Visitors for DMS at NSF, 2004; Scientific Advisory Committee, Banff Research Station, 2006–2009; Scientific Advisory Committee, MSRI, 2006–2010 (co-chair, 2008–2010); Editor, *Tracts in Mathematics*, European Mathematical Society, 2006–present; Bôcher Prize, AMS, 2008; Decadal Review Committee, IAS, 2008; Editor, *Inventiones Mathematicae*, 2009–present; US delegate to the General Assembly of the International Mathematical Union, 2010; Fellow of the AMS, 2013; Editor, *Forum of Mathematics Pi/Sigma*, 2013–present; Chair, Program Committee, International Congress of Mathematicians 2014, 2011–2014; Member, National Academy of Sciences, 2014.
Selected Publications: 1. with G. Ponce and L. Vega, Well-posedness and scattering results for generalized Korteweg-de Vries equations via the contraction mapping principle, *Comm. Pure Appl. Math.*, **46** (1993), no. 3, 527–620. **MR1211741 (94h:35229)**; 2. with J. Sjostrand and G. Uhlmann, The Calderón problem with partial data, *Ann. of Math.*, **165** (2007), 567–591. **MR2299741 (2008k:35498)**; 3. with F. Merle, Global well-posedness, scattering and blow-up for the energy critical focusing non-linear wave equation, *Acta Math.*, **201** (2008), no. 2, 147–212. **MR2461508 (2011a:35344)**; 4. with F. Lin and Z. Shen, Homogenization of elliptic systems with Neumann boundary conditions, *J. Amer. Math. Soc.*, **26** (2013), 901–937. **MR3073881**; 5. with T. Duyckaerts and F. Merle, Classification of radial solutions of the focusing, energy-critical wave equation, *Cambridge Journal of Mathematics*, **1** (2013), 75–144.
Statement by Candidate: It is a great honor to be nominated for the vice-presidency of the AMS. It would be a privilege to have the opportunity to serve the AMS and the mathematical community in this position. The AMS is the premier organization in the USA that champions research and education in mathematics, which is its core mission. It has played a major role in my professional life, going back to my graduate student days. I have a strong commitment to the core mission of the AMS and to making sure that underrepresented groups are full participants in the enterprise of the AMS. We are living in a rapidly changing world and I would like to have the opportunity to contribute, should I be elected, to the task of ensuring that the AMS continues to evolve, adapting to these changes.

Board of Trustees

Daniel M. Burns Jr.



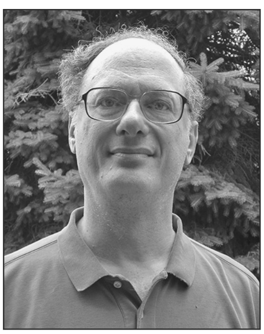
Professor of Mathematics, University of Michigan.
Born: August 25, 1946, Brooklyn, NY.
Ph.D.: MIT, 1972.
AMS Offices: AMS Council, 1987–1989.
AMS Committees: Nominating Committee, 1992–1994; Transactions Editorial Committee, 1995–2000.
Selected Addresses: Invited address, Central Section Meeting, Notre Dame, 1982; many special sessions.
Additional Information: Sloan Fellow, 1978–1982; AMS Fellow, 2013.
Selected Publications: 1. with M. Rapoport, On the Torelli problem for kählerian K–3 surfaces, *Ann. Sci. École Norm. Sup.*, **8** (1975), no. 2, 235–274. **MR0447635 (56 #5945)**; 2. Curvatures of Monge-Ampère foliations and parabolic manifolds, *Ann. Math.*, **115** (1982), no. 2, 349–373. **MR0647810 (84a:32031)**; 3. with C. L. Epstein, A global invariant for three-dimensional CR-manifolds, *Invent. Math.*, **92** (1988), no. 2, 333–348. **MR0936085 (89b:53060)**;

4. with J.-S. Ryu, Rationality of renormalized Chern classes, *Pure App. Math. Q.*, **1** (2005), no. 3, Special Issue: In memory of Armand Borel. Part 2, 449–478. **MR2201325 (2006i:32032)**; 5. with N. Sibony, Limit currents and value distribution of holomorphic maps, *Ann. Inst. Fourier (Grenoble)*, **62** (2012), no. 1, 145–176. **MR2986269**.

Statement by Candidate: The AMS appears to be in a healthy financial situation and it is the primary responsibility of the Board of Trustees to keep things that way. I have been active in recent years in mathematics developments in Africa, and I would like to see the AMS play a more outgoing role in this part of the world. The AMS already has initiatives around the world, most notably jointly held meetings abroad. I would like to see the AMS foster the formation of sister societies in some of those areas of Africa and other parts of the developing world, sharing practical expertise on organization, offering infrastructure support, etc. I think it would be great if we were to do that in collaboration with some of our sister societies which have already blossomed more recently than our own, e.g., those of Mexico and Brazil. This is just one way the AMS and its funding potential could help to shepherd mathematics globally, another dimension of the diversity we wish to see in the profession.

Joseph H. Silverman

Professor of Mathematics, Brown University.



Born: March 27, 1955, New York, New York.

Ph.D.: Harvard University, 1982.

AMS Elected Offices: AMS Council, 2008–2013; AMS Executive Committee, 2009–2013.

AMS Committees: Conant Prize Selection Committee, 2000–2003; University Lecture Series Editorial Committee, 2006–2008; Committee on Publications, 2008–2011 (chair 2011); AMSTexts Editorial Board, 2009–present; Fellows Selection Committee, 2013.

Selected Addresses: Five Lectures on Moduli for Dynamical Systems, Barbados, 2010; Four Special Sessions, Joint Mathematics Meetings, Boston, 2012; ICERM Semester Program on Complex and Arithmetic Dynamics, lead scientific organizer, Providence, 2012; AMS Special Session, Boston College, 2013; Eight Lectures on Elliptic Curves and Lattices, Seoul National University, 2014.

Additional Information: *Fellowships*: NSF Post-Doctoral Fellow, 1983–1986; Sloan Foundation Fellow, 1987–1991; Guggenheim Foundation Fellowship, 1998–1999. *Editorial Boards*: *Compositio Mathematica*, 1993–2005; AMSTexts 2009–present; *Algebra and Number Theory*, 2011–present. *Awards*: MAA Lester Ford Award, 1994; AMS Steele Prize for Mathematical Exposition, 1998; NES MAA Award for Distinguished Teaching, 2011; ECC Visionary Award, 2011; Fellow of the AMS, 2012. *Governing Boards*: IPAM Board of Trustees, 2003–2005; Shannon Institute Advisory Board, 2006–2012. *Programs Co-Organized*: AMS special sessions, Providence, 1999, New Jersey, 2004, JMM San Francisco 2010, workshops on cryptography, IPAM 2002, 2006, Montreal, 2010, workshops on arithmetic dynamics, AIM, 2008, Toronto, 2008, CUNY, 2010, ICERM, 2012, Berkeley, 2012, ICERM Semester Program, 2012, ICERM IdeaLab, 2013.

Selected Publications: 1. T*he Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics, vol. 106, Springer-Verlag, N.Y., 1986, 2nd edition 2009. **MR0817210 (87g:11070)**; 2. with M. Hindry, The canonical height and integral points on elliptic curves, *Invent. Math.*, **93** (1988), 419–450. **MR0948108 (89k:11044)**; 3. with M. Rosen, On the rank of an elliptic surface, *Invent. Math.*, **133** (1998), 43–67. **MR1626465 (99f:11081)**; 4. *The Arithmetic of Dynamical Systems*, Graduate Texts in Mathematics, vol. 214, Springer-Verlag, N.Y., 2007. **MR2316407 (2008c:11002)**; 5. An algebraic approach to certain cases of Thurston rigidity, *Proc. Amer. Math. Soc.*, **140** (2012), no. 10, 3421–3434. **MR2929011**.

Statement of Candidate: I have been actively involved for more than 30 years in mathematics research and mathematics education at the undergraduate and graduate levels, including supervision of 27 students who have received their Ph.D.'s. Having recently completed terms on the AMS Council and Executive Committee, I look forward to further service as a member of the Board of Trustees. This board has the responsibility of ensuring the AMS's financial stability, while also funding programs that promote the vitality of the mathematics community. As a member, I will encourage the AMS to find innovative ways to positively influence graduate students and young mathematicians, while at the same time serving the full spectrum of our membership. As an example of the former, I recently chaired the subcommittee that created the new AMS Graduate Student Chapter program, which in its second year already has 24 chapters. Another important aspect of AMS finances concerns its publishing enterprise, including its many journals, book series, and MathSciNet. Having published eight textbooks and having served on the AMS Council's publishing subcommittee and the AMSTexts editorial board, I feel qualified to help make the financial decisions necessary for the AMS to succeed in today's challenging publishing environment.

Nominating Committee

Douglas N. Arnold

McKnight Presidential Professor of Mathematics, University of Minnesota.

Born: April 30, 1954, New York, NY.

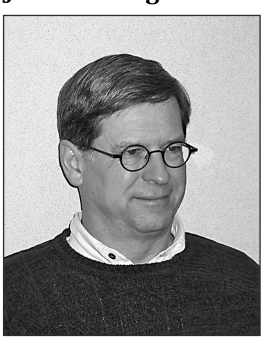
Ph.D.: University of Chicago, 1979.

AMS Committees: Liaison committee to the AAAS, 2000–2002, 2007–2009; Birkhoff Prize selection committee, 2002; Fellows selection committee, 2012; Gibbs Lecturer selection committee, 2013–2014.

Selected Addresses: Plenary Address, International Congress of Mathematicians, Beijing, 2002;

Plenary Talk, Central Sectional Meeting, Notre Dame, 2006; AMS–MAA Invited Address, Joint Mathematics Meetings, Washington, DC, 2009; NSF–CBMS lecture series, Providence, RI, 2012.
Additional Information: Director, Institute for Mathematics and its Applications, 2001–2008; Guggenheim Fellow, 2008–2009; Foreign member, Norwegian Academy of Science and Letters, elected 2009; SIAM Fellow, appointed 2009; President of SIAM, 2009–2010; AAAS Fellow, elected 2011; AMS Fellow, appointed 2012; SIAM Prize for Distinguished Service to the Profession, 2013.
Selected Publications: 1. with R. Falk and R. Winther, Finite element exterior calculus, homological techniques, and applications, *Acta Numer.*, **15** (2006), 1–155. **MR2269741 (2007j:58002)**; 2. with R. Falk and R. Winther, Finite element exterior calculus: From Hodge theory to numerical stability, *Bull. Amer. Math. Soc. (N.S.)*, **47** (2010), 281–354. **MR2594630 (2011f:58005)**; 3. with K. Fowler, Nefarious numbers, *Notices Amer. Math. Soc.*, **58** (2011), 434–437. **MR2789123**; 4. with G. Awanou, Finite element differential forms on cubical meshes, *Math. Comp.*, **83** (2014), 1551–1570. **MR3194121**; 5. with R. Falk, J. Guzman, and G. Tsogtgerel, On the consistency of the combinatorial codifferential, *Trans. Amer. Math. Soc.*, 2014.
Statement by Candidate: Much of the strength of the AMS derives from the involvement of talented, committed, and thoughtful volunteers. Consequently, the nominating committee plays a crucial role. In various capacities I have had the pleasure of working with many mathematicians to advance our profession. If chosen to serve on the nominating committee, I will put this experience to work to help involve a broad and diverse group of effective people in AMS service.

James W. Cogdell

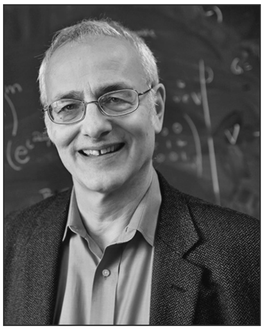


Professor, Ohio State University.
Born: September 22, 1953, Little Rock, Arkansas.
Ph.D.: Yale University, 1981.
AMS Committees: AMS Central Section Program Committee, 2007–2009.
Selected Addresses: Plenary address, XXII Journées Arithmétiques, Lille, France, July 2001; Invited 45-minute address, Number Theory Section, ICM, Beijing, China, 2002; Whittemore Lectures, Yale University, November 2002; Erwin Schrödinger Lecture, Erwin Schrödinger Institute, January 2009.
Additional Information: NSF Postdoctoral Fellowship, 1982–1983; Inaugural Fellow of the AMS, 2012.
Selected Publications:
1. with I. I. Piatetski-Shapiro, Converse theorems for GL_n, *Inst. Hautes Études Sci. Publ. Math.*, **79** (1994), 157–214. **MR1307299 (95m:22009)**; 2. with I. I. Piatetski-Shapiro, Converse theorems, functoriality, and applications to number theory, *Proceedings of the International Congress of Mathematicians, Vol. II* (Beijing, 2002), 119–128. **MR1957026 (2004c:11071)**; 3. On sums of three squares, *J. Théor. Nombres Bordeaux*, **15** (2003), 33–44. **MR2018999 (2005d:11072)**; 4. with H. Kim, I. I. Piatetski-Shapiro and F. Shahidi, Functoriality for the classical groups, *Publ. Math. Inst. Hautes Études Sci.*, **99** (2004), 163–233. **MR2075885 (2006a:22010)**.
Candidate Statement: I am pleased to have been nominated by the Society to serve on the Nominating Committee. This committee has a great responsibility as it serves as the gateway to service on the other committees. It must assure the other committees have a balanced slate of members of the Society that are able and willing to get their work done. I will fulfill this responsibility to the best of my ability.

Christine Guenther

Professor of Mathematics, Pacific University.
Born: August 5, 1966, Denver, Colorado.
Ph.D.: University of Oregon, 1998.
AMS Committees: Joint Committee on Women in the Mathematical Sciences, 2012–2015 (co-chair, 2014–2015).
Selected Addresses: I have given numerous colloquia and frequent talks. Recent examples: AMS Special Sessions, 2009–2012; Max-Planck-Institut für Gravitationsphysik, 2012; University of Arizona, Colloquium, 2013; Stanford University, joint PNGS/BADGS, 2014.
Additional Information: Thomas and Joyce Holce Chair in Science, Pacific University, 2005–2008; Department Chair, Pacific University, 2004–2006, 2009–2010; Simons Foundation Collaboration Grant, 2013–2018; Editorial Board, *Geometric Flows*, deGruyter, 2014–present.
Selected Publications: 1. with D. Knopf and J. Isenberg, Stability of the Ricci flow at Ricci flat metrics, *Comm. Anal. Geom.*, **10** (2002), no. 4, 741–777. **MR1925501 (2003g:53118)**; 2. with B. Chow, et al., *The Ricci Flow: Techniques and Applications Pts I – III*, Mathematical Surveys and Monographs, American Mathematical Society, Providence, RI (2007, 2008, 2010). **MR2302600 (2008f:53088), MR2365237 (2008j:53114), MR2604955 (2011g:53142)**; 3. with T. Oliynyk, Stability of the (two-loop) renormalization group flow for nonlinear sigma models, *Lett. Math. Phys.*, **84** (2008), no. 2–3, 149–157. **MR2415546 (2009c:81060)**; 4. with K. Gimre and R. Whiteley, The analytical determination of kinetic parameters for a bimolecular EC mechanism from chronoamperometric data, *J. Math. Chem.*, **50** (2012), no. 4, 805–818. **MR2903697**; 5. with K. Gimre and J. Isenberg, Short-time existence for the second-order renormalization group flow in general dimensions, *Proc. Amer. Math. Soc.*, to appear (2014).
Statement by Candidate: It would be a privilege to serve on the nominating committee of the AMS. I would work to nominate highly qualified candidates to represent the broad constituency of the AMS in pure and applied mathematics, at research universities and liberal arts institutions, in industry and government.

Phil Kutzko



Professor of Mathematics and Collegiate Fellow, University of Iowa.
Born: November 24, 1946, Brooklyn, New York.
Ph.D.: University of Wisconsin, 1972.
AMS Committees: Centennial Fellowship Committee, 2005-2007; Committee to Select the Winner of the Prize for Exemplary Program or Achievement by a Mathematics Department, 2011-2013.
Selected Addresses: Brandeis-Harvard-MIT Joint Mathematics Colloquium, 1979; International Congress of Mathematicians, Berkeley, 1986; University of Iowa Presidential Address, 2004; Mathematical Association of America James R. C. Leitzel Lecture, 2011.
Additional Information: Director, National Alliance for Doctoral Studies in the Mathematical Sciences; Iowa State Regents Award for Faculty Excellence, 2002; Brody Award for Service, 2003; Hubbard Award for Teaching, 2003; National AGEP Mentor of the Year, 2006; Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring, 2008 (Awarded by President Barack Obama, January, 2010); Fellow of the AAAS, 2010; American Mathematical Society Award for Distinguished Public Service, 2014.
Selected Publications: 1. The Langlands conjecture for Gl_2 of a local field, *Ann. of Math. (2)*, **112** (1980), 381-412. **MR0592296 (82e:12019)**; 2. with C. J. Bushnell, *The Admissible Dual of GL_N via Compact Open Subgroups*, Annals of Mathematics Studies, vol. 129, Princeton University Press, Princeton, NJ, 1993. **MR1204652 (94h:22007)**; 3. with C. J. Bushnell, Smooth representations of reductive p-adic groups: Structure theory via types, *Proc. London Math. Soc. (3)*, **77** (1998), 582-634. **MR1643417 (2000c:22014)**; 4. with C. J. Bushnell and G. Henniart, Local Rankin-Selberg convolutions for GL_n: Explicit conductor formula, *J. Amer. Math. Soc.*, **11** (1998), 703-730. **MR1606410 (99h:22022)**; 5. with L. Morris, Explicit Plancherel theorems for $H(q_1,q_2)$ and $SL_2(F)$, *Pure Appl. Math. Q. (Serre 80th Birthday volume)*, **5** (2009), 435-467. **MR2531913 (2010m:20009)**.
Statement by the Candidate: I am honored to have been nominated to serve on the Nominating Committee of the American Mathematical Society. We are going through a period of great change in our nation, becoming less and less European, more and more American. Our challenge is to embrace these changes, to transform our profession to reflect the new realities of our society, so as to maintain the central role that mathematics plays in all aspects of our intellectual life. If elected to the Nominating Committee, I will work to ensure that the candidates for our elected positions in the AMS will provide strong vision and leadership during this critical period of transition.

Douglas Lind

Professor Emeritus of Mathematics, Department of Mathematics, University of Washington.
Born: August 11, 1946, Arlington, Virginia.
Ph.D.: Stanford University, 1973
AMS Committees: Centennial Fellowship Committee, 1991-1993; AMS Task Force on Excellence, 1995-2000; Editorial Board, *Electronic Research Announcements*, 1997-1999; Associate Editor, Research-Expository Articles, *Bulletin*, 1999-2002; AMS Working Group on Graduate Education, 2011-2013.
Selected Addresses: Invited lecturer, AMS Short Course on Dynamical Systems, San Diego, January, 2002; Invited speaker, Conference on Algebraic Dynamics, University of New South Wales, Sydney, February, 2005; Invited lecturer, Summer School in Dynamical Systems and Number Theory, Technical University of Graz, Austria, July, 2007; Invited Speaker, Warwick Conference on Dynamics and Number Theory, University of Warwick, April, 2011; Invited Speaker, Conference on Periodic Orbits in Dynamical Systems, Schrodinger Institute, Vienna, May, 2012; Invited Lecture Series, Workshop on Operator Algebras and Dynamical Systems, University of Wollongong, Australia, July, 2014.
Additional Information: Vice Chair, Board of Trustees, MSRI, Berkeley, 1989-1995; Professeur Invité, Université Aix-Marseilles, 1993; Mathematics Department Chair, University of Washington, 1993-1998; Chair, Organizing Committee, AMS Conference on Leadership in Doctoral Mathematics Departments, Bloomington, 1999; Chair, MSRI Building Addition Design Committee, 2003-2006; Research Member, MSRI Program on Ergodic Theory and Additive Combinatorics, Autumn Semester, 2008; Organizing Committee, First Pacific Rim Congress of Mathematicians, Sydney, July, 2009; Principal Organizer, NSF Advisory Workshop on Research Networks, April, 2009; Organizing Committee, Second Pacific Rim Congress of Mathematicians, Shanghai, June, 2013; Inaugural Fellow, American Mathematical Society, 2013.
Selected Publications: 1. The entropies of topological Markov shifts and a related class of algebraic integers, *Ergodic Theory Dynam. Systems*, **4** (1984), 283-300. **MR0766106 (86c:58092)**; 2. with K. Schmidt and T. Ward, Mahler measure and entropy for commuting automorphisms of compact groups, *Invent. Math.*, **101** (1990), 593-629. **MR1062797 (92j:22013)**; 3. with B. Marcus, *An Introduction to Symbolic Dynamics and Coding*, Cambridge University Press, Cambridge, 1995. **MR1369092 (97a:58050)**; 4. with M. Einsiedler and M. Kapranov, Non-archimedean amoebas and tropical varieties, *J. Reine Angew. Math.*, **601** (2006), 139-157. **MR2289207 (2007k:14038)**; 5. with K. Schmidt and E. Verbitskiy, Homoclinic points, atoral polynomials, and periodic points of algebraic Z^d-actions, *Ergodic Theory Dynam. Systems*, **33** (2013), no. 4, 1060-1081. **MR3082539**.

Statement by Candidate: The Nominating Committee plays a crucial role in finding strong candidates for the most important leadership positions of the AMS. If elected, I would try hard to represent the broad interests of our community thoughtfully and fairly.

Kavita Ramanan

Professor of Applied Mathematics, Brown University.

Born: Chennai, Tamil Nadu, India.

Ph.D.: Brown University, 1998.

AMS Committees: Eastern Section Program Committee Member, 2012-2014 (chair, 2013-2014)

Selected Addresses: Invited talks at Special Sessions at AMS meetings in 1996, 1999, 2001, 2002, 2014; Plenary Lecture, Conference on "Skorokhod Space: 50 Years On", Kiev, Ukraine, June 2007; Plenary Lecture, Conference on "Stochastic Processes and their Applications", Boulder, Colorado, July 2013; Plenary Lecture, "Frontier Probability Days" Conference, Arizona, May 2014; Plenary Lecture, "ICM Satellite Conference on Stochastic Analysis", Seoul, Korea, August 2014.

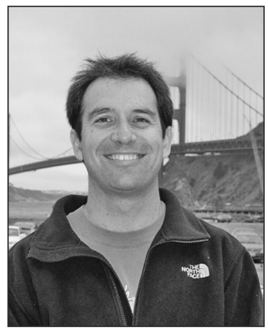
Additional Information: *Awards and Honors*: Simon Ostrach Fellowship, 1996; Stella Dafermos Award, 1996; Recipient of the Erlang Prize, INFORMS Applied Probability Society, 2006; Fellow, Institute of Mathematical Statistics, 2013; IMS (Institute of Mathematical Statistics) Medallion lecturer, 2015. *Editorial boards*: *Annals of Probability*, 2006-2012, *Annals of Applied Probability*, 2009-present, *Mathematics of Operations Research*, 2007-present, *Stochastic Analysis and Applications*, 2002-2010. *Member of Scientific Council*: French Applied Maths Society (SMAI), 2014-present. *Member of Nominations Committee*: IMS, 2011-2013, Bernoulli Society, 2013-present. *Member of Prize Committees*: Nicholson Prize, member, 2013, chair, 2014; Erlang Prize, 2014-present. *Faculty Sponsor*: AWM Chapter at the Division of Applied Mathematics, Brown University, 2013-present. *Conference Organizer*: Stochastic Networks meeting, Newton Institute, Cambridge, UK, 2010; Applied Probability conference, Stockholm, Sweden, 2011; semester program on Computational Challenges in Probability, ICERM, Providence, 2012; IMI Meeting, Limit Theorems in Probability, Bangalore, India. *Member*: AWM, SIAM, INFORMS.

Selected Publications: 1. with P. Dupuis, Convex duality and the Skorokhod problem - Parts I and II, *Probab. Theory Related Fields*, **115** (1999), no. 2, 153-195, 197-236. **MR1720348 (2001f:49041)**; 2. Reflected diffusions defined via the extended Skorokhod map, *Electron. J. Probab.*, **11** (2006), 934-992. **MR2261058 (2008c:60054)**; 3. with L. Kruk, J. Lehoczky and S. Shreve, An explicit formula for the Skorokhod map on [0, *a*], *Ann. Probab.*, **35** (2007), no. 5, 1740-1768. **MR2349573 (2008k:60087)**; 4. with L. Kontorovich, Concentration inequalities for dependent random variables via the martingale method, *Ann. Probab.*, **36** (2008), no. 6, 2126-2158. **MR2478678 (2010f:60057)**; 5. with W. Kang, Fluid limits of many-server queues with reneging, *Ann. Appl. Probab.*, **20** (2010), no. 6, 2204-2260. **MR2759733 (2012a:60090)**.

Statement by Candidate: I am honored to have been chosen as a candidate for the AMS Nominating Committee, which is charged with the important task of identifying candidates for election to AMS offices and committees. If elected, I will help identify dedicated candidates who are willing to devote some of their energy and creativity to implement the broad mission of the AMS, which includes promoting mathematics research and scholarship internationally and in an inclusive fashion, maintaining high standards of publication, improving public understanding of the importance of mathematics, and fostering the interaction of mathematics with other disciplines.

Member at Large

Matthew Baker



Professor of Mathematics, Georgia Institute of Technology.

Born: January 1973, Silver Spring, Maryland.

Ph.D.: University of California, Berkeley, 1999.

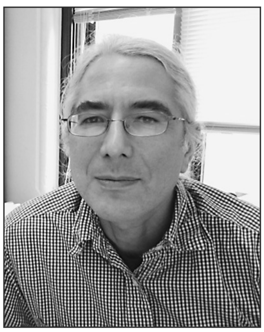
Selected Addresses: Invited speaker, Arizona Winter School, Tucson, AZ, Spring 2007; Plenary Talk, Journées Arithmétiques, Saint-Étienne, France, Summer 2009; Featured speaker, Michigan Lectures in Number Theory, University of Michigan, Spring 2010; Invited address, AMS Southeastern Section Meeting, University of Richmond, Fall 2010; Principal speaker, Bellairs Workshop in Number Theory, Barbados, Summer 2011.

Additional Information: University System of Georgia Board of Regents Teaching Excellence Award, 2010; Fellow of the American Mathematical Society.

Selected Publications: 1. Torsion points on modular curves, *Invent. Math.*, **140** (2000), 487-509. **MR1760749 (2001g:11092)**; 2. with S. Norine, Riemann-Roch and Abel-Jacobi theory on a finite graph, *Adv. Math.*, **215** (2007), 766-788. **MR2355607 (2008m:05167)**; 3. with R. Rumely, *Potential Theory and Dynamics on the Berkovich Projective Line*, Mathematical Surveys and Monographs, vol. 159, Amer. Math. Soc., 2010. **MR2599526 (2012d:37213)**; 4. with O. Amini and X. Faber (eds.), *Tropical and Non-Archimedean Geometry*, Contemp. Math., vol. 605, Amer. Math. Soc. (2013). 5. with L. De Marco, Special curves and postcritically-finite polynomials, *Forum Math. Pi*, **1** (2013), e3, 35 pages. **MR3141413**.

Statement by Candidate: Academia, education, and the publishing industry are all changing rapidly as a result of technology, budget cuts, and globalization. The AMS needs to be on top of these changes in order to remain a forceful advocate for mathematics. What is the future of open access journals? How will online instruction change the way mathematics is taught? How can we spot and nurture mathematical talent in the face of ever-increasing gaps between the rich and poor? How can we better harness the internet and social media for the benefit of mathematics? I don't have answers to all of these questions, but I'm very interested in helping discover and implement innovative solutions. Although I've never held an AMS office before, I do have experiences which are relevant to the tasks of the AMS Council. For example, I write a popular blog at http://mattbakerblog.wordpress.com and am currently developing an online Number Theory and Cryptography course for talented high school seniors. Last year I co-organized an AMS Math Research Communities workshop and I've been heavily involved with undergraduate research for more than a decade. If elected, I will try my best to promote mathematics research and education at all levels.

Yuliy Baryshnikov



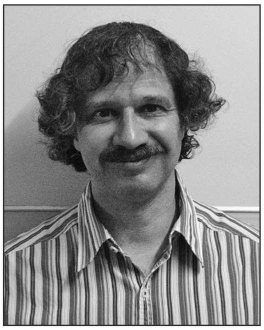
Professor of Mathematics and Electrical and Computer Engineering, University of Illinois, Urbana-Champaign.
Born: March 30, 1961, Moscow, Russia.
Ph.D.: Institute for Control Sciences, Moscow, 1987.
AMS Committees: Short Course Committee, 2010-2012.
Selected Addresses: Plenary, Conference on Analysis of Algorithms, Vienna, 2010; Plenary, SIAM Conference on Applied Algebraic Geometry, Fort Collins, 2013.
Additional Information: Alexander von Humboldt Fellow, 1992-1995; Lady Davis Professorship at Technion, 2005.
Selected Publications: 1. Complexity of trajectories in rectangular billiards, *Comm. Math. Phys.*, **174** (1995), no. 1, 43-56. **MR1372799 (96m:58065)**; 2. On small Carnot-Carathéodory spheres, *Geom. Funct. Anal.*, **10** (2000), no. 2, 259-265. **MR1771429 (2002h:53046)**; 3. GUEs and queues, *Probab. Theory Related Fields*, **119** (2001), no. 2, 256-274. **MR1818248 (2002a:60165)**; 4. with R. Ghrist, Euler integration over definable functions, *Proc. Natl. Acad. Sci. USA*, **107** (2010), no. 21, 9525-9530. **MR2653583 (2011j:90038)**; 5. with R. Pemantle, Asymptotics of multivariate sequences, part III: Quadratic points, *Adv. Math.*, **228** (2011), no. 6, 3127-3206. **MR2844940 (2012k:05035)**.
Statement by Candidate: The role mathematics is playing in science and engineering is becoming increasingly more visible. This process presents a remarkable opportunity for our community to assert the position of mathematics as the key element in advancement of science and technology, and to expand further the variety of ways mathematics contributes to the society.

Reinforcing ties of the mathematical profession to the broader science and technology community, I plan, if elected, to use my experience of two decades in industrial research to further the connections of the Society with the broader scientific and engineering communities. Reinforcing the ties of mathematical profession with the broader science and technology can be extremely beneficial for the profession itself: in particular, the career options for the young mathematicians can be vastly improved by closer interactions with scientific and engineering labs in academia, national laboratories, and industrial research.

Edward Frenkel

Professor of Mathematics, University of California, Berkeley.
Born: May 2, 1968, Kolomna, Russia.
Ph.D.: Harvard University, 1991.
AMS Committees: Editorial Board of the *Bulletin of AMS*, 2007-present.
Selected Addresses: International Congress of Mathematical Physics, Paris, 1994; International Congress of Mathematicians, Zürich, 1994; Séminaire Bourbaki, 2000, 2008; Plenary Address, Centennial Meeting of the Royal Spanish Mathematical Society, Avila, Spain, 2011; AMS Colloquium Lectures, Joint Mathematics Meetings, Boston, 2012.
Additional Information: Hermann Weyl Prize in mathematical physics, 2002; Chaire d'Excellence from Fondation Sciences Mathématiques de Paris, 2008; Eilenberg Chair, Columbia University, 2012; Fellow of the American Mathematical Society, 2013; "Love and Math" selected as one of the Best Books of 2013 by both Amazon and iBooks; Member of the American Academy of Arts and Sciences, 2014.
Selected Publications: 1. with D. Ben-Zvi, *Vertex Algebras and Algebraic Curves*, Mathematical Surveys and Monographs, vol. 88, American Mathematical Society, Providence, RI, Second Edition, 2004 (First Edition, 2001). **MR2082709 (2005d:17035)**; 2. *Langlands Correspondence for Loop Groups*, Cambridge Studies in Advanced Mathematics, vol. 103, Cambridge University Press, Cambridge, 2007. **MR2332156 (2008h:22017)**; 3. with E. Witten, Geometric endoscopy and mirror symmetry, *Commun. Number Theory Phys.*, **2** (2008), 113-283. **MR2417848 (2009e:14017)**; 4. with D. Gaitsgory, Localization of $\mathfrak{g}$-modules on the affine Grassmannian, *Ann. of Math.*, **170** (2009), no. 3, 1339-1381. **MR2600875 (2011h:17034)**; 5. with R. Langlands and B. C. Ngô, Formule des traces et fonctorialité: Le debut d'un programme, *Ann. Sci. Math. Québec*, **34** (2010), no. 2, 199-243. **MR2779866 (2012c:11240)**.
Statement by Candidate: While fostering top-level mathematical research remains our priority, it is equally important, in my view, for the AMS to become more visible and more active in the public domain. We have to find more creative ways to convey to the public what mathematics is really about; show that math is a much bigger and more fascinating subject than most people are led to believe. We have to actively promote better math education (including the K–12 system), disseminate mathematical knowledge to the widest audience, and redouble our efforts on increasing diversity and attracting more women and underrepresented groups to the subject. If elected to the Council, I will work toward these goals.

Solomon Friedberg



James P. McIntyre Professor of Mathematics, Boston College.
Born: September 26, 1958, New York, NY.
Ph.D.: University of Chicago, 1982.
AMS Committees: Working Group on Preparation for Technical Careers, 2007-2008; Joint Mathematics Meetings Travel Grants Selection Committee, Chair, 2009-2010.
Selected Addresses: Plenary Speaker (4 lectures), Number Theory Xi'an, Northwest University, Xi'an, China, 2011; Plenary Speaker, Texas-Oklahoma Representations and Automorphic Forms I, Denton, TX, 2011; Plenary Speaker, Palmetto Number Theory Seminar XVIII, Wake Forest University, Winston-Salem, NC, 2012; Invited Address, Matemáticos en la Educación Matemática Escolar: En la búsqueda de impacto en nuestra realidad educacional, Santiago, Chile, 2012; Invited Address, Conference on Stark's Conjectures and Related Topics, University of California, San Diego, 2013.
Additional Information: Sloan Fellow, 1989-1992; Distinguished Visiting Professor of Mathematics, Brown University, 2002; MAA Northeastern Section Award for Distinguished College or University Teaching, 2009; Board of Directors, Math for America Boston, 2012-present; Distinguished Ordway Visitor, University of Minnesota, 2014; Fellow of the AMS, 2014.
Selected Publications: 1. with D. Bump and J. Hoffstein, On some applications of automorphic forms to number theory, *Bull. Amer. Math. Soc.*, **33** (1996), no. 2, 157–175. **MR1359575 (97a:11072)**; 2. with B. Brubaker and J. Hoffstein, Cubic twists of GL(2) automorphic *L*-functions, *Invent. Math.*, **160** (2005), no. 1, 31–58. **MR2129707 (2005m:11091)**; 3. with G. Chinta and P. E. Gunnells, On the *p*-parts of quadratic Weyl group multiple Dirichlet series, *J. Reine Angew. Math.*, **623** (2008), 1-23. **MR2458038 (2009j:11144)**; 4. with B. Brubaker and D. Bump, Schur polynomials and the Yang-Baxter equation, *Comm. Math. Phys.*, **308** (2011), no. 2, 281-301. **MR2851143**; 5. with B. Brubaker and D. Bump, Weyl group multiple Dirichlet series, Eisenstein series and crystal bases, *Ann. of Math.*, **173** (2011), no. 2, 1081-1120. **MR2776371 (2012c:11113)**.
Statement by Candidate: The AMS is the primary advocate for mathematics scholarship in the US. In these challenging times—cuts in research funding, a difficult job market for young scholars, an increasing reliance on temporary and part-time faculty, and vastly uneven access to quality math instruction at the K–12 level—the AMS must do its utmost to ensure that mathematics scholarship remains vibrant. It must work to communicate to the public and elected officials the value of mathematics, to support young researchers, to develop increased ties to mathematicians in industry as well as throughout academia, to encourage interactions with scholars in neighboring disciplines, to promote diversity with energy and conviction, to support mathematics teachers at all levels, and to share with the next generation the excitement and beauty of mathematics. If elected to the Council I will encourage high-impact activities by the AMS in these areas.

Pamela Gorkin

Professor of Mathematics, Bucknell University.
Born: November 5, 1954, New York, New York.
Ph.D.: Michigan State University, 1982.
AMS Committees: Editor, *Proceedings of the American Mathematical Society*.
Selected Addresses: Banach algebras conferences, Stefan Banach International Mathematical Center, Bedlewo, Poland, 2009; Keynote speaker, Canadian Undergraduate Mathematical Conference, Laval University, Quebec City, 2011; Fields Institute, Conference on Blaschke Products, 2011; Plenary Speaker, Banach algebras and their applications, Gothenburg, Sweden, 2013; Special session invited speaker, Joint international meeting of the AMS-Romanian Mathematical Society, Operator theory and Function theory, 2013.
Additional Information: National Science Foundation Grants, 1984-1986, 1987-1990; Lindback Award for Distinguished Teaching, Bucknell University, 1987; Presidential Professor, Bucknell University, 2000-2003; Research in Pairs, Oberwolfach, July 2000, July 2001, November 2002, July 2003, July 2006; Visiting Research Positions: University of Karlsruhe, Germany, 1992, University of Metz, France, 1996, 1997, 2002, University of Bern, Switzerland, 2002, Lehrauftrag, University of Zaragoza, Spain, Fall 2009, Lund University, Sweden, Summer 2012, 2014; Association for Women in Mathematics, Alice T. Schafer Prize Selection Committee, 2013-2016; Book reviewer for the *Mathematical Intelligencer*, 8 reviews; Mathematical Reviews, 120 reviews; Bucknell University, Faculty Fellow, providing advice on funding and applying for grants in the natural sciences, mathematics, and engineering, 2010-2011; Simons Collaboration Grant, 2012-2017.
Selected Publications: 1. with U. Daepp, *Reading, Writing, and Proving: A Closer Look at Mathematics*, Undergraduate Texts in Mathematics, Springer-Verlag, New York, Second Edition (2011). **MR2809225**; 2. with E. Skubak, Polynomials, ellipses, and matrices: Two questions, one answer, *Amer. Math. Monthly*, **118** (2011), no. 6, 522-533. **MR2812283 (2012h:30012)**; 3. with E. Gallardo-Gutiérrez, Interpolating Blaschke products and angular derivative, *Trans. Amer. Math. Soc.*, **364** (2012), no. 5, 2319-2337. **MR2888208**; 4. with I. Chalendar and J. R. Partington, Prime and semiprime inner functions, *J. London Math Soc.*, **88** (2013), no. 3, 779-800. **MR3145131**; 5. with S. Pott and B. Wick, Thin sequences and their role in H^p theory, model space and uniform algebras, *Rev. Mat. Iberoam.*, to appear.
Statement by Candidate: It is an honor to be nominated for the position of Member at Large of the Council. I am fortunate to have spent my career at a liberal arts college that values and supports both research in and the teaching of mathematics, as well as outreach. My experiences have

provided me with opportunities to advance mathematics in the public sphere, to support young mathematicians, and to understand the importance of the scholarship, research and teaching of mathematics. Through my travels and visiting positions at institutions in other countries, I have gained an understanding of other mathematical communities that I hope will be beneficial to the AMS. If elected, I will use these experiences to encourage a diverse group of talented undergraduate and graduate students, advise those looking for employment in the field, and foster engagement from mathematicians at a variety of institutions.

Michael Anthony Hill

Associate Professor of Mathematics, University of Virginia.
Born: February 12, 1980, Alexandria, LA.
Ph.D.: Massachusetts Institute of Technology, 2006.
Selected Addresses: Guterman Lecture, Tufts University, April 2013; Master class, Vietnam Institute for Advanced Study in Mathematics, July 2013; Master class, University of Copenhagen, August 2013; AMS Invited Address, Fall Southeastern Sectional Meeting, University of Louisville, Louisville, KY, October 2013; International Congress, Topology session, Seoul, Korea, August 2014.
Additional Information: Alfred P. Sloan Research Fellowship, 2011; Member: AWM.
Selected Publications: 1. with M. Behrens, M. J. Hopkins and M. Mahowald, On the existence of a v_2^{32}-self map on $M(1,4)$ at the prime 2, *Homology, Homotopy Appl.*, **10** (2008), no. 3, 45–84. **MR2475617 (2009j:55015)**; 2. with T. Lawson, Automorphic forms and cohomology theories on Shimura curves of small discriminant, *Adv. Math.*, **225** (2010), no. 2, 1013–1045. **MR2671186 (2011f:55016)**; 3. with V. Angeltveit and T. Lawson, Topological Hochschild homology of l and *ko*, *Amer. J. Math.*, **132** (2010), no. 2, 297–330. **MR2654776 (2011i:19008)**; 4. Ext and the motivic Steenrod algebra over R, *J. Pure Appl. Algebra*, **215** (2011), no. 5, 715–727. **MR2747214 (2012i:55020)**; 5. with M. Hopkins and D. Ravenel, On the non-existence of elements of Kervaire invariant one, to appear.
Statement by Candidate: It is an honor to be nominated to serve the AMS. We have a wonderful community built around our common love of mathematics and being able to help the AMS with its missions is a wonderful opportunity. The AMS plays a vital role in our community, from helping mathematicians navigate jobs in academia and industry to fostering interest in mathematics in the broader community.
If elected, my goals are threefold:
1. Work to increase diversity in the field, emphasizing the inclusion of underrepresented groups. Organizations like AWM, NAM, and Math Alliance do incredible work with underrepresented groups, and the AMS can do more to support their efforts and the participation of mathematicians from these groups.
2. Help mathematics students determine their best career options with more transparent avenues to industry. Students at research institutions may not know what sorts of skills and approaches best help them secure industry jobs. The AMS can help connect students with this kind of information.
3. Help mathematicians navigate an increasingly web-centric world. The AMS can help provide information and resources for mathematicians interested in exploring MOOCs, online collaborative tools, MathOverflow, and other tools.

Wen-Ching Winnie Li

Distinguished Professor of Mathematics, Pennsylvania State University.
Born: December 25, 1948, Taiwan.
Ph.D.: University of California, Berkeley, 1974.
AMS Committees: Committee on Human Rights of Mathematicians, 1992-1995, 2007-2010; Editorial Committees: *Transactions* and *Memoirs of the AMS*, 1992-1996, *Proceedings of the AMS*, 2002-2010.
Selected Addresses: Invited Plenary Address, AMS Summer Meeting, Albany, 1983; Invited Plenary Address, Taiwanese Mathematical Society, Annual Meeting, Taipei, 2006; Invited Plenary Address, Joint Mathematics Meetings, San Diego, 2008; Invited Plenary Address, Fifth International Congress of Chinese Mathematicians, Beijing, 2010; Oliver Atkin Memorial Lecture, University of Illinois at Chicago, 2011.
Additional Information: Alfred P. Sloan Fellow, 1981-1983; AMS Visiting Professorship for Women Award, 1991-1992; Chern Prize, International Congress of Chinese Mathematicians, 2010; Inaugural Fellow, American Mathematical Society, 2012; Director, National Center for Theoretical Sciences, Taiwan, 2009-present; Editorial Boards: *Taiwanese Journal of Mathematics*, 1998-present; *International Journal of Number Theory*, 2005-present; *Journal of Combinatorics and Number Theory*, 2008-present; Monographs in Number Theory book series, World Scientific, Singapore, 2008-present; *Tamkang Journal of Mathematics*, 2013-present.
Selected Publications: 1. with A. O. L. Atkin, Twists of newforms and pseudo-eigenvalues of *W*-operators, *Invent, Math.*, **48** (1978), 221-243. **MR0508986 (80a:10040)**; 2. *Number Theory with Applications*, Series on University Mathematics, **7**, World Scientific, Singapore, 1996. **MR1390759 (98b:11001)**; 3. Ramanujan hypergraphs, *Geom. Funct. Anal.*, **14** (2004), no. 2, 380-399. **MR2060199 (2005i:11172)**; 4. with A. O. L. Atkin and L. Long, On Atkin and Swinnerton-Dyer congruence relations II, *Math. Ann.*, **340** (2008), no. 2, 335-358. **MR2368983 (2009a:11102)**; 5. with M.-H. Kang, Zeta functions of complexes arising from PGL(3), *Adv. Math.*, **256** (2014), 46-103. **MR3177290**.
Statement by Candidate: I strongly support the central role of the AMS in promoting mathematical research and the interests of mathematicians, enhancing mathematics

education at all levels, and publicizing the developments in pure and applied mathematics. If elected, it would be my honor to serve on the Council to help the society accomplish these goals.

Ezra Miller

Professor of Mathematics, Duke University; Associate Director, Statistical and Applied Mathematical Sciences Institute (SAMSI).
Born: Maryland, 1974.
Ph.D.: University of California, Berkeley, 2000.
AMS Committees: AMS Southeastern Section Program Committee, 2012-2014; AMS Short Course Subcommittee, 2012-2015; AMS Fellows Selection Committee, 2013-2016.
Selected Addresses: Invited Address, AMS Sectional Meeting, Cincinnati, OH, 2006; Plenary Address, Formal Power Series and Algebraic Combinatorics, Tianjin, China, 2007; Lecture Series, CIMPA-TÜBITAK Summer School, Istanbul, Turkey, 2009; Invited Address, Geometry and Statistics in Bioimaging, Sandbjerg, Denmark, 2012; Invited Address, German Probability and Statistics Days, Ulm, Germany, 2014.
Additional Information: Alfred P. Sloan Doctoral Dissertation Fellow, 1999-2000; University of Minnesota "Thank a Teacher" award, 2004; NSF CAREER award, 2005-2010; University of Minnesota McKnight Presidential Fellow, 2007-2009; Fellow, American Mathematical Society, 2012; Editorial board member: *Advances in Math.*, *Discrete Math.*, *Beiträge zur Algebra und Geometrie, SIAM J. Discrete Math.*
Selected Publications: 1. with B. Sturmfels, *Combinatorial Commutative Algebra*, Graduate Texts in Mathematics, vol. 227, Springer-Verlag, New York, 2004. **MR2110098 (2006d:13001)**; 2. with A. Knutson, Gröbner geometry of Schubert polynomials, *Ann. of Math.*, **161** (2005), 1245-1318. **MR2180402 (2006i:05177)**; 3. with L. Matusevich and U. Walther, Homological methods for hypergeometric families, *J. Amer. Math. Soc.*, **18** (2005), no. 4, 919-941. **MR2163866 (2007d:13027)**. 4. with T. Hotz, S. Huckemann, H. Le, J. S. Marron, J. C. Mattingly, J. Nolen, M. Owen, V. Patrangenaru and S. Skwerer, Sticky central limit theorems on open books, *Ann. of Appl. Probab.*, **23** (2013), no. 6, 2238-2258. **MR3127934**; 5. with M. Gopalkrishnan and A. Shiu, A projection argument for differential inclusions, with applications to persistence of mass-action kinetics, *SIGMA Symmetry Integrability Geom. Methods Appl.*, **9** (2013), Paper 025, 25 pages. **MR3056169**.
Statement by Candidate: In today's evolving interdisciplinary world, it is vital that the mathematical community increase the real and perceived importance of our field and raise scientifically multilingual young practitioners. I would be honored to represent these interests on the Council, bringing to bear experiences running annual programs at MSRI and SAMSI as well as smaller-scale events at other institutes. These organizational activities have bolstered my research and mentoring in pure mathematics while additionally leading me to interactions between mathematics, statistics, and basic or applied sciences such as biology, chemistry, medical imaging, and neuroscience.

Mary Pugh

Associate Professor, University of Toronto.
Born: Washington, DC, 1966.
Ph.D.: University of Chicago, 1993.
AMS Committees: Editorial board of AMS *Proceedings of Symposia in Applied Mathematics*, 2003-2014 (chair, 2012-2014); AMS Centennial Fellowship Committee, 2004-2006; AMS Committee on Committees, 2005-2007; AMS-ASA-AWM-IMS-MAA-NCTM-SIAM Committee on Women in the Mathematical Sciences, 2005-2008; SIAM representative to the selection committee for the 2014 AMS-MAA-SIAM Porter Lecture.
Additional Information: National Science Foundation Post-Doctoral Fellowship, 1993-1994, 1995-1997; Alfred P. Sloan Fellowship, 1999-2003; extensive activity in SIAM, including election to two terms on SIAM Council, 2005-2010.
Selected Publications: 1. with M. Chugunova and R. M. Taranets, Nonnegative solutions for a long-wave unstable thin film equation with convection, *SIAM Journal on Mathematical Analysis*, **42** (2010), no. 4, 1826-1853. **MR2679597 (2011f:35177)**; 2. with D. Slepcev, Selfsimilar blowup of unstable thin-film equations, *Indiana Univ. Math. J.*, **54** (2005), no. 6, 1697-1738. **MR2189683 (2007a:35130)**; 3. with R. S. Laugesen, Linear stability of steady states for thin film and Cahn–Hilliard type equations, *Arch. Ration. Mech. Anal.*, **154** (2000), 3-51. **MR1778120 (2002k:35056)**; 4. with A. L. Bertozzi, The lubrication approximation for thin viscous films: Regularity and long time behavior of weak solutions, *Commun. Pure Appl. Math.*, **49** (1996), no. 2, 85-123. **MR1371925 (97b:35114)**; 5. with P. Constantin, Global solutions for small data to the Hele–Shaw problem, *Nonlinearity*, **6** (1993), no. 3, 393-416. **MR1223740 (94j:35142)**.
Statement by Candidate: I'm honored and excited to stand for election to the AMS council! The AMS does an excellent job serving and promoting the mathematics community. It provides an extensive and exciting collection of journals and books, runs many conferences a year, and is tireless in advocating the importance of mathematics. It is an effective, open, democratic, and welcoming society with many proud members.

I have been extensively involved with SIAM, including being elected to and serving two terms on SIAM council as well as serving on various other SIAM committees. Also, since 2001 I have been based in Canada. As a result, I would view things from a slightly different angle from many other council members—a valuable contribution, I hope.

One thing that I am especially concerned about are the options for students and postdocs who leave academia —we have provided them with wonderful mathematical training in many ways but there could be further support for those who choose to transition out of academia. And there are many things that we can learn from those using their mathematical training and skills outside of academia; it would be good to have more communication between these worlds.

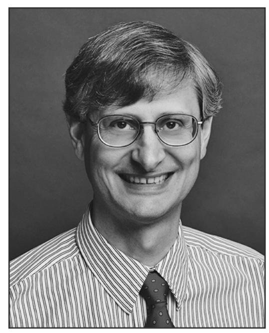
For example, the AMS offers corporate memberships. It would be interesting to have an AMS industrial internship program for students and postdocs. The AMS's reputation and stability would make it attractive for companies to commit to such partnerships. Among the benefits, interns would return to their home institutions with interesting and vital research problems, the boundaries between academia and non-academia would become more porous, and a successful internship program would recruit new corporate members and as well as benefit the existing corporate members.

Jared Wunsch

Professor of Mathematics and Department Chair, Northwestern University.
Born: 1971, Boston, MA.
Ph.D.: Harvard University, 1998.
AMS Committees: Central Section Speakers Committee, 2011-2013.
Additional information: Maître de Conférence Invité, Université de Paris XI, Orsay, May 2004; Professeur Invité, Université de Paris Nord, May-June, 2007; Research Professor, MSRI, 2008–2009; Distinguished Teaching Award in the Weinberg College of Arts and Sciences, Northwestern University, 2011; Professeur Invité, Université de Nantes, July 2013; Fellow of the AMS, 2013; Department Chair, Northwestern University Department of Mathematics, 2013-present.
Selected Addresses: Clay Mathematics Institute Summer School on Evolution Equations, ten-lecture course, ETH Zürich, June 2-July 4, 2008; MSRI Evans Lecture, Berkeley, September 2008; Invited address, Fall Central Section Meeting, Notre Dame, November 2010.
Selected Publications: 1. Propagation of singularities and growth for Schrödinger operators, *Duke Math. J.*, **98** (1999), 137-186. **MR1687567 (2000h:58054)**; 2. with R. Melrose, Propagation of singularities for the wave equation on conic manifolds, *Invent. Math.*, **156** (2004), no. 2, 235-299. **MR2052609 (2005e:58048)**; 3. with A. Hassell, The Schrödinger propagator for scattering metrics, *Ann. Math.*, **162** (2005), 487–523. **MR2178967 (2006k:58048)**; 4. with M. Zworski, Resolvent estimates for normally hyperbolic trapped sets, *Ann. Henri Poincaré*, **12** (2011), 1349–1385. **MR2846671**; 5. with R. Melrose and A. Vasy, Diffraction of singularities for the wave equation on manifolds with corners, *Astérisque*, **351** (2013). **MR3100155**.
Statement by candidate: Mathematics enjoys an unusually democratic social structure. The widespread recognition that great mathematical ideas can come from anywhere and anyone has mostly served to keep our community supportive of all its members. At the same time, considerable pressure from funding agencies and deans' offices is pushing us toward ever more focused celebration of the few biggest success stories, and the effects of the "star system" are ever more visible in academic recruitment and grant funding. We need to find ways of promoting our achievements to the wider world without betraying the interests of the larger math community. These are issues that I have faced on a small scale as a department chair and that the AMS is in a position to tackle much more broadly. Math is the apotheosis of a small science, and we need our achievements to be celebrated and our research funded without compromising our core values or our mission. Another central issue facing the AMS is the future of academic publishing. Careful consideration needs to be given to the headlong rush toward open access as well as to the need to accommodate e-books in the AMS's excellent book publishing operation.

Editorial Boards Committee

Todd Arbogast

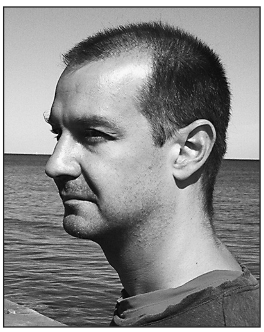


Professor of Mathematics, The University of Texas at Austin.
Born: December 9, 1957, Minneapolis, MN.
Ph.D.: University of Chicago, 1987.
Selected Addresses: Mathfest, Joint AMS and MAA invited address, "Mathematical simulation of flow in porous media," Minneapolis, MN, 1994; 13th International Conference on Domain Decomposition Methods plenary lecture, "A two-scale framework for approximating the solution of an elliptic equation," Lyon, France, 2000; Numerical Analysis of Multiscale Problems, LMS-EPSRC Durham Symposium plenary lectures, "Mixed multiscale methods for heterogeneous elliptic problems," Durham, England, 2010; Eighth International Conference on Scientific Computing and Applications semi-plenary lecture, "Multiscale mixed methods for heterogeneous elliptic problems," University of Nevada, Las Vegas, 2012; SIAM Conference on Mathematical and Computational Issues in the Geosciences plenary lecture, "Approximation of transport processes using Eulerian-Lagrangian techniques," Padova, Italy, 2013.
Additional Information: Associate Editor: *SIAM Journal on Numerical Analysis*, 1999-2013; Editorial Board Member: *Advances in Water Resources*, 2000-present; Program Director and Chair, SIAM Activity Group on Geosciences, 2007-2008, 2013-2014; Institute for Computational Engineering & Sciences Distinguished Research Award, University of Texas at Austin, 2011; Fellow of the AMS, appointed 2012.
Selected Publications: 1. with J. Douglas Jr. and U. Hornung, Derivation of the double porosity model of single phase flow via homogenization theory, *SIAM J. Math. Anal.*, **21** (1990), 823-836. **MR1052874 (91d:76074)**; 2. with Z. Chen, On the implementation of mixed methods as nonconforming methods for second-order elliptic problems, *Math. Comp.*, **64** (1995), 943–972. **MR1303084 (95k:65102)**; 3. with M. F. Wheeler, A characteristics-mixed finite element method for advection-dominated transport problems, *SIAM J. Numer. Anal.*,

32 (1995), 404-424. **MR1324295 (95m:65151)**; 4. with L. C. Cowsar, M. F. Wheeler and I. Yotov, Mixed finite element methods on nonmatching multiblock grids, *SIAM J. Numer. Anal.*, **37** (2000), 1295-1315. **MR1756426 (2001h:65140)**; 5. with G. Pencheva, M. F. Wheeler and I. Yotov, A multiscale mortar mixed finite element method, *Multiscale Model. Simul.*, **6** (2007), 319-346. MR2306414 (2008k:65234).

Statement by Candidate: One of the most important functions of the AMS is to publish first rate mathematics journals and books. The publishing industry is undergoing significant change; nevertheless, high standards are maintained by rigorous peer review and copyedited archival documents. If elected to the Editorial Boards Committee, I would strive to maintain the high standards and stature of AMS publications.

Danny Calegari



Professor of Mathematics, University of Chicago.

Born: May 24, 1972, Melbourne, Australia.

Ph.D.: University of California, Berkeley, 2000.

AMS Committees: Associate Editor, *Notices of the American Mathematical Society*, 2013-present.

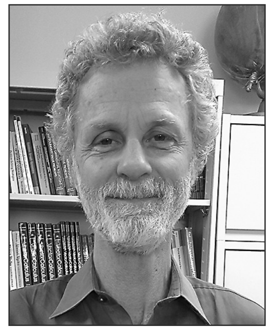
Selected Addresses: Clay Lecture Series, Melbourne-Sydney-Canberra-Adelaide, July-October 2009; Namboodiri Lectures, Chicago, April 2012; Blumenthal Lectures, Tel Aviv, January 2013.

Additional Information: Clay Research Award, 2009; Royal Society Wolfson Research Merit Award, 2011; AMS Fellow, 2012.

Selected Publications: 1. with D. Gabai, Shrinkwrapping and the taming of hyperbolic 3-manifolds, *J. Amer. Math. Soc.*, **19** (2006), no. 2, 385–446. **MR2188131 (2006g:57030)**; 2. *Foliations and the Geometry of 3-Manifolds*, Oxford Mathematical Monographs, Oxford University Press, Oxford (2007). **MR2327361 (2008k:57048)**; 3. Stable commutator length is rational in free groups, *J. Amer. Math. Soc.*, **22** (2009), no. 4, 941–961; 4. with M. Freedman and K. Walker, Positivity of the universal pairing in 3 dimensions, *J. Amer. Math. Soc.*, **23** (2010), no. 1, 107–188; 5. with A. Walker, Random groups contain surface subgroups, *J. Amer. Math. Soc.* (to appear).

Statement by Candidate: The AMS journals are a model for the near future of mathematical publishing, with their commitment to low cost, high quality, electronic accessibility, and open-minded copyright policy. It is important that much of the best that our discipline produces should be curated by a professional organization answerable to mathematicians, and not to commercial interests. Mathematics is deep, broad, and diverse; and the members of the AMS editorial boards should be receptive to depth, breadth, and diversity.

Richard Hain



Professor of Mathematics, Duke University.

Born: August 15, 1953, Sydney, Australia.

Ph.D.: University of Illinois, 1980.

AMS Offices: Member at Large of the Council, 2010-2013.

AMS Committees: Centennial Fellowship Committee, 1991-1993; Southeastern Section Program Committee, 2000-2001; Program Committee for National Meetings, 2003-2006 (chair, 2005-2006); Nominating Committee, 2003-2005; AMS-MAA Joint Program Committee, 2004-2005; Advisory Board for Employment Services, 2009-2011; Committee on Publications, 2010-2013.

Selected Addresses: Arbeitstagung, Bonn, 1988; AMS Invited Hour Address, Memphis, TN, 1997; Frontiers in Mathematics Lectures, Texas A&M University, 1997; Current Developments in Mathematics, Harvard-MIT, 2002; Course at IHES, May 2014.

Additional Information: Member, Institute for Advanced Study, 1985-1986, fall 1994, 2014-2015 and MSRI, spring, 2009; AMS Research Fellowship, 1987; Japan Society for the Promotion of Science Fellow, May, 1998; Special session organizer, AMS meeting, Memphis, 1997; Co-organizer of Duke Mathematical Journal Conferences, 1998, 2001, 2004; Special session co-organizer, AMS meeting, Melbourne, Australia, 1999; Department Chair, Duke University, 1999-2002, 2004-2006; Editor, *Illinois Journal of Mathematics*, 2002-2006; Director, IAS/Park City Mathematics Institute, September 2009-2014.

Selected Publications: 1. with S. Zucker, Unipotent variations of mixed Hodge structure, *Invent. Math.*, **88** (1987), 83-124. **MR0877008 (88i:32035)**; 2. Infinitesimal presentations of Torelli groups, *J. Amer. Math. Soc.*, **10** (1997), 597–651. **MR1431828 (97k:14024)**; 3. with E. Looijenga, Mapping class groups and moduli spaces of curves, *Algebraic Geometry-Santa Cruz 1995*, Proc. Symp. Pure Math., vol. 62 (1997), part II, 97–142. **MR1492535 (99a:14032)**; 4. Rational points of universal curves, *J. Amer. Math. Soc.*, vol. 24 (2011), no. 3, 709-769. **MR2784328 (2012f:14044)**; 4. Normal functions and the geometry of moduli spaces of curves, *Handbook of Moduli, vol. I*, edited by Gavril Farkas and Ian Morrison, Adv. Lect. Math., International Press, (2013), 527–578. **MR3184171**.

Statement by Candidate: One of the most important functions of the Society is to produce high quality, reasonably priced books and journals. This is particularly important in these days of constrained budgets. If elected, I will seek to identify individuals to serve on the editorial boards of AMS publications who will maintain the quality and integrity of the Society's publications.

Hee Oh

Professor of Mathematics, Yale University.
Born: October 27, 1969, Gwang-Ju, Korea.
Ph.D.: Yale University, 1997.
AMS Committees: Eastern sectional committee, 2014-2016.
Selected Addresses: Invited address, ICM, 2010; Joint AMS-MAA invited address, JMM, 2012; Heilbronn Distinguished lecture series, Bristol University, UK, 2013; Takagi lecture series, Kyoto, 2013; Plenary lecture, ICWM, 2014.
Additional Information: Scientific advisory board at American Institute of Mathematics, 2010-present; US delegate to the 17th IMU General Assembly, Gyeongju, Korea, 2014.
Selected Publications: 1. with L. Clozel and E. Ullmo, Hecke operators and equidistribution of Hecke points, *Invent. Math.*, **144** (2001), no. 2, 327-351. **MR1827734 (2002m:11044)**; 2. Uniform pointwise bounds for matrix coefficients of unitary representations and applications to Kazhdan constants, *Duke Math. J.*, **113** (2002), 133-192. **MR1905394 (2003d:22015)**; 3. with A. Eskin and S. Mozes, On uniform exponential growth for linear groups, *Invent. Math.*, **160** (2005), 1-30. **MR2129706 (2006a:20081)**. 4. with A. Kontorovich, Apollonian circle packings and closed horospheres on hyperbolic 3-manifolds, *J. Amer. Math. Soc.*, **24** (2011), 603-648. **MR2784325**. 5. with N. Shah, The asymptotic distribution of circles in the orbits of Kleinian groups, *Invent. Math.*, **187** (2012), 1-35. **MR2874933 (2012k:37011)**.
Statement by Candidate: I am honored to have been asked to run for election to the Editorial committee. The AMS journals play a very important role in publishing high quality research papers. If elected, I will do my best to select candidates with strong research credentials as well as a high level of responsibility in dealing with submissions in a timely manner.

2015 AMS Election

Nominations by Petition

Vice President or Member at Large

One position of vice president and member of the Council *ex officio* for a term of three years is to be filled in the election of 2015. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

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

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

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

Editorial Boards Committee

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

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

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

Nominating Committee

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

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

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

Rules and Procedures

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

1. To be considered, petitions must be addressed to Carla D. Savage, Secretary, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA, and must arrive by 24 February 2015.
2. The name of the candidate must be given as it appears in the *Combined Membership List* (www.ams.org/cml). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices*. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or by the candidate contacting the AMS headquarters in Providence (amsmem@ams.org).
3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.
4. On the next page is a sample form for petitions. Petitioners may make and use photocopies or reasonable facsimiles.
5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.
6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the *CML*. A name neither in the *CML* nor on the mailing lists is not that of a member. (Example: The name Carla D. Savage is that of a member. The name C. Savage appears not to be.)
7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.

Nomination Petition
for 2015 Election

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

____

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

- ☐ **Vice President** (term beginning 02/01/2016)
- ☐ **Member at Large of the Council** (term beginning 02/01/2016)
- ☐ **Member of the Nominating Committee** (term beginning 01/01/2016)
- ☐ **Member of the Editorial Boards Committee** (term beginning 02/01/2016)

of the American Mathematical Society.

Return petitions by 24 February 2015 to:
Secretary, AMS, 201 Charles Street, Providence, RI 02904-2294 USA

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

Doctoral Degrees Conferred

2012–2013

ALABAMA

Auburn University (15)

Department of Mathematics and Statistics

Bahmanian, Mohammad, Amalgamations and detachments of graphs and hypergraphs

Bindele, Huybrechts, Rank-based regression for nonlinear and missing models

Brown, Wesley, Modular balanced graphs

Carrigan, Braxton, Triangulations and simplex tilings of polyhedra

Clark, Jonathan, Nim on graphs

Couch, P. J. (Phillip), The metamorphosis of maximum packings of $2K_n$ with triples into maximum packings of $2K_n$ with 4-cycles

Jiang, Nan, Upper bounds on the coarsening rates for some non-conserving equations

Li, Geng, Semi-supervised classification techniques in big data text analytics

Liu, Xuhua, Gradient flows, convexity and adjoint orbits

Noble, Abigail, Maximal sets of Hamilton cycles in complete multipartite graphs

Ohlson, Vicky, Almost resolvable maximum packings of bipartite graphs with 4-cycles

Petrie, Caleb, On security, (F, I)-security, and ultra-security in graphs

Roberts, Daniel, Stars and hyperstars

Thompson, Mary Clair, Asymptotic results in noncompact semisimple Lie groups

Whitt, Thomas, Path decompositions of the Kneser graph

University of Alabama (4)

Department of Mathematics

Chen, Jing, Most likely path to the shortfall risk in long-term hedging with short-term future contracts

Holloway, Caleb, Wolff's theorem on ideals for mathematics

Karatas, Yalcin, Groups whose non-permutable subgroups satisfy certain conditions

Ross, Lance, Context sensitive languages and word problems

University of Alabama at Birmingham (5)

Department of Biostatistics

Mbowe, Omar, An investigation of the effect of misspecifying the random effect distribution and the incorrect assumption of equal intraclass correlation coefficients among treatment groups in the analyses of data from cluster randomized trials

Yang, Celeste T., Hypothesis tests of equivalence and their application to microarray and clinical trial data

Department of Mathematics

Bledsoe, Matthew, Resonances and inverse scattering

Huang, Qizhuo, Geometric fitting in errors-in-variables model

Ma, Hui, Geometric fitting of quadratic curves and surfaces

University of Alabama-Tuscaloosa (2)

Information Systems, Statistics, and Management Science Department

Mercado, Gary, On the detection and estimation of changes in a process mean based on kernel estimators

Oh, Dong-Yop, GA-Boost: A genetic algorithm for robust boosting

ARIZONA

Arizona State University (10)

School of Human Evolution and Social Change

Murillo, David, Cites in ecology: Settlement patterns and diseases

Salau, Kehinde, Assessing the effects of institutional and spatial arrangements in analytical and computational models of conservation

Vega-Guzman, Jose, Solution methods for certain diffusion-type equations

School of Mathematical and Statistical Sciences

Bilinsky, Lydia, Dynamic Hopf bifurcation in spatially extended excitable systems from neuroscience

Horan, Victoria, Listing combinatorial objects

Huang, Qing, Some topics concerning the singular value decomposition and generalized singular value decomposition

Jones, Jeremiah, Drift-diffusion simulation of the ephaptic effect in the triad synapse of the retina

Li, Jingjin, Multivariate generalization of reduced major axis regression

Rabern, Landon, Coloring graphs from almost maximum degree sized palettes

Smith, Matt, On-line coloring of partial orders, circular arc graphs, and trees

University of Arizona (11)

Department of Mathematics

Acosta, Enrique, Leading order asymptotics of a partition function for colored triangulations

Bishop, Michael, Low energy states of quantum systems in disordered Bernoulli environments

Hadad, Yaron, Integrable nonlinear relativistic equations

Nguyen, Dong Quan, Nonexistence of rational points on certain varieties

Park, Chol, Semi-stable deformation rings in Hodge-Tate weights $(0, 1, 2)$

Schaeffer Fry, Amanda, Irreducible representations of finite groups of Lie type: On the irreducible restriction problem and some local-global conjectures

Smith, Ryan, Serre weights: The partially ramified case

The above list contains the names and thesis titles of recipients of doctoral degrees in the mathematical sciences (July 1, 2012, to June 30, 2013) reported in the 2013 Annual Survey of the Mathematical Sciences by 197 departments in 143 universities in the United States. Each entry contains the name of the recipient and the thesis title. The number in parentheses following the name of the university is the number of degrees listed for that university. A supplementary list containing names received since compilation of this list will appear in a later 2014 issue of the *Notices*.

Program in Applied Mathematics

Fry, Brendan, Theoretical models for blood flow regulation in heterogeneous microvascular networks

Hottovy, Scott, The Smoluchowski-Kramers approximation for stochastic differential equations with arbitrary state-dependent friction

McGuire, Luke, Modeling the evolution of Rill networks, debris fans, and cinder cones: Connections between sediment transport processes and landscape development

Tolwinski-Ward, Susan, Inference on tree-ring width and paleoclimate using a proxy model of intermediate complexity

ARKANSAS

University of Arkansas at Fayetteville (3)

Department of Mathematical Sciences

Bloomfield, Nathan, On the representation of inverse-semigroups by difunctional relations

Espinosa Lucio, Belen, Hardy space properties of the Cauchy kernel function for strictly convex planar domain

Myers, Jeanine, The effect of symmetry on the Riemann map

CALIFORNIA

California Institute of Technology (9)

Department of Computing and Mathematical Sciences

Cheng, Mulin, Adaptive methods exploring intrinsic sparse structures of stochastic partial differential equations

Elling, Timothy, GPU-accelerated Fourier-continuation solvers and physically-exact computational boundary conditions for wave scattering problems

Gittens, Alex, Topics in randomized numerical linear algebra

McCoy, Michael, A geometric analysis of convex demixing

Department of Mathematics

Bartlett, Padraic, Completions of ε-dense Latin squares

Peskin, Laura, Ordinary mod p representations of the metaplectic cover of p-adic SL_2

Teh, Kevin, Dirac spectra, summation formulae, and the spectral action

van Garrel, Michel, Relative mirror symmetry and ramifications of a formula for Gromov-Witten invariants

Wong, Wing Hong Tony, Diagonal forms, linear algebraic methods and Ramsey-type problems

Claremont Graduate University (16)

Institute of Mathematical Sciences

Baik, Eunsil, Dynamics of two-component Bose-Einstein condensates

Berggren, Susan Anne Elizabeth, Computational and mathematical modeling of coupled superconducting quantum interference devices

Billen, Joris, Simulated associating polymer networks

Bliss, David Atwood, Periodic boundary value problems and the Dancer-Fucik spectrum under conditions of resonance

Caplan, Ronald Meyer, Study of vortex ring dynamics in the nonlinear Schrödinger equation utilizing GPU-accelerated high-order compact numerical integrators

Che, Xiaoyu, Joint modeling and analysis of recurrent and terminal events

De Cecchis, Dany, Development of a parallel coupler library with minimal inter-process synchronization

Frumkin, Jesse Peter, Induction of chromosome instability by gene dosage and over-expression in saccharomyces cerevisiae

Glueck, Ruben Jeffrey, Pseudo-spectral and Kronecker product methods for fourth order partial differential equations

Lo, Shin-en, A fire spread model using level set methods

Moberly, Raymond Bion, Quantization of a low-density parity-check (LDPC) decoder

Navarro, Rafael, Dynamical properties of Bose-Einstein condensates

Schmieder, Robert Armin, A framework for identifying antibiotic resistance in the human microbiome

Shu, Jody Hewychun, Autonomous voice and motion controlled video camera system for instructional technology

Wilson, Jonathon Louis, Advancements in elicitation, aggregation, and forecasting of probability distributions under time constraints

Zarei, Sara, Mathematical modeling of cystic fibrosis

Stanford University (23)

Department of Mathematics

Bellovin, Rebecca, p-adic Hodge theory in rigid analytic families

Campbell, Jonathan, Some results on K-theory, topological Hochschild homology, and parameterized spectra

de Matos Geraldes Diogo, Luis, Filtered Floer and symplectic homology via Gromov-Witten theory

Fouladgar, Kaveh, Regularity theory for the symmetric minimal surface equation

Jiang, Yunjiang, Mixing time of Markov chains on finite and compact Lie groups

Kozai, Kenji, Singular hyperbolic structures on pseudo-Anosov mapping tori

Miller, Jeremy, The topology of spaces of J-holomorphc maps to CP^2

Murphy, Emmy, Loose Legendrian embeddings in high dimensional contact manifolds

Nance, Tracy, Equivariant algebraic k-theory of products of motivic circles

Peng, Minyu, Deviation inequalities for eigenvalues of deformed random matrices

Pham, Ha, A model diffractive boundary value problem on an asymptotically anti-de Sitter space

Radziwill, Maksym, Zero-distribution and size of the Riemann zeta-function on the critical line

Rubinstein-Salzedo, Simon, Controlling ramification in number fields

Stiennon, Nisan, The moduli space of real curves and a $Z/2$-equivariant Madsen-Weiss theorem

Zhao, James, A random walk through combinatorial probability

Zhou, Xin, On the variational methods for minimal submanifolds

Department of Statistics

Chen, Hao, Two graph-based tests for high-dimensional inference

He, Pei, Non-proportional hazards in clinical trials with failure time endpoints

Liao, Yueh-Wen, Adaptive design of clinical trials with interim selection of treatment arms

Mukherjee, Gourab, Sparsity and shrinkage in predictive density estimation

Ray, Nelson, Topics in two-sample testing

Simon, Noah, Interactions and high dimensional data

Su, Yong, Statistical methods for dynamical panel data and their applications

University of California, Berkeley (48)

Department of Mathematics

Bayer, Robertson, Lowness for computational speed

Berwick Evans, Daniel, Supersymmetric signal models, partition functions, and the Chern-Gauss-Bonnet theorem

Cramer, Scott, The inverse limit reflection and the structure of $L(V_{\lambda+1})$

Cristofaro-Gardiner, Daniel, Some results involving contact homology

Critch, Andrew, Algebraic geometry of hidden Markov and related models

DeIonno, John, Quasi-variational inequalities for source-expanding Hele-Shaw problems

Donatelli, Jeffrey, Reconstruction algorithms for x-ray nanocyst

Dyatlov, Semyon, Resonances in general relativity

Erhard, Julia, The Carlson-Simpson lemma in reverse mathematics

Ettinger, Boris, Well-posedness of the three-form field equation and the minimal surface equation in Minkowski space

Ghosh, Subhroshekar, Rigidity phenomena in random point sets

Grip Barros Ramos, Vinicius, The asymptotics of ECH capacities and absolute gradings on Floer homologies

Halpern-Leistner, Daniel, Geometric invariant theory and derived categories of coherent sheaves

Hartglass, Michael, Free probability, planar algebras and the multicolored Guinnot-Jones-Shylakhtenko construction

Hengesbach, Conrad, Prescribed mean curvature systems

Hening, Alexandru, Two models of default from finance and a model of invasion from ecology

Igusa, Gregory, Generic reduction, and work with partial computations and partial oracles

Iveson, Sarah, A special case of the k-Littlewood-Richardson rule for k-Schur functions

Johnson-Freyd, Theodore, Perturbative methods in path integration

Kazi, Michaeel K., Reconstruction from volume fraction data using variational techniques and level set methods

Kominiarczuk, Jakub, Acyclic Monte Carlo

Lin, Haijian Kevin, Two studies of topological quantum field theory in two dimensions

Martirosyan, Lilit, The representation theory of the exceptional Lie superalgebras $F(4)$ and $G(3)$

Oliveira e Silva, Diogo, Oscillatory integrals and external problems in harmonic analysis

Potter, Trevor, Dynamics and stability of rolling viscoelastic tires

Saye, Robert, The Voronoi implicit interface method and applications to multiphase fluid flow and multiscale modeling of foam dynamics

Seyfaddini, Sobhan, C^0 rigidity in Hofer geometry and Floer theory

Tran, Hung, Some new methods for Hamilton-Jacobi type nonlinear partial differential equations

Voroninski, Vladislav, Phaselift: A novel framework for phase retrieval

Wilson, Trevor, Contributions to descriptive inner model theory

Yoo, Hwajong, Modularity of residually reducible Galois representations and Eisenstein ideals

Department of Statistics

Abramson, Joshua, Some minorants and majorants of random walks and Lévy processes

Benjamini, Yuval, Predictive models in neuroscience and bioinformatics

Cai, Mu, High dimensional covariance estimation and variable selection

Gagnon-Bartsch, Johann, Removing unwanted variation from microarray data with negative controls

Heggeseth, Brianna, Longitudinal cluster analysis with applications to growth trajectories

Higgins, Michael, Applications of integer programming methods to solve statistical problems

Lee, Wayne, Bayesian analysis in problems with high dimensional data and complex dependence structure

Lin, Winston, Essays on causal inference in randomized experiments

Neeman, Joseph, Isoperimetry and noise sensitivity in Gaussian space

Purdy, David, Sparse models for sparse data: Methods, limitations, visualizations, and ensembles

Raskutti, Garvesh, Large-scale sparse regression models under weak assumptions

Ting, Daniel, Graphs and combinatorial representations of stochastic processes

Wang, Yueqing, Aerosol retrieval using remote-sensed observations

Group in Biostatistics

Chaffee, Paul, Targeted minimum loss based estimation for longitudinal data

Kim, Kyung Pil, Application of statistical methods to integrative analysis of genomic data

Li, Jingyi (Jessica), Statistical and computational methods for analyzing high-throughput genomic data

McLoughlin, Kevin Shane, Modeling and analysis of oligonucleotide microarray data for pathogen detection

University of California, Davis (15)

Department of Mathematics

Barrera-Rodriguez, Carlos, A collection of multicurve complexes

Dobrin, Adam, Exploring the effects of enforced proximity in enzyme reaction kinetics

Hildebrand, Robert, Algorithms and cutting planes for mixed integer programs

Hole, Jason, Well-posedness of the free-boundary compressible 3-D Euler equations with surface tension and the zero surface tension

Kemper, Yvonne, Problems of enumeration and realizability on matroids, simplicial complexes, and graphs

Mach, Paul, Protein sequence design for fold recognition using a new quantification of protein geometry

Travers, Nicholas, Bounds on convergence of entropy rate approximations in hidden Markov processes

Woei, Ernest, Characterization and clustering of dendritic trees using morphological features extracted by graph spectra

Xia, Jing, Finding disease associated genes from microarray data

Department of Statistics

Chen, Jun, Statistical methods for diffusion magnetic resonance imaging

Chen, Senke, Predictive modeling for clustered data with applications

Gottlieb, Andrea, Functional methods for stickiness and compositional longitudinal data

Qiao, Wanli, On estimation of filamentary structures

Tan, Zheng, Testing contagion in multivariate financial time series based on residual and recurrence times

Wang, Lu, Generalized exponential prediction for time series analysis

University of California, Irvine (19)

Department of Mathematics

Chen, Meng, Study of noise attenuation in feedback systems

Choi, Timothy, Kloosterman sums and L-functions

Faubion, Zachary, Improving the consistency strength of stationary set reflection at aleph omega plus one

Gong, Keqin, Portfolio optimization under multiscale volatility model

Huang, Chien-Hao, Random potentials for pinning models with interactions

Huber, Kenn, Disorder relevance in continuous time polymer models

Jankans, Jeremy, Tangent space of Chow variables

Mei, May, Spectral properties of primitive invertible substitution Schrödinger and Jacobi operators

Moobed, Shabnam, Multi-scale models of solid tumor growth from the cell level to the continuum

Nguyen, Son, The bootstrap multi-scale analysis for the multi-particle Anderson model

Ovadia, Jeremy, Computational modeling of tissue growth, organization, and patterning

Pachas, William, On the invariance principle and central limit theorems on stochastic flow

Rael, Michael, Results on the parabolic Anderson model

Wang, Fan, Fast calibration in SLV model

Wang, Jingyu, On the geometry of Beilinson quiver moduli spaces for P^2

Wong, Angela, Primality test using elliptic curves with complex multiplication by $Q(\sqrt{-7})$

Wu, Min, Modeling of microenvironmental fluid dynamics and vascular tumor growth

Yessen, William, Dynamical methods in one-dimensional quasi-periodic lattice models

Yin, Deliang, Paraxial coupling of electromagnetic waves in random media

University of California, Los Angeles (29)

DEPARTMENT OF BIOSTATISTICS, FIELDING SCHOOL OF PUBLIC HEALTH

He, Ren, Multiple imputation of high-dimensional mixed incomplete data

Jeffries, Robin, Sequential Bayesian regression for multiple imputation and conditional editing

Liao, Eileen, Challenges in high-throughput data analysis: Proteomic data preprocessing and network methods for integrating multiple data types

Shih, Vivian, Statistical methods for evaluating relational structures in multidimensional phenotypic data for neuropsychiatric disorders

DEPARTMENT OF MATHEMATICS

Baron, Joshua, Efficient secure computation and randomness

Compton, Ryan, Sparsity promoting optimization in quantum mechanical signal processing

Givens, Clinton, Measures of efficiency for secure multiparty computation

Hall, Michael, Spectral theory for semiclassical operators and artificial black holes

Hammock, Frances, POD investigations

Lane, Matthew, Generalized Atkin polynomials and non-ordinary hyperelliptic curves

Liu, Wenjian, The tightness of the Kesten-Stigum reconstruction bound

McKinlay, Christopher, Efficient algebraic representations for throughput-oriented algorithms

Navkal, Viraj, K'-theory of a Cohen-Macaulay local ring with n-cluster tilting object

O'Brien, Michael, The role of short-term synaptic plasticity in neural network spiking dynamics and in the learning of multiple distal rewards

Palumbo, Justin, Hechler forcing and its relatives

Stomakhin, Alexey, Part I: Reconstruction of missing data in social networks based on temporal patterns of interactions. Part II: Constitutive modeling in solid mechanics for graphics applications

Sun, Hui, Singular solutions and pattern formation in aggregation equations

Taylor, David, Moduli of hyperelliptic curves and invariants of binary forms

Thamrongthanyalak, Athipat, Extensions and smooth approximations of definable functions in O-minimal structures

Tong, Melissa, Restoration of images in the presence of Rician noise and in the presence of atmospheric turbulence

Tserunyan, Anush, Finite generators for countable group actions; finite index pairs of equivalence relations; complexity measures for recursive programs

Yang, Jed, Computational complexity and decidability of tileability

DEPARTMENT OF STATISTICS

Fellows, Ian, Exponential family random network models

Fu, Fei, Sparse causal network estimation with experimental intervention

Hu, Wenze, Integrating 3D and 2D representations for view invariant object recognition

Jaynes, Jessica, Contributions in design of experiments: Methods and applications

Kukuyeva, Irina, Array independent component analysis with application to remote sensing

Yau, Nathan, An online tool for personal data collection and exploration

You, Jiashen, A statistical modeling methodology for the analysis of term structure of credit risk and its dependency

University of California, Merced (1)

DEPARTMENT OF APPLIED MATHEMATICS

Kumar, Nitesh, Modeling dependence in data: Option pricing and random walks

University of California, Riverside (10)

DEPARTMENT OF MATHEMATICS

Gumaer, Dennis, A Jacobi field splitting theorem for positive curvature

Highfield, Matthew, Twisted graded Hecke algebras for elementary abelian groups

Quinn, John, Scale covariance of fractal sets and measures, a differential approach to the box-counting functions, with applications

DEPARTMENT OF APPLIED STATISTICS

Ambartsoumian, Tatevik, Cumulative sum algorithms based on nonparametric kernel density estimators

Ban, Jifei, Comparison of species assemblages using data depth and mixture model

Fu, Yingzhou (Joyce), Statistical process control tools for network monitoring using generalized linear mixed models

Hansen, Anne, Goodness-of-fit tests for autoregressive logistic regression models and generalized linear mixed models

Murillo, Gabriel, SNP calling using genotype model selection on high-throughput sequencing data

Yang, Cheng-Hsueh (Peter), Prediction intervals in generalized linear mixed models

Yu, Yao, Bayesian and non-parametric approaches to missing data analysis

University of California, San Diego (19)

DEPARTMENT OF MATHEMATICS

Banham, Timothy, A phase field model for cell shapes: Gamma-convergence and numerical simulations

Berglund, James, $\mathbb{Z}$-graded maximal orders of GK 3

Duane, Adrian Scott Campe, Pattern matching statistics in the permutations and the alternating permutations

Eustis, Alex, Hypergraph independence numbers

Hall, James, Convergence of Galerkin variational integrators for vector spaces and Lie groups

Hicks, Angela, Parking function polynomials and their relation to the Shuffle Conjecture

Hughes, Jacob, Stochastic processes arising from graph manipulations

Hummon, Benjamin, Surface diagrams for Gray categories

Jones, Miles, Consecutive matches in permutations and cycles

Kenter, Franklin H. J., On spectral properties of graph coloring, directed graphs, and hypergraphs

Kungurtsev, Vyacheslav, Second derivative sequential quadratic programming methods for nonlinear optimization

Lipshutz, David, Existence, uniqueness and stability of slowly oscillating periodic solutions for delay differential equations with non-negativity constraints

Meier, Caleb, Generalized solutions and non-uniqueness in the Einstein constraint equations: Some unresolved issues with the conformal formulation

Metti, Maximilian Sloan, Analysis of some higher order space-time moving finite element methods

Oliver, Jesus, A vector field method for non-trapping spacetimes

Parrish, Andrew, Adventures in graph Ramsey theory

Serencsa, Jonathan, A development of discretization techniques for some elliptic and hyperbolic PDE

Wilson, Ben, Topics in Khovanov homology

Yang, Bo, Some results on gradient Ricci solitons and complete Kähler manifolds with nonnegative curvature

University of California, Santa Barbara (17)

DEPARTMENT OF MATHEMATICS

Albrecht, Brent, Optimal mass transport and curvature bounds

Brighton, Kevin, Geometry of nonnegatively curved smooth metric spaces

Cass, Jonathan, Generalized arithmetic functions

Chang, Liang, Non-semisimple generalizations of Turaev-Viro TQFTs and their lattice model realizations

Grano, Ellie, Algorithms for planar algebras

Kabbabe, Tomas, In search of exceptional collections

Kennedy, Kathleen Grace, A diagrammatic multivariate Alexander invariant of tangles

Martin, Charles, Variational methods in potential theory and planar elliptic growth

Plunkett, Laura, An analysis of shape, scaling and knotting in polymer models with and without excluded volume

Thompson, Keith, Group actions on spaces with surface quotients

Valdman, David, Spectral methods for analyzing biological polymers

Yoshizawa, Michael, High distance Heegaard splittings via Dehn twists

Department of Statistics and Applied Probability

Gao, Chunkai, Diversification, systemic default and regulation

Kim, Mee-Kyung, Semi-parametric mixed-effect models for the analysis of QT intervals

Kulikova, Varvara, Mixture tests with contributions to the analysis of times between events in a LOB

Ren, Bin, Asymptotic behavior of worst case scenario prices in uncertain volatility models

Shen, Qunying, European option pricing in liquid markets

University of California, Santa Cruz (11)

Applied Mathematics and Statistics Department

He, Yuning, Variable-length functional output prediction and boundary detection for an adaptive control simulator

Wang, Ziwei, A Bayesian nonparametric modeling framework for extreme value analysis

Department of Mathematics

Batoreo, Marta, Coisotropic symplectic topology and periodic orbits in symplectic dynamics

Howard, Wyatt, The Monster Tower and action selectors

Jiao, Kiangyu, Quantum dimensions and quantum Galois theory

Nitz, Frederic, On lattice-like subgroups of Witt group schemes, and associated moduli spaces

O'Hare, Shawn, Fusion systems and biset functors via ghost algebras

Shanbrom, Corey, Two problems in sub-Riemannian geometry

Shelley, Christopher, An arithmetic construction of the Gaussian and Eisenstein topographs

Xu, Zhe, Spectral gaps of random Hecke operators

Yu, Nina, Representations of vertex operator algebras

University of Southern California (14)

Department of Mathematics

Courter, Rebecca, Computing higher indicators for the double of a symmetric group

Dreyer, Guillaume, Geometric properties of Anosov representations

Du, Jie, Stochastic games on stopping time

Huang, Yang, Homotopy classes of 2-plane fields in low dimensional topology

Ko, Hong Fu, Recurrence and Renyi entropy

Lin, Ning, Estimation on coefficients in stochastic differential equations

Moers, Michael, Statistical inference of stochastic differential equations driven by Gaussian noise

Nibert, Joel, Invariant measures of a stochastic predator prey model

Pham, Triet, Zero-sum stochastic differential games in weak foundation and related norms for semi-martingales

Song, Jinlin, Time-sequential testing for multiple hypotheses

Wang, Huanhuan, Asset management with incomplete information

Wang, Xin, Nonlinear expectations for continuous time model with jumps and applications

Xu, Shanshan, Non-parametric multivariate regression hypothesis testing

Zhong, Jie, Second order in time stochastic evolution equation and Wiener chaos approach

COLORADO

Colorado School of Mines (2)

Department of Applied Mathematics and Statistics

Lucero, Christian, Bayes risk *A*-optimal experimental design methods for ill-posed inverse problems

Thompson, Ty, Algorithms and analysis for simulation of deterministic and stochastic Ginzburg-Landau models

Colorado State University (9)

Department of Mathematics

Bayens, Luke, Hyperovals, Laguerre planes and hemisystems—an approach via symmetry

Brake, Daniel, Homotopy continuation methods, intrinsic localized modes, and cooperative robotic workspace

Marks, Justin, Mean variants on matrix manifolds

Rohrbacker, Nicholas, Sparse multivariate analyses via l_1-regularized optimization problems solved with Bregman iterative techniques

Williams, Cassandra, Conjugacy classes of matrix groups over local rings and an application to the enumeration of abelian varieties

Zou, Yang, Spatiotemporal complexity in Ginzburg Landau equations for anisotropic systems

Department of Statistics

Dahlke, Markk, Survey sampling with nonparametric regression: Endogenous post-stratification and penalized instrumental variables

Hernandez-Stumpfhauser, Daniel, Bayesian analysis of directional data based on the projected normal distribution

Weller, Grant, Joint tail modeling via regular variation with applications in climate and environmental studies

University of Colorado, Boulder (26)

Department of Applied Mathematics

Alexander, Zachary, A topology-based approach for nonlinear time series with applications in computer performance analysis

Baldwin, Douglas, Dispersive shock wave interactions and two-dimensional ocean-wave soliton interactions

Biagioni, David, Numerical construction of Green's functions in high-dimensional elliptic problems with variable coefficients and analysis of renewable energy data via sparse and separable approximations

Fox, Adam, Destruction of invariant tori in volume-preserving maps

Hammond, Jason, Analysis and simulation of partial differential equations in mathematical biology: Applications to bacterial biofilms and Fisher's equation

Hampton, Jerrad, Dissimilarity and optimal sampling in urn ensembles

Kaslovsky, Daniel, Analysis of high-dimensional data

Lewis, Ryan, Nonlinear approximations in filter design and wave propagation

Lipinski, Douglas, Efficient ridge tracking algorithms for computing Lagrangian coherent structures in fluid dynamics applications

Liu, Kuo, Hybrid first-order system least-squares finite element methods with the application to Stokes and Navier-Stokes equations

Mosovsky, Brock, Finite-time transport in aperiodic dynamical systems

Reeger, Jonah, A computational study of the fourth Painlevé equation and a discussion of Adams predictor-corrector methods

Reynolds, Matthew, Nonlinear approximations in tomography, quadrature construction, and multivariate reductions

Skardal, Per Sebastian, Periodic behavior in cardiac tissue: Dynamics

Taylor, Dane, Spectral theory for the robustness and dynamical properties of complex networks

Villavert, John, The analysis of some nonlinear partial differential equations

Wu, Yuqi, Parallel scalable domain decomposition methods for simulating blood flows in three-dimensional compliant arteries

Department of Mathematics

Chriestenson, Bryce, The real homotopy type of singular spaces via the Whitney-de Rham complex

Cong, Cui, Implicit space-time domain decomposition methods for stochastic parabolic partial differential equations

Gern, Tyson, Leading coefficients of Kazhdan-Lusztig polynomials in type D

Kish, Jonathan, Harmonic analysis on the positive rationals: Multiplicative functions and exceptional Dirichlet characters

Ma, Chao, Qualitative and quantitative analysis of nonlinear integral and differential equations

Martinez, Michael, The relative K-theory of an algebraic pair

McGregor-Dorsey, Zachary, Some properties of full heaps

Moore, Matthew, The undecidability of the definability of principal subcongruences

Wakefield, Nathan, Primitive divisors in generalized iterations of Chebyshev polynomials

University of Colorado, Denver (3)

Department of Biostatistics

Horton, Kenneth, A multiple-subject analysis of pulsatile hormones using birth-death Markov chain Monte Carlo

Pyle, Laura, Inference for incompletely observed longitudinal endpoints in clinical trials with application to trial monitoring

Sillau, Stefan, Local likelihood nonparametric and semi-parametric methods for longitudinal data applied to a study of air pollution and asthma

University of Denver (2)

Department of Mathematics

Greer, Mark, Loops and their permutation groups

Kirshtein, Jenya, Cayley-Dickson loops

University of Northern Colorado (2)

School of Mathematical Sciences

Glassmeyer, David, Secondary teacher models of quantitative reasoning

Yestness, Nissa, A study of undergraduate students' use of diagrams in understanding and constructing proofs about groups, subgroups, and isomorphisms

CONNECTICUT

University of Connecticut, Storrs (14)

Department of Mathematics

Daniels, Harris, Siegel functions, modular curves and Serre's uniformity problem

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Mathematics, Statistics and Computer Science Department

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Applied Mathematical and Computational Sciences

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Department of Biostatistics

Foster, Eric D., State-space time series clustering using discrepancies based on the Kullback-Leibler information and Mahalanobis distance

Kliethermes, Stephanie A., A Bayesian nonparametric approach to modeling longitudinal growth curves with non-normal outcomes

Mills, Elizabeth Dastrup, Adjusting for covariates in zero-inflated gamma and zero-inflated log-normal models for semicontinuous data

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Zupan, Alexander, Thin position, bridge structure, and monotonic simplification of knots

Department of Statistics and Actuarial Science

Li, Jinzheng, Statistical detection with weak signals via regularization

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KANSAS

Kansas State University (12)

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Wichita State University (2)

Department of Mathematics, Statistics, and Physics

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KENTUCKY

University of Kentucky (4)

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Hineman, Jay, The hydrodynamic flow of nematic liquid crystals in $\mathbb{R}^3$

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Department of Statistics

Wang, Zilong, Analysis of binary data via spatial-temporal autologistic regression models

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Caragianis, Christophe, Connected matchings in special families of graphs

Leidner, Maxfield, A study of the total coloring of graphs

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LSU Health Science Center, New Orleans (3)

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Burton, Jeffrey, Improved hypothesis tests for linear combinations of fixed effects parameters in nonlinear random effects models

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Computational Analysis and Modeling Program

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MARYLAND

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Galetto, Federico, Free resolutions of orbit closures for representations with finitely many orbits

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Stella, Salvatore, Discrete structures in finite type cluster algebras

Tufts University (3)

Department of Mathematics

Chen, Donghui, Numerical methods for edge preserving image restoration

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University of Massachusetts, Amherst (4)

Department of Mathematics and Statistics

Gasca-Aragon, Hugo, Data combination from multiple sources under measurement error

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Zhao, Yue, Improved computational methods for Bayesian tree models

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MICHIGAN

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Balm, Cheryl, Topics in knot theory: On generalized crossing changes and the additivity of the Turaev genus

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Musselman, Bernard, Diffusion for Markov wave equations

Pattakos, Nikolas, Continuity of weighted estimates in harmonic analysis with respect to the weight

Van Groningen, Gerard, Implicit solutions to the wave equation based on the method of lines transpose

Weiwen, Gu, A decomposition algorithm of skew-symmetric and skew-symmetrizable exchange matrices

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Michigan Technical University (4)

Department of Mathematical Sciences

Al-Jamal, Mohammad, Numerical solutions of elliptic inverse problems via the equation error method

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Molzon, Raymond, Berry-Esseen bounds for nonlinear statistics, and asymptotic relative efficiency between correlation statistics

Oakland University (1)

Department of Mathematics and Statistics

Lolla, Madhuri, Comparison of numerical methods for 2D crystals under anisotropic surface free energy and through evolution

University of Michigan (38)

Department of Biostatistics

Boonstra, Phil, Shrinkage methods utilizing auxiliary information to improve high-dimensional prediction models

Gao, Xin, Causal modeling with principal stratification to assess effects of treatment with partial compliance, noncompliance, and principal surrogacy in longitudinal and time-to-event settings

Gong, Qi, Semiparametric methods for estimating the effect of a longitudinal covariate and time-dependent treatment on survival using observational data with dependent censoring

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Hu, Chen, Semiparametric regression models for disease natural history and multiple events in cancer research

Hu, Youna, Statistical methods on emerging medical studies

Jia, Nan, Generalized statistical approaches for the design for phase I trials

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Li, Yijiang, Optimization and simulation of kidney paired donation programs

Ma, Yu, Analysis of marked recurrent events in the presence of a terminating event

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Sun, Rena, Evaluating failure outcomes with applications to transplant facility performance

Wang, Fei, Development of joint estimating equation approaches to merging clustered or longitudinal datasets from multiple biomedical studies

Wu, Meihua, Study design for longitudinal and high dimensional measures

Xiang, Fang, Developing pseudo-observation and multiple imputation approaches for analysis of dependently censored survival and quality adjusted survival data

Department of Mathematics

Ahn, Taeyong, Foliation structure for generalized Henon mappings

da Cunha, Aubrey, Turing machines, Cayley graphs, and inescapable groups

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Holland, Ashley, Penalized spline estimation in the partially linear model

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Zangeneh, Sahar, Model-based methods for robust finite population inference in the presence of external information

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Western Michigan University (5)

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University of Minnesota-Twin Cities (43)

Division of Biostatistics, School of Public Health

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Li, Shuzhen, Statistical modeling of signal detection in fMRI data

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Zhong, Wei, Bayesian adaptive designs in phase I/II clinical trials

School of Mathematics

Byrnes, Patrick, Structural aspects of differential posets

Chen, Haojie, Generalized complex structures on 4-manifolds

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Waters, Jiajia, Discontinuous Galerkin finite element methods for Maxwell's equations in dispersive and metamaterials media

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DEPARTMENT OF MATHEMATICS

Gottschlich, Avram, Elliptic curves from a statistical point of view

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DEPARTMENT OF MATHEMATICS AND STATISTICS

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NEUROSCIENCE INSTITUTE

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Department of Mathematics and Computer Science

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Stevens Institute of Technology (3)

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NEW MEXICO

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Zhang, Bingzhi, On composition data modeling and its biomedical applications

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Cornell University (18)

Department of Mathematics

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DEPARTMENT OF STATISTICAL SCIENCES

Cunningham, Caitlin, Markov methods for identifying ChIP-seq peaks

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Zeber, David, Extremal properties of Markov chains and the conditional extreme value model

Graduate Center, City University of New York (14)

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COURANT INSTITUTE OF MATHEMATICAL SCIENCES

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Mohylevskyy, Yevhen, Ergodicity and percolation for variants of one-dimensional voter models

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Zhu, Lingjiong, Nonlinear Hawkes processes

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INFORMATION, OPERATIONS, AND MANAGEMENT SCIENCES–STATISTICS GROUP

Kovtun, Vladimir, The value of information sharing in supply chains facing ARMA demand

Liu, Jun, 1. The slow convergence of OLS estimators and estimated portfolio weights under long-memory stochastic volatility; 2. Nonparametric tests of independence and Markov property for interval censored models; 3. Nonparametric estimation of the cumulative intensities in an interval censored competing risks model

Polytechnic Institute of New York University (1)

DEPARTMENT OF MATHEMATICS

Lazarashvili, Liana, A new normed space for acoustic inverse problems

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Department of Mathematics

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Popa, Alexandra, Two-point Gromov-Witten formulas for symplectic toric manifolds

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Young, Matthew, Self-dual Hall modules

Zhang, Yongsheng, Gluing techniques in calibrated geometry

University at Albany, SUNY (2)

Department of Mathematics and Statistics

DeGraw, Arthur, Optimal recovery of holomorphic functions from inaccurate information about integration type operators

Macrina, Amy, The spectral analysis of longitudinal data with applications to atmospheric variables

University at Buffalo, SUNY (8)

Department of Biostatistics

Attwood, Kristopher, Selected topics in two and three class ROC analysis

Brady, William, Methods for early phase clinical development

Kim, Song Eun, Efficient novel nonparametric tests and estimations with applications to biomedical studies

Tsai, Wan-Min, Advanced and novel parametric and nonparametric likelihood statistical techniques with applications in epidemiology

Department of Mathematics

Halliwell, Garry, An unconditionally stable spectral method for an isotropic thin-film equation

Huang, Huichi, Compact quantum group actions on compact quantum spaces

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Department of Biostatistics and Computational Biology

Chen, Zhen, A flexible copula model for bivariate survival data

Department of Mathematics

da Silva, Daniel, Non-concentration of energy in generalized wave maps

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Lester, Stephen, The distribution of values of the Riemann zeta-function

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Zhang, Xiang, A small data global well-posedness result for the 2 + 1-dimensional equivariant Fadeev model

NORTH CAROLINA

Duke University (14)

Department of Mathematics

Kim, Hyeongkwan, Gersten-Witt complex of Hirzebruch surfaces

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Parry, Alan, Wave dark matter and dwarf spheroidal galaxies

Department of Statistical Science

Banerjee, Anjishnu, Scalable nonparametric Bayes learning

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North Carolina State University (22)

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Attarian, Adam, Patient specific subset selection, estimation and validation of an HIV-1 model with censored observations under an optimal treatment schedule

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Kundu, Suprateek, Bayesian nonparametric methods for conditional distributions

Long, Dorothy Leann, Marginalized zero-inflated Poisson regression

Long, Dustin, Casual inference and principal stratification: Competing risks, bounds and surrogates

Powers, James, Population-averaged models for diagnostic accuracy studies and meta-analysis

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Fovargue, Lauren, Addressing the computational bottleneck of the immersed boundary method through multi-implicit and multi-rate strategies with time parallelism

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NORTH DAKOTA

North Dakota State University, Fargo (2)

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Anderson, Benjamin, NAK for Ext, ascent of module structures, and the blindness of extended modules

Hasenauer, Richard, Almost Dedekind domains and atomicity

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Air Force Institute of Technology (2)

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Poteet, Miriam, Parametrizing finite frames and optimal frame completion

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Case Western Reserve University (6)

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Ohio State University, Columbus (21)

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Wang, Xiaopei, Multi-way block models

Yin, Zhijun, Security of unbalanced oil-vinegar signature scheme

University of Toledo (2)

Department of Mathematics and Statistics

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Nikpour, Mehdi, Toeplitzness of composition operators and parametric Toeplitzness

OKLAHOMA

Oklahoma State University (5)

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Tanabe, Naomi, Arithmetic properties of L-functions attached to Hilbert modular forms

Department of Statistics

Lin, Lichi, Multivariate normal inference for heterogeneous samples and an application to meta analysis

Nicholson, Janae, Methods of genome association mapping with rate variants for normal responses

University of Oklahoma (8)

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Balasubramanian, Kumar, Self-dual representations with vectors fixed under an Iwahori subgroup

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Lee, Sang Rae, The geometry of Houghton's groups

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Lin, Weihua, Trinomial-tree distribution of a nonlinear positive stochastic interest rate model with connections to the potential approach and its application to computing corporate default risk

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OREGON

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Carnegie Mellon University (16)

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Hall, Robert, New statistical applications for differential privacy

Liu, Di, Comparing data sources in high dimensions

Studer, Cassandra, Incorporating learning over time into the cognitive assessment framework

Sweet, Tracy, Statistical network models for replications and experimental interventions

Drexel University (3)

Department of Mathematics

Jordon, Daniel, Spectral properties of differential operators with vanishing coefficients

Nolan, Kimberly, Forward and inverse Born series for diffuse, scalar, and electromagnetic waves

Yu, Le, Automorphisms of random trees

Lehigh University (2)

Department of Mathematics

Chen, Qiang, Some uniqueness and rigidity results on gradient Ricci solitons

Shelton, Brittany, Combinatorial interpretations of induced sign characters of the Hecke algebra

Pennsylvania State University (18)

Department of Mathematics

Ai, Chong, Effect of tidal dissipation on the motion of celestial bodies

Chen, Jianyu, Coexistence of hyperbolic and non-hyperbolic behavior in smooth dynamical systems

Chen, Yao, Algbraic multilevel methods for graph Laplacians

Crisp, Tyrone, Equivariant homology and representation theory of p-adic groups

Hong, Seunghun, A Lie-algebraic approach to the local index theorem on compact groups

Hong, Wei, Some problems in Poisson geometry

Huang, Jing-Jing, Analytic methods for Diophantine problems

Hudelson, William, Partial randomness and Kolmogorov complexity

Misiats, Oleksandr, Asymptotic analysis of Ginzburg-Landau superconductivity model

Nowakowski, Brian, On multi-parameter semimartingales, their integrals and weak convergence

Qu, Qingqin, The generalized finite element method, numerical treatment of singularities, interfaces and boundary conditions

Saadatpour Moghaddam, Assieh, Dynamic modeling of biological and physical systems

Siegel, Paul, Homological calculations with the analytic structure group

Tseng, Michael, Rokhlin actions on AF C^*-algebras and classifiability

Verma, Manoj, Representation of integers by a family of cubic forms in seven variables

Zhang, Jingyan, Shrinking dimer dynamics (SDD) and saddle point search

Zhang, Tianyou, The structure of solutions near a degenerate line for mixed type equations in gas dynamics

Zhu, Lin, Livšic theorem for cocycles with value in $GL(N, \mathbb{Q}_P)$

Pennsylvania State University, University Park (12)

Department of Statistics

Changpetc, Pannapa, Model selection for logistic regression via association rules

Fu, Guifang, Statistical models for mapping genes that contribute to shape variation

Jandarov, Roman, Inference with implicit likelihoods for infectious disease models

Kurum, Esra, Joint modeling of longitudinal binary and continuous responses

Lee, Kuang-Yao, A general theory of nonlinear sufficient dimension reduction: Formulation and estimation

Liu, Jingyuan, Statistical methods for different ultrahigh dimensional models

Simeonov, Ivan, Spatial point process modeling of viral infections in cell cultures

Vu, Duy, Statistical models and algorithms for large network analysis

Wang, Qing, Investigation of topics in U-statistics and their applications in risk estimation and cross-validation

Xu, Jialin, A generalized linear model for peak calling in ChIP-Seq data

Zambom, Adriano, Hypothesis testing and variable selection in nonparametric regression

Zhong, Wei, Feature screening and variable selection for ultrahigh dimensional data analysis

Temple University (5)

Department of Statistics

Cheng, Aili, Confidence regions for optimal controllable variables for the robust parameter design problem

Clements, Nicole, Multiple testing in grouped dependent data

Strandberg, Alicia, A nonparametric test for deviation from randomness

Su, Ying, Designs for testing lack of fit for a class of Sigmoid curve models

Turkoz, Ibrahim, Blinded evaluations of effect sizes in clinical trials: Comparisons between Bayesian and EM analysis

University of Pennsylvania (7)

Department of Mathematics

Abuzzahab, Omar, The 2-core of a random inhomogeneous hypergraph

Hasson, Hilaf, The prime-to-p part of étale fundamental groups of curves

Lu, Zhentao, Topics in quantum sheaf cohomology

Topaz, Adam, Commuting-liftable subgroups of Galois groups

Wei, Zhaoting, Baum-Connes conjecture, flag varieties and representations of semisimple Lie groups

Wharton Statistics Department

Entine, Oliver, Disease diagnosis from immunoassays with plate to plate variability

Wang, Pengyuan, Informative Bayesian modeling with applications to media data

University of Pittsburgh (24)

Department of Biostatistics

Adeniji, Abidemi, Incorporating diagnostic accuracy into the estimation of discrete survival function

Choi, Ji-In, Prediction in the joint modeling of mixed types of multivariate longitudinal outcomes and a time-to-event outcome

Emeremni, Chetachi, Inference for right censored, and right censored length biased data through inverse weighting

Fu, Bo, Joint modeling of time-to-event data with competing risks

Hong, Seo Yeon, Multilevel joint analysis of longitudinal and binary outcomes

Im, Kyung-Ah, A stochastic EM algorithm for G-rho family accelerated failure time model with random effects

Kidwell, Kelley, Survival analysis of shared-path adaptive treatment strategies

Ozbek, Umut, Statistical methods for recovering GWAS data

Pugh, Nathan, The use of multiple group outlier detection methods to identify informative brain regions in magnetic resonance images

Shah, Nilesh, The latent group-based trajectory model: Development of discrimination measures and joint modeling with subdistributions

Tu, Li-Chuan, The performance of biased-coin minimization in multicenter randomized clinical trials

Yabes, Jonathan, Semiparametric estimators in competing risks regression

Department of Mathematics

Everest, Thomas, Fixed points of nonexpansive maps on closed, bounded, convex sets in ℓ^1

Huang, Junming, Hierarchical structural models of portfolio credit risk

Jones, Christopher, Optimal mortgage prepayment under the Cox-Ingersoll-Ross model

Kovan-Bakan, Merve, Complexity of families of compact sets in $\mathbb{R}^N$

Liu, Zhuomin, Conformal mappings and isometric immersions under second order Sobolev regularity

Nezir, Veysel, Fixed point properties for c_0-like spaces

Smith, Daniel, Mathematical models of branching actin networks: Results and methods

Solovyev, Alexey, Formal computations and methods

Spardy, Lucy, Investigating the effects of network structure and afferent feedback in models of rhythmic movement

Department of Statistics

Jeong, Hyewook, The spectral analysis of nonstationary categorical time series using local spectral envelope

Shi, Haiwen, Parametric regression analysis and discrimination analysis of competing risk data

Zhang, Qi, Optimal procedures in high-dimensional variable selection

RHODE ISLAND

Brown University (11)

Department of Mathematics

Anderson, Jacqueline, p-adic analogues of the Mandelbrot set

Davis, Diana, Cutting sequences on translation surfaces

Hong, Younghun, Nonlinear Schroedinger equations with potentials

Hulse, Thomas A., Triple shifted sums of automorphic L-functions

Lim, Li-Mei, Multiple Dirichlet series associated to prehomogeneous spaces and the relation with $GL_3(\mathrm{Z})$ Eisenstein series

Muthiah, Dinakar, Double MV cycles, affine PBW bases and crystal combinatorics

Sprung, Florian, The arithmetic of elliptic curves in towers of number fields

Division of Applied Mathematics

Liu, Yufei, Large deviation theory for empirical measures: Explicit formulas and application to Monte Carlo

Yang, Yang, High order numerical methods for hyperbolic equations: Superconvergence, and applications to delta-singularities and cosmology

Zhang, Yifan, Discontinuous Galerkin methods for convection-diffusion equations: Positivity preserving and multiscale resolution

Zhu, Xueyu, Reduced basis methods and their applications

University of Rhode Island (7)

Department of Mathematics

Drymonis, Emmanouil, Patterns of boundedness of rational systems in the plane

Gilbert, Adam, Some results on graph representations and closure systems

Heissan, Mia, Some results on graph representations and graph colorings

Krul, Michael, Commutative algebra, Groebner bases, and hypergraph colorings

Lapierre, Evelina, On the global behavior of some systems of difference equations

Lugo, Gabriel, Unboundedness results for rational difference equations

Lynd, Chris, On the global character of some systems of rational difference equations in the plane

SOUTH CAROLINA

Clemson University (8)

Department of Mathematical Sciences

Cooper, John, Sparsity regularization in diffuse optical tomography

Gillam, Christopher, Sensitivity analysis in magnetic resonance elastography and a local wavelength based on wave direction

Muldoon, Frank, Polyhedral approximations of quadratic semi-assignment problems, disjunctive programs, and base-2 expansions of integer variables

Wang, Min, Bayesian hypothesis testing and variable selection in high-dimensional regression

White, Catherine, Sensitivity analysis and detectability of magnetic resonance elastography

Wickramarachchi, Tharanga, Asymptotics for the arc length of a multivariate time series and its applications as a measure of risk

Wilson, Nicholas, Physics-based algorithms and divergence-free finite elements for coupled flow problems

Zheng, Qi, Robust and efficient regression

Medical University of South Carolina (3)

Department of Public Health Sciences

Boan, Andrea, An assessment of the hospitalization rates and associated comorbid conditions in secondary stroke prevention

Parker, Anthony, New statistical methods for the analysis of periodontal data

Weng, Yanqiu, Impact of safety monitoring on efficacy analyses in large confirmatory group sequential trials with non-trivial safety event rate

University of South Carolina (14)

Department of Mathematics

Barwick, Brett, A computational approach to the Quillen-Suslin theorem, Buchsbaum-Eisenbud matrices, and generic Hilbert-Burch matrices

Basu, Kandapriya, Mathematical modeling and computational studies for cell signaling

Basu, Treena, Fast solution methods for fractional diffusion equations and their applications

Brown, Kenneth, Shimura images of a family of half-integral weight modular forms

Chen, Chen, Phase-field model for heterogeneous bio-film solvent interaction and 3-D numerical simulation by GPUs

Hankins, Jeffrey, The uniform box product of some spaces with one non-isolated point

Johnson, Virginia, Enumeration results on leaf-labeled trees

Mohr, Austin, Applications of the lopsided Lovasz local lemma regarding hypergraphs

Peng, Xing, Fractional chromatic numbers and spectra of graphs

Department of Statistics

Chen, Yuhui, Bayesian nonparametric models and tests for association in survival data

Du, Jiejun, Measurement error models in shape analysis

Feng, Yuling, Estimation and Q-matrix validation for diagnostic classification models

Lewis, Nicole, Protein identification using Bayesian stochastic search

Yang, Na, Modeling mixed unfolding/monotone dichotomous item exams

SOUTH DAKOTA

South Dakota State University (1)

Department of Mathematics and Statistics

Pottala, James, Advanced statistical methods for analyzing heart disease risk factors based on blood fatty acid data

TENNESSEE

University of Memphis (2)

Department of Mathematical Sciences

Riet, Ago-Erik, On integer sequences and packings and games on graphs

Wu, Yanan, Stochastic models of human kidney cancer

University of Tennessee, Knoxville (4)

Department of Mathematics

Eaton, Carrie, Modeling the genetic consequences of mutualism on communities

Guan, Zhen, First and second order unconditional energy stable schemes for nonlocal Cahn-Hilliard and Allen-Cahn equations

Penrod, Keith, Big homotopy theory

Rand, Ashley, Multiplicative sets of atoms

Vanderbilt University (9)

Department of Mathematics

Boatman, Nicholas Stephen, Partial-Burnside groups

Chen, Xuemei, Stability of compressed sensing for dictionaries and almost sure convergence rate for the Kaczmarz algorithm

Hull, Michael Bradley, Properties of acylindrically hyperbolic groups and their small cancellation quotients

Kapitanov, Georgi Ivanov, A mathematical model of cancer stem cell

Kent, Curtis A., Topological properties of asymptotic cones

LeCrone, Jeremy, On the axisymmetric surface diffusion flow

Wang, Lujun, Trivariate polynomial splines on 3D T-meshes

Wires, Alexander Duane, Some results in universal algebra

Young, William, An investigation of residuated lattices with modal operators

TEXAS

Baylor University (4)

Department of Mathematics

Sutherland, Shawn M., Existence of positive solutions to right focal threepoint singular boundary value problems

Department of Statistical Sciences

Bray, Ross, A bivariate regression model with correlated mixed responses

Falley, Brandi, Bayesian approaches for design of psychometric studies with underreporting and misclassification

Patrick, Joshua, Semiparametric estimation and forecasting for functional-coefficient autoregressive models

Rice University (9)

Computational and Applied Mathematics Department

Liu, Kun, Discontinuous Galerkin methods for parabolic partial differential equations with random input data

Sun, Dong, A nonlinear differential semblance algorithm for waveform inversion

Wang, Xin, Transfer-of-approximation approaches for subgrid modeling

Department of Mathematics

Martin, Taylor, Lower order solvability of links

McNeil, Reagan, A new filtration of the Magnus kernel

Department of Statistics

Banuelos, Rosa, A simulation-based approach to study rare variant association across the disease spectrum

Grolemund, Garrett, Tools and theory to improve data analysis

Hicks, Stephanie, Probabilistic models for genetic and genomic data with missing information

Silver, Justin, Robust parametric functional component estimation using a divergence family

Southern Methodist University (7)

Department of Mathematics

Case, Elizabeth, Numerical integral equations in solidification and melting problems

Pampell, Alyssa, Multiscale dynamics and stochastic forcing of the Atlantic meridional overturning circulation in conceptual models

Stein, Kurt, Complete radiation boundary conditions: Corner and edge closure conditions

Tiedeman, Hilari, Multilevel Schur complement preconditioning for multiphysics simulations

Statistical Science Department

Hu, Yalan, Spike detection and accommodation for functional magnetic resonance imaging data

Jayalath, Kalanka, Spatial point processes in pre-historic house structures

Turner, Jacob, A novel approach to modeling immunology data derived from flow cytometry

Texas A&M University (23)

Department of Mathematics

Brown, Donald, Multiscale methods for fluid-structure interaction with applications to deformable porous media

Chavez Dominguez, Javier, Operator ideals in Lipschitz and operator spaces categories

Ferguson, Lauren, Brittle fracture modeling with a surface tension excess property

Gou, Kun, Recovery of the shear modulus and residual stress of hyperelastic soft tissues by inverse spectral techniques

Irving, Corey, Wachspress varieties

Joshi, Sunnie, A model for the estimation of residual stresses in soft tissues

Kang, Seul-Ki, Multiscale simulation and uncertainty quantification techniques for Richards' equation in heterogeneous media

Martin Del Campo Sanchez, Abraham, Galois groups of Schubert problems

Mehmetoglu, Orhan, Stability and convergence of high order numerical methods for nonlinear hyperbolic conservation laws

Shroff, Piyush, Finite generation of cohomology of quotients of a PBW algebra

Wei, Jia, Reduced order model and uncertainty quantification for stochastic porous media flows

Yang, Ming, On partial and generic uniqueness of block term tensor decomposition in signal processing

Ye, Ke, Tensor network states, immanants and the geometric complexity theory program

Department of Statistics

Ball, Robyn, Statistical methods for high dimensional biomedical data

Crawford, Scott, Efficient estimation in a regression model with missing responses

Gaucher, Beverly, Factor analysis for skewed data and skew-normal maximum likelihood factor analysis

Jann, Dominic, Bayesian logistic regression with Jaro-Winkler string comparator scores provides sizable improvement in probabilistic record matching

Kim, Mi Jeong, Efficient semiparametric estimators for nonlinear regressions and models under sample selection bias

Kohli, Priya, Prediction and estimation of random fields

Mukhopadhyay, Subhadeep, Nonparametric inference for high dimensional data

Park, Jincheol, Bayesian analysis for large spatial data

Wang, Yiyi, Statistical models for next generation sequencing data

Zhang, Lin, Application of Bayesian hierarchical models in genetic data analysis

Texas State University-San Marcos (4)

Department of Mathematics

Gerber, Lindsey, The effects of a model developmental mathematics program on elementary and middle school preservice teachers

Jaster, Robert W., Inverting the classroom in college algebra: An examination of student perceptions and engagement and their effect on grade outcomes

Tennant, Aimee, Adult student learning behaviors in a roadblock mathematics course

Wilson, Aaron T., Developing measures of teachers' knowledge for teaching mathematics to Latino English language learners

Texas Tech University (7)

Department of Mathematics and Statistics

Bulut, Ummugul, Derivation of SDEs for correlated random walk models and phylogenetic trees

Cho, Jea-Pil, The Kauffman bracket skein algebra of the punctured torus

De Silva, Rondombage Nadeeka, Span of subcontinua

Kliewer, Anton, Parameter sensitivity for stochastic differential equations in tumor growth, exit distributions, and biomathematical modeling

Lahodny, Glenn, Persistence and extinction of disease in stochastic epidemic models and dynamically consistent discrete Lotka-Volterra competition models

Li, Siming, A new model for the simulation of dynamic clinical trials

Wickramasinghe, Indika, Extensions of saddlepoint-based bootstrap inference with application to moving average model of order one

University of Houston (8)

Department of Mathematics

Ankita, Jain, Data-driven techniques for estimation and stochastic reduction of multi-scale systems

Han, Qi, Exterior regularized harmonic and harmonic functions

Liao, Qing-Qing, Wavelet approaches to seismic data analysis

Negi, Pooran, Directional multiscale analysis using shearlet theory and applications

Shi, Lingling, Numerical simulation of cell motion in microchannels

Singh, Pankaj, Frames as codes for structured erasures

Tumel, Filiz, Random walks on a lattice with deterministic local dynamics

Zeleke, Kidist, Numerical simulations of surface acoustic wave-actuated cell sorting and enantiomer separation

University of North Texas (11)

Mathematics Department

Akter, Hasina, Real analyticity of Hausdorff dimension of disconnected Julia sets of cubic parabolic polynomials

Cohen, Michael, Descriptive set theory and measure theory in locally compact and non-locally compact groups

Das, Tushar, Kleinian groups in Hilbert space

Foster-Greenwood, Briana, Hochschild cohomology of skew group algebras

Herath, Dushanthi, Nonparametric estimation of receiver operating characteristic surfaces via Bernstein polynomials

Larsen, Jeannette, Equivalence classes of subquotients of pseudodifferential operator modules on the line

Pannu, Husanbir, Semi-supervised and self-evolving learning algorithms with application to anomaly detection in cloud computing

Paudel, Laxmi, Traveling wave solutions of the porous medium equation

Shi, Xiaohui (Rebecca), Graev metrics and isometry groups of Polish ultrametric spaces

Walker, Daniel, Determinacy-related consequences on limit superiors

Xuan, Mingzhi, On Steinhaus sets, orbit trees and universal properties of various families of subgroups in S_∞

University of Texas at Arlington (7)

Department of Mathematics

Chen, Linlin, On primitivity and dimension of finite semifields and their planes

Garrett, Charles, Numerical integration of matrix Riccati differential equations with solution singularities

Moon, Byungsoo, A study of the generalized two-component Hunter-Saxton system and Burger $\alpha\beta$ type equations

Rhoden, Aubrey, Applications and adaptions of a globally convergent method in inverse problems

Seaquist, Thomas, Optimal stopping for Markov modulated Ito diffusions with applications to finance

Uechi, Katsuhiro, Smooth quantile processes for right censored data

Veerapen, Padmini, Point modules over regular graded Clifford algebras

University of Texas at Austin (26)

Department of Mathematics

Alter, Mio, Differential $\mathbb{T}$-equivalent K-theory

Ballas, Samuel, Flexibility and rigidity of three-dimensional convex projective structures

Chang, Hector, Regularity for solutions of nonlocal fully nonlinear parabolic equations and free boundaries on two dimensional cones

Indrei, Emanuel, Optimal transport, free boundary regularity, and stability results for geometric and functional inequalities

Kim, Seong Jun, Numerical methods for highly oscillatory dynamical systems using multiscale structure

Lee, Yoonsang, Towards seamless multiscale computations

Maximo, Davi, On the blow-up of four-dimensional Ricci flow singularities

Monin, Phil, Essays on achieving investment targets and financial stability

Moore, Allison, Behavior of knot Floer homology under Conway and genus two mutation

Norfleet, Mark, Fuchsian groups of signature $(0:2,\ldots,2;1;0)$ with rational hyperbolic fixed points

Quitalo, Veronica, Regularity of a segregation problem with an optimal control operator

Rauh, Nick, Resultants and height bounds for zeros of homogeneous polynomial systems

Vipismakul, Wasin, The stabilizer of the group determinant and bounds for Lehmer's conjecture of finite abelian groups

Wu, Haotian, Analysis of Ricci flow on noncompact manifolds

Yao, Yuan, A criterion for toric varieties

Institute for Computational Engineering and Sciences

Blom, Ulf Martin, Automated prediction of human disease genes

Borden, Michael, Isogeometric analysis of phase-field models for dynamic brittle and ductile fracture

Bramwell, Jamie, A discontinuous Petrov-Galerkin method for seismic tomography problems

Garg, Vikram, Coupled flow systems, adjoint techniques and uncertainty quantification

Gatto, Paolo, Modeling bone conduction of sound in the human head via hp-finite elements

Kirschenmann, Thomas, A collection of Bayesian models of stochastic failure processes

Poulson, Jack, Fast parallel solution of heterogeneous 3D time-harmonic wave equations

Povich, Timothy, Discontinuous Galerkin (DG) methods for variable density groundwater flow and solute transport

Tsuji, Paul, Fast algorithms for frequency domain wave propagation

Windle, Jesse, Forecasting high-dimensional, time-varying variance-covariance matrices with high-frequency data and sampling Pólya-gamma random variates for posterior distributions derived from logistic likelihoods

Worthen, Jennifer, Inverse problems in mantle convection: Models, algorithms, and applications

University of Texas at Dallas (4)

Department of Mathematical Sciences

Nguyen, Minh Phuoc, Shape analysis using geometric features and diffeomorphic deformation

Nguyen, My Linh, Symmetric boundary value problems for vector nonlinear pendulum equation: Equivariant degree approach

Ogola, Gerald O., Statistical methods for planning and interpretation of prostate cancer biopsy sessions

Sengupta, Dishari, A robust linear mixed effects model with application to method comparison studies

University of Texas-School of Public Health (9)

Division of Biostatistics

Cheng, Lee, Developing the follow-up schedules for women with breast cancer

Gu, Xuemin, Clinical trial design for biomarker-based targeted therapy development

Huang, Furong, Robust effect sizes and their confidence intervals for group difference between trajectories in hierarchical linear growth model

Liang, Fu-Wen, Mixture modeling for joint analysis of survival, discrete and continuous data

Liu, Jun, Analyzing left-truncated right-censored data with uncertain onset time with parametric models

Liu, Ping, On Bayesian seamless phase I–II designs

Liu, Suyu, Bayesian adaptive designs in early phase clinical trials

Wang, Tao, A simulation study of the standard design, the rolling six design, the CRM and the modified CRM in phase I clinical trials

Zhang, Hong, Optimal and minimal two-stage designs in phase II dose clinical trials

UTAH

Brigham Young University (4)

Department of Mathematics

Francis, Amanda, New computational techniques in FJRW theory with applications to Landau-Ginzburg mirror symmetry

Li, Ji, Persistence and foliation theory for random dynamical systems and their application to geometric singular perturbation

Luo, Yi, Spread option pricing with stochastic interest rate

Turner, Emma, k-S-rings

University of Utah (3)

Department of Mathematics

Bannish, Brittany, Mathematical models of fibrinolysis

Graham, Erica, Mathematical models of mechanisms underlying long-term type 2 diabetes progression

Wood, Aaron, A minimal type of the 2-adic Weil representation

VIRGINIA

George Mason University (4)

Department of Mathematical Sciences

Beagley, Jonathan, Extremal combinatorics in geometry and graph theory

Berry, Tyrus, Model free techniques for reduction of high-dimensional dynamics

Department of Statistics

Parhat, Parwen, Randomization tests for regression models in clinical trials

Wang, Yang, Optimal randomization procedures for clinical trials

Old Dominion University (3)

Department of Mathematics and Statistics

Jayatillake, Rasika, A statistical model to determine multiple binding sites of a transcription factor on DNA using ChIP-seq data

Mushti, Sirisha, Analysis of continuous longitudinal data with ARMA(1,1) and antedependence correlation structures

Ravi, Bhaskara, Analysis of discrete probit models with structured correlation matrices

University of Virginia (13)

Department of Mathematics

Baltera, Constance, Coinvariant algebras and fake degrees for spin Weyl groups

Dobbs, Daniel, Properties of measures and processes related to Brownian motion on infinite-dimensional Heisenberg-like groups

Droms, Sean, Constructions of Stein fillings

Emerick, Timothy, A group-theoretic characterization of the unipotent radical

Graber, Philip, The wave equation with generalized nonlinear acoustic boundary conditions

Johnson, Joseph, $K(X)$: An equivariant K-theory functor from spaces to lambda-rings

Kleski, Craig, Boundaries for operator systems

Mazur, Kristen, On the structure of Mackey functors and Tambara functors

McCarty, Jason, The mod 2 homology of infinite loopspaces

Peng, Yung-Ning, Parabolic presentations of the super Yangian $Y(\mathfrak{gl}_{M/N})$ and applications

Pollio, Timothy, The multinorm principle

Webster, Justin, Analysis of flow-plate interactions: Semigroup well-posedness and long-time behavior

Yarnall, Carolyn, The slices of suspensions of HZ for cyclic p-groups

Virginia Commonwealth University, Medical Center (4)

Biostatistics Department

Carrico, Caroline, Characterization of a weighted quantile sum approach for highly correlated data in risk analysis scenarios

Carrico, Robert, Unbiased estimation for the contextual effect of duration of adolescent height growth on adulthood obesity and health outcomes via hierarchical linear and nonlinear models

Sheldon, Emily, Choosing the cut-point for a restricted mean in survival analysis, a data driven method

Sima, Adam, Accounting for model uncertainty in linear mixed-effects models

Virginia Polytechnic Institute and State University (14)

Department of Mathematics

Cao, Zhenwei, Quantum evolution: The case of weak localization for a 3D alloy-type Anderson model and application to Hamiltonian based quantum computation

Farlow, Kasie, The reflected quasipotential: Characterization and exploration

Foster, Erich, Finite elements for the quasi-geostrophic equations of the ocean

Leite Dos Santos Nunes, Vitor, Fréchet sensitivity analysis and parameter estimation in groundwater flow models

Mattox, Wade, Homology of group von Neumann algebras

Murrugarra Tomairo, David, Algebraic methods for modeling gene regulatory networks

Zhang, Xu, A posteriori error analysis for a discontinuous Galerkin method applied to hyperbolic problems on tetrahedral meshes

DEPARTMENT OF STATISTICS

Fang, Zaili, Some advanced model selection problems on nonparametric/semiparametric models for high dimensional data

Han, Chao, Bayesian visual analytics: Interactive visualization for high-dimensional data

Johnson, Nels G., Semiparametric regression methods with covariate measurement error

Kensler, Jennifer, Analysis of reliability experiments with random blocks and subsampling

Maiti, Dipayan, Model selection and averaging and interactive visual analytics for high-dimensional data

Xiao, Pei, Robust MEWMA-type control charts for monitoring the covariance matrix of multivariate processes

Xu, Liaosa, The design of GLR control charts for process monitoring

WASHINGTON

University of Washington (30)

APPLIED MATHEMATICS DEPARTMENT

Cain, Nicholas, Probabilistic, statistical, and dynamical models of neural decision making

Jacobs, Joshua, Vortex dynamics of geostrophically adjusted density perturbations in stratified incompressible fluids

Lemoine, Grady, Numerical modeling of poroelastic-fluid systems using high-resolution finite volume methods

Zhang, Yun, ETG-ETL portfolio optimization

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Zhou, Ying, Geographic range shifts under climate warming

BIOSTATISTICS DEPARTMENT

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Gabriel, Erin, Education of potential surrogate endpoints

Levin, Gregory, An evaluation of adaptive clinical trial designs with pre-specified rules for modifying the sampling plan

Pashova, Hristina, Methods for detection of interactions with multiple components

Ross, Michelle, The Bayesian analysis of data arising from complex sampling designs

Saegusa, Takumi, Weighted likelihood estimation under two-phase sampling

Teeple, Elizabeth, Adjusting for misclassified outcomes in a multistate model

Zhao, Shanshan, Covariate measurement error correction methods in mediation analysis with failure time data

Zheng, Xiuwen, Covariate measurement error correction methods in mediation analysis with failure time data

DEPARTMENT OF MATHEMATICS

Aholt, Christopher, Polynomials in multiview geometry

Blair-Stahn, Nathaniel, A geometric perspective on first-passage competition

Grigg, Nathan, Deformations of categories of coherent sheaves and Fourier-Mukai transforms

Ning, Weiyang, Markov chain mixing time, card shuffling and spin systems dynamics

Patrolia, Lee, The radiative transfer equation in photoacoustic imaging

Wang, Wenhan, Isolated curves for hyperelliptic curve cryptography

Wong, Chun Wai Carto, Smoothness of Loewner slits

DEPARTMENT OF STATISTICS

Bauer, Cici, Bayesian modeling of health data in space and time

Maravina, Tatiana, Tests for differences between least squares and robust regression parameter estimates and related topics

Palacios Roman, Julia, Bayesian nonparametric inference of effective population size trajectories from genomic data

Perrault-Joncas, Dominique, Learning and manifolds: Leveraging the intrinsic geometry

Wheldon, Mark, Bayesian population reconstruction: A method for estimating age- and sex-specific vital rates and population counts with uncertainty from fragmentary data

Washington State University (5)

DEPARTMENT OF MATHEMATICS

Smith, Gavin, Simplicial complexes and the Optimal Homologous Chain Problem

Trinh, Giang Bang, Computation of multivariate normal probabilities using bivariate conditioning with simulation

Van Dyke, Benjamin, Directional direct-search optimization methods with polling directions based on equal angle distributions

Van Dyke, Heather, A study of p-variation and the p-Laplacian for $0 < p < 1$ and finite hyperplane traversal algorithms for signal processing

Wu, Peiling, Tail densities of copulas and their applications to extremal dependence analysis of vines

WEST VIRGINIA

West Virginia University (7)

DEPARTMENT OF MATHEMATICS

Li, Ping, Cycles and bases of graphs and matroids

Liang, Yanting, Cycles, disjoint spanning trees and orientations of graphs

Wenliang, Tang, Circuits, perfect matchings, and paths in graphs

Wu, Yezhou, Integer flows and modulo orientations

Yao, Senmei, Group connectivity of graphs

Ye, Dong, Perfect matching and circuit cover of graphs

Zhang, Zheng, Optimal portfolio and consumption with transaction costs

WISCONSIN

Marquette University (2)

DEPARTMENT OF MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

Haque, Md, Mobile based symptom management for palliative care

Rahman, Farzana, Ensuring application specific security, privacy and performance goals in RFID systems

University of Wisconsin, Madison (33)

DEPARTMENT OF MATHEMATICS

Amorim, Lino, A Künneth theorem in Lagrangian Floer theory

Bao, Erkao, On J-holomorphic curves in almost complex manifolds with asymptotically cylindrical ends

Beros, Achilles, Applications of arithmetic complexity and priority arguments in algorithmic learning theory

Beros, Konstantinos, Descriptive group theory

Boonkasame, Anakewit, On propagation and stability of internal waves

Brown, George, Leonard triples associated with the anticommutator spin algebra

Deng, Qiang, Tropical cyclogenesis and vertical shear in a moist Boussinesq model

Durfee, Christina, Groups with a character of large degree relative to a normal subgroup

Garton, Derek, Random matrices and Cohen-Lenstra statistics for global fields with roots of unity

Li, Qin, Modeling and computation methods for multi-scale quantum dynamics and kinetic equations

Ling, Jie, Arithmetic intersection and resultants

Lock, Michael, Index theorems for anti-self-dual and self-dual orbifolds

Qi, Peng, Surface hopping and related problems

Seal, David, Discontinuous Galerkin methods for Vlasov models of plasma

Tumasz, Sarah, Topological mixing

Vincent, Christelle, Drinfeld modular forms modulo P and Weierstrass points on Drinfeld modular curves

Wang, Li, Numerical methods for multi-scale hyperbolic and kinetic equations

Wang, Rui, The contact triad connection and contact instantons

Wang, Zhan, Dynamics of strongly nonlinear water waves with capillary and flexure effects

Zhao, Luanlei, Period integral of automorphic Green functions

Department of Statistics

Chung, Dongjun, Statistical methods and software for ChIP-seq data analysis

Chung, Yujin, Inference of gene tree discordance and recombination

Dai, Bin, Multivariate Bernoulli distribution and its applications

Ding, Shilin, Learning graph structure with parametric and non-parametric models

He, Qiuling, Model-based analysis methods in statistical genomics

Hwang, Youngdeok, Topics on the design and analysis on computer experiments

Jin, Chongyang, Statistical modeling and inference for spatial categorical data

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Lin, Yunzhi, Model selection methods for cancer staging and other disease stratification problems

Moon, Jee Young, A causal gene network with genetic variations incorporating biological knowledge and latent variables

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Gaddis, Jason, PBW deformations of Artin-Schelter regular algebras and their homogenizations

Masaros, America, Category $\mathcal{O}$ representations of the Lie superalgebra $\mathfrak{osp}(3,2)$

Olivas Saunders, Rolando, Improved estimation of PM2.5 using Lagrangian satellite-measured aerosol optical depth

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University of Wyoming (5)

Department of Mathematics

Cerwinsky, Derrick, Algebraic multigrid (AMG) methods with an introduction to AMGLab

Lenth, Kevin, Application of a perturbation method to nonlinear stochastic PDEs

Quade, Eric, A new construction of viscous weak detonation profiles

Department of Statistics

Gemoets, Darren, Bayesian parameter estimation in dynamic ecological models

Singh, Sarabdeep, Statistical analysis of gene duplication data

Mathematics Calendar

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

September 2014

1–5 **International School on Mathematical Epidemiology-ISME 2014**, Strathmore University, Nairobi, Kenya. (May 2014, p. 555)
Description: ISME 2014 is the first school of annual series of international graduate schools on Mathematical Modelling in Biology and Medicine organized by CARMS of Strathmore University, Kenya. The school will include lectures on mathematical epidemiology, and one of the most important aspects will be projects for groups of 4.6 participants, mixing scientific backgrounds and levels of experience, and focusing on real-world problems around which participants develop and analyze models. It will also incorporate several lectures on public-health topics with focus on those relevant to other events such as global spread, indigenous population's health, vector-borne diseases and integration of surveillance, statistical data analysis and dynamical modelling and simulations.
Information: http://www.strathmore.edu/carms.

1–12 **Advanced School and Workshop on L-functions and modular forms**, The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy. (Aug. 2014, p. 794)
Description: This two-week activity consists of a school on aspects of computational algebra and number theory with an emphasis on modular forms and L-functions in the first week and a more focused workshop on the same theme in the second week. The school is intended for advanced graduate students and young researchers. During the school there will be lectures on both theoretical and computational aspects of algebra and number theory, including a general introduction to scientific computing. The afternoons will be devoted to concrete hands-on computational projects. The workshop in the second week will also have a computational bent, being part of the research project LMF: L-functions and Modular Forms (a six year Programme Grant from EPSRC, grant reference EP/K034383/1). The High Performance Computing staff at ICTP will take part of the workshop with the goal of helping the interested participants make the jump from desktops to bigger machines.
Information: http://agenda.ictp.it/smr.php?2602.

1–December 19 **Trimester program on Non-commutative Geometry and its Applications**, Hausdorff Research Institute for Mathematics, Bonn, Germany. (Nov. 2013, p. 1399)
Description: This two-week activity consists of a school on aspects of computational algebra and number theory with an emphasis on modular forms and L-functions in the first week and a more focused workshop on the same theme in the second week. The school is intended for advanced graduate students and young researchers. During the school there will be lectures on both theoretical and computational aspects of algebra and number theory, including a general introduction to scientific computing. The afternoons will be devoted to concrete hands-on computational projects. The workshop in the second week will also have a computational bent, being part of the research project LMF: L-functions and Modular Forms (a six year Programme Grant from EPSRC, grant reference EP/K034383/1). The High Performance Computing staff at ICTP will take part of the workshop with the goal of helping the interested participants make the jump from desktops to bigger machines.
Description: There will be four workshops during the trimester, a series of lecture courses aimed at postgraduate students and post-doctoral level researchers, and also a weekly seminar series on current research topics and a working seminar within that part of the program aimed at junior researchers.

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

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

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

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

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

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

Information: http://www.him.uni-bonn.de/programs/future-programs/future-trimester-programs/non-commutative-geometry-2014/description/.

2–5 **Black-Box Global Optimization: Fast Algorithms and Engineering Applications (part of the CST2014 Conference)**, Hotel Royal Continental, Naples, Italy. (Mar. 2014, p. 315)
Description: The aim of this session is to create a multidisciplinary discussion platform focused on new theoretical, computational and applied results in solving black-box multiextremal optimization problems. In these problems, frequently encountered in engineering design, the objective function and constraints (if any) are multidimensional functions with unknown analytical representations often evaluated by performing computationally expensive simulations. Researchers from both theoretical and applied sciences are welcome to present their recent developments concerning this important class of optimization problems. To encourage young researchers to attend these conferences a 1000 Euro Young (35 years or younger) Researcher Best Paper Prize will be awarded to the best paper presented at the conferences.
Deadlines: Submission of one-page abstracts: December 5, 2013. Notification of acceptance: December 20, 2013. Payment of the regular registration fee: April 15, 2014
Information: http://www.civil-comp.com/conf/cstect2014/cst2014-s23.htm.

2–5 **Introductory Workshop: Geometric Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2013, p. 1112)
Description: Geometric Representation Theory is a very active field, at the center of recent advances in Number Theory and Theoretical Physics. The principal goal of the Introductory Workshop will be to provide a gateway for graduate students and new post-docs to the rich and exciting, but potentially daunting, world of geometric representation theory. The aim is to explore some of the fundamental tools and ideas needed to work in the subject, helping build a cohort of young researchers versed in the geometric and physical sides of the Langlands philosophy.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9804.

2–5 **NUMAN2014 Recent Approaches to Numerical Analysis: Theory, Methods and Applications**, Chania, Crete, Greece. (Feb. 2014, p. 214)
Description: The themes of the conference are in the broad area of numerical analysis and applications, including numerical methods, algorithms and software; numerical and scientific computing; numerical methods and computational modeling; high-performance numerical computing. All areas of numerical analysis are considered, including numerical linear algebra; numerical solution of ODEs, PDEs and stochastic DEs. Several Workshops will be organized to highlight current mathematical, numerical and computational trends in areas of high scientific interest, including Mathematical Biology and Medicine; Enviromental Science and Engineering; Multiphysics/Multidomain Problems. We invite interested researchers to submit one-page abstracts, for lecture or poster presentations, by April 23, 2014.
Information: http://numan2014.amcl.tuc.gr.

2–5 **XXIII International Fall Workshop on Geometry and Physics**, Faculty of Sciences of Granada University, Granada, Spain. (Aug. 2014, p. 794)
Description: The Fall Workshops on Geometry and Physics have been held yearly since 1992, and bring together Spanish and Portuguese geometers and physicists, along with an ever increasing number of participants from outside the Iberian peninsula.
Aim: The meetings aim to provide a forum for the exchange of ideas between researchers of different fields in differential geometry, applied mathematics and physics, and always include a substantial number of enthusiastic young researchers amongst the participants. The Workshop is open to any topic in the interplay between geometry and physics, including classical theory of fields, control theory, integrable systems, Lie algebroids and mechanics, Lorentz geometry, mechanics of continuous media, poisson geometry, quantum gravity, quantum mechanics, relativity, Riemannian and pseudo-Riemannian geometry, string theory, supergravity and supersymmetry, and symplectic and contact geometry.
Deadline: For abstract submissions is May 31, 2014.
Information: http://gigda.ugr.es/ifwgp2014/.

2–7 **12th AHA Conference-Algebraic Hyperstructures and its Applications**, Democritus University of Thrace, School of Engineering, Department of Production and Management Engineering 67100, Xanthi, Greece International Algebraic Hyperstructures Association (IAHA). (Oct. 2013, p. 1204)
Description: The series of International Conferences on Algebraic Hyperstructures and Applications (AHA) aims at bringing together researchers and academics for the presentation and discussion of novel theories and applications of Algebraic Hyperstructures. The conference covers a broad spectrum of topics related to Algebraic Hyperstructures including (but not limited): Hypergroupoids, semihypergroups, hypergroups, hyperrings, hyperfields, hypervector spaces, hyperalgebras, hyperlattices, hv-structures, hv-matrices, hyperstructures associated with binary or n-ary relations, non-associative hyperstructures, join spaces, hyperstructures associated to geometric spaces, ordered hyperstructures, t-groupoids, partial semihypergroups, fuzzy algebraic hyperstructures, fuzzy/rough/soft sets and hyperstructures, cryptography, codes, assembly line design, graph and hypergraph theory, formal languages, automata, artificial intelligence, etc.
Information: http://aha2014.pme.duth.gr.

3–5 **4th IMA Numerical Linear Algebra and Optimisation**, University of Birmingham, Birmingham, United Kingdom. (Apr. 2014, p. 432)
Description: The success of modern methods for large-scale optimisation is heavily dependent on the use of effective tools of numerical linear algebra. On the other hand, many problems in numerical linear algebra lead to linear, nonlinear or semidefinite optimisation problems. The purpose of the conference is to bring together researchers from both communities and to find and communicate points and topics of common interest.
Information: http://www.ima.org.uk/conferences/conferences_calendar/4th_ima_conference_on_numerical_linear_algebra_and_optimisation.cfm.

3–5 **International Workshop on Operator Theory 2014 (iWOP2014)**, Queen's University Belfast, Belfast, Northern Ireland. (Mar. 2014, p. 316)
Description: This meeting intends to bring together mathematicians working in the areas of Operator Theory on Banach and on Hilbert space. The program will consist of six one-hour plenary lectures by the main speakers and contributed talks by the participants.
Information: http://iwop2014.martinmathieu.net/.

3–5 **Workshop on Finite Type Submanifolds**, Istanbul Technical University, Istanbul, Turkey. (Jun/Jul. 2014, p. 660)
Description: We aim to discuss the recent process on the theory of submanifolds; in particular, finite type mappings and finite type submanifolds. We will have invited talks and also some short talks on this topic. The invited talks will last 30 minutes plus 10 minutes for question and discussion. Short talks will last 15 minutes plus 7 minutes for question and discussion. In general, we want the speaker to give more details than a 15 minute plus regular talk in a symposium, because the workshop is aiming for the participiants who are related with this topic.
Information: http://www.matmuh.itu.edu.tr/Icerik.aspx?sid=12826.

5–6 **Symposium on Trustworthy Global Computing**, Rome, Italy. (Mar. 2014, p. 316)

Call for Papers: `http://www.cs.le.ac.uk/events/tgc2014/`. (co-located with Concur 2014). The Symposium on Trustworthy Global Computing is an international annual venue dedicated to secure and reliable computation in the so-called global computers, i.e., those computational abstractions emerging in large-scale infrastructures such as service-oriented architectures, autonomic systems, and cloud computing.

Highlights: Parallel submission to CONCUR 2014 allowed (see submission instructions below).

Keynote speakers: Véronique Cortier (CNRS, France) and Catuscia Palamidessi (INRIA Saclay and LIX, France).

Deadline for abstract submission: May 2, 2014. The TGC series focuses on providing frameworks, tools, algorithms, and protocols for rigorously designing, verifying, and implementing open-ended, large-scaled applications.

Information: `http://www.cs.le.ac.uk/events/tgc2014/`.

7–12 **Workshop on "Exceptional Orthogonal Polynomials and Exact Solutions in Mathematical Physics"**, Segovia, Spain. (Jun/Jul. 2014, p. 660)

Description: Exceptional orthogonal polynomials are dense families of Sturm-Liouville orthogonal polynomials with gaps in their degree sequence. They appear as eigenfunctions of rational extensions of exactly solvable potentials in quantum mechanics, and they are related to Darboux transformations and bispectrality in the theory of integrable systems. The past five years have seen a considerable activity in this field and we feel the time is ripe for bringing together many of the scientists who have contributed to this development, and others who might be interested in them.

Invited speakers: ∗ to be confirmed: Alexander P. Veselov (Loughborough University, UK), Robert Milson (Dalhousie University, Canada), Antonio Durán (Universidad de Sevilla, Spain), Alexei Zhedanov∗ (Donetsk Institute for Physics and Technology, Ukraine), Ryu Sasaki (Kyoto University, Japan), Luc Vinet (Centre de Recherches Mathématiques, Canada), Peter Clarkson (University of Kent, UK), Manuel Mañas (Universidad Complutense, Spain), Boris Shapiro∗ (Stockholm University, Sweden), Lance Littlejohn (Baylor University, United States).

Grants: There will be a limited number of grants for younger participants. Details on how to apply will be given in the website.

Information: Check the website below for detailed information on the scientific program, venue, sponsors, organizing committees, invited speakers, key dates and deadlines for abstract submissions is available, and will be updated in real time. `http://www.icmat.es/congresos/2014/xopconf/`.

8–11 **CICAM 7, Seventh China-Italy Colloquium on Applied Mathematics**, Palermo, Italy. (May 2014, p. 555)

Description: The Italian-Chinese Congress of Applied Mathematics was born in consequence of a long scientific collaboration between mathematicians at the University of Napoli, Catania, Bologna, Palermo and Torino and some universities of China. Over the years, there were two editions of the Conference in Napoli, three in China (Xian, Chonqing, Shanghai) and one in Catania. One of the main purposes of the conference is to strengthen and develop scientific cooperation between the research groups of Applied Mathematics, Physics and Biomathematics operating in Italy and China.

Information: `http://www.math.unipa.it/~cicam7`.

8–12 **Workshop on Special Geometric Structures in Mathematics and Physics**, University of Hamburg, Hamburg, Germany. (May 2014, p. 555)

Description: This 5-day workshop aims to bring together researchers in various fields of differential geometry with theoretical physicists. Each speaker will give two talks, one of which will be of a more introductory nature, thus making the workshop accessible also for Ph.D. students.

Information: `http://www.math.uni-hamburg.de/sgstructures/`.

8–17 **CIMPA Research School on "Operator theory and the principles of quantum mechanics"**, University Moulay Ismail, Meknes, Morocco. (Aug. 2014, p. 794)

Description: Linear Algebra and Operator Theory are powerful tools in the study of Quantum Mechanics. The main aim of this CIMPA research school is to introduce students, young researchers and all interested mathematicians having background in linear algebra and basic operator theory to the foundations of Quantum Mechanics and Quantum Information.

Information: `http://www.cimpa-icpam.org/spip.php?article581`.

8–December 5 **ICERM Semester Program: High-Dimensional Approximation**, Brown University, Providence, Rhode Island. (May 2014, p. 555)

Description: This program addresses a broad spectrum of approximation problems, from the approximation of functions in norm, to numerical integration, to computing minima, with a focus on sharp error estimates. It will explore the rich connections to the theory of distributions of point-sets in both Euclidean settings and on manifolds and to the computational complexity of continuous problems. It will address the issues of design of algorithms and of numerical experiments. The program will attract researchers in approximation theory, compressed sensing, optimization theory, discrepancy theory, and information based complexity theory.

Information: `http://icerm.brown.edu/sp-f14/`.

8–December 12 **Mathematics of Turbulence**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2013, p. 1204)

Description: This IPAM program is centered on fundamental issues in mathematical fluid dynamics, scientific computation, and applications including rigorous and reliable mathematical estimates of physically important quantities for solutions of the partial differential equations that are believed, in many situations, to accurately model the essential physical phenomena. This program will bring together physicists, engineers, analysts, and applied mathematicians to share problems, insights, results and solutions. Enhancing communications across these traditional disciplinary boundaries is a central goal of the program. An application and registration form are available online.

Application deadline: June 8, 2014.

Information: `http://www.ipam.ucla.edu/programs/mt2014/`.

9–12 **Summer School on Spectral Geometry**, University of Göttingen, Göttingen, Germany. (Jun/Jul. 2014, p. 661)

Description: This school event is jointly organized by the Research Training Groups "Mathematical Structures in Modern Quantum Physics" (`http://www.uni-goettingen.de/en/139006.html`) in Göttingen and "Analysis, Geometry and String Theory" (`http://www.grk1463.uni-hannover.de`) in Hannover. It will give current and prospective Ph.D. students an introduction to the fascinating subject of spectral geometry, with an emphasis on microlocal techniques. A particular focus will be on parabolic and hyperbolic methods in spectral geometry, while also a discussion of analytic torsion and of spectral zeta functions is offered. Participants will have an opportunity to present a poster.

Funding: Is available to a limited number of Ph.D. students.

Information: `http://www.uni-math.gwdg.de/SpecGeo2014/`.

10–12 **IMA Conference on Mathematical Modelling of Fluid Systems**, University of Bath, United Kingdom. (May 2014, p. 555)

Description: As the most versatile medium for transmitting signals and power, fluids (gas or liquid) have wide usage in industry. Fluid

systems are used in machine tool applications, vehicle control systems, where high power to weight ratio, accuracy and quick response are required. Fluid systems for industrial processes often involve networks consisting of tanks, pipes, orifices, valves, pumps and other flow devices. It is important to develop a systematic method to mathematically model different types of fluid systems for safe and optimal operations.
Information: http://www.ima.org.uk/conferences/conferences_calendar/ima_conference_on_mathematical_modelling_of_fluid_systems.html

11–13 **Second International Conference on Analysis and Applied Mathematics (ICAAM 2014)**, M. Auezov South Kazakhstan State University, Shymkent, Kazakhstan. (Apr. 2014, p. 432)
Aim: To bring mathematicians working in the area of analysis and applied mathematics together to share new trends of applications of mathematics. In mathematics, the developments in the field of applied mathematics open new research areas in analysis and vice versa. That is why we plan to found the conference series to provide a forum for researchers and scientists to communicate their recent developments and to present their original results in various fields of analysis and applied mathematics.
Information: http://www.icaam-online.org/index/.

14 **Future Directions in Commutative Rings Inspired by the Work of Laszlo Fuchs**, Tulane University, New Orleans, Louisiana. (Aug. 2014, p. 794)
Description: Laszlo Fuchs is an outstanding researcher and author, whose extraordinary productivity and influential monographs in the areas of abelian groups, ordered algebraic structures, rings, and modules, have directly impacted the growth and direction of research in these important areas of algebra for the past half century. He has published roughly 250 research papers, four very influential research monographs, and numerous lecture notes. This short conference will primarily focus on Prof. Fuchs' contributions to the theory of commutative rings, with some connections to noncommutative ring theory. His work in commutative rings accentuates the unifying nature of all his work in algebra, and is among his greatest contributions to the broader field. As impressive as his life's work is, Prof. Fuchs' most telling accomplishment has perhaps been his ability to help other researchers focus on the right problems.

14–18 **Getting Started with PDE - Summer Workshop for Undergraduate and Graduate Students**, Department of Mathematics, Technion - I.I.T., 32000 Haifa, Israel. (Jun/Jul. 2014, p. 661)
Description: The workshop's aim is to introduce undergraduate and graduate students in Mathematics, Science, and Engineering to a variety of subjects of current research in Partial Differential Equations and Applied Mathematics. The only required prerequisite is a basic undergraduate course in Partial Differential Equations. Four mini-courses will be given, by Xavier Cabre (Barcelona), Ross Pinsky (Technion), Jean-Michel Roquejoffre (Toulouse), and Koby Rubinstein (Technion). In addition, outreach lectures will be given by Ram Band (Technion), Haim Brezis (Rutgers University & Technion), Dan Mangoubi (Hebrew University), and Lenya Ryzhik (Stanford).
Information: http://www.math.technion.ac.il/cms/decade_2011-2020/year_2013-2014/PDE-workshop/.

15–19 **AIM Workshop: Generalized persistence and applications**, American Institute of Mathematics, Palo Alto, California. (Apr. 2014, p. 432)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to generalizations of persistent homology with a particular emphasis on finding calculable algebraic invariants useful for applications.
Information: http://aimath.org/workshops/upcoming/persistence.

15–19 **ICERM Semester Program Workshop: Information-Based Complexity and Stochastic Computation**, Brown University, Providence, Rhode Island. (Jun/Jul. 2014, p. 661)
Description: Topics covered in the workshop will include: adaptive and nonlinear approximation for SPDEs, infinite-dimensional problems, inverse and ill-posed problems, quasi-Monte Carlo methods, PDEs with random coefficients, sparse/Smolyak grids, stochastic multi-level algorithms, SDEs and SPDEs with nonstandard coefficients, tractability of multivariate problems. This workshop will bring together researchers from these different fields. The goal is to explore connections, learn and share techniques, and build bridges.
Information: http://icerm.brown.edu/sp-f14-w1/.

* 15–19 **Summer School of Mathematics for Economics and Social Sciences**, Fondazione Conservatorio Santa Chiara, San Miniato, Italy.
Description: The School aims to improve the knowledge of mathematical methods among graduate students in economics and social sciences, with a focus on techniques which, albeit widespread in use, are not properly covered in typical graduate programs. The School is an interdisciplinary venue intended to foster the interaction of people coming from the communities of mathematical and social scientists. Topics: The Evolution of Games and Social Contacts: Preferences, Norms and Interactions. Participation subject to selection. 20-25 positions available.
Organizer: Centro di Ricerca Matematica Ennio De Giorgi, Pisa, Italy.
Board and support: Board and accommodation provided. On-line application: http://www.crm.sns.it/event/304/financial.html. Application deadline: August 1, 2014. Syllabus: Evolutionary dynamics, Norms, learning and evolution of preferences, Stochastic stability, Social networks and cooperation, Network games A working knowledge of high-level programming language (e.g. Mathematica, MATLAB, Octave) would be useful.
Information: http://www.crm.sns.it/event/304/.

15–19 **Workshop 1: Ecology and Evolution of Cancer**, Mathematical Biosciences, Institute The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p. 661)
Description: This workshop will bring together cancer researchers and mathematical oncologists as well as ecologists with the aim of understanding how ecological principles can be used to understand cancer, how the mathematical tools used by theoretical ecologists could be used to gain new insights in cancer research and what principles of ecological management could be used to produce new therapies to treat cancer in the clinic.
Information: http://mbi.osu.edu/event/?id=495; phone: 614-292-3648.

17–20 **Joint Meeting of the German Mathematical Society (DMV) and the Polish Mathematical Society (PTM)**, The Faculty of Mathematics and Computer Science of the Adam Mickiewicz University, Campus UAM, Morasko, 61-616 Poznań, Poland. (Jun/Jul. 2014, p. 661)
Description: The meeting is a joint initiative of the Polish Mathematical Society (Polskie Towarzystwo Matematyczne) and the German Mathematical Society (Deutsche Mathematiker-Vereinigung). Mathematicians from other countries are also cordially invited to participate. There are 10 plenary lectures, 38 thematic sessions, an open general session "Contributed Talks", and the poster session.
Plenary speakers: Zbigniew Błocki (UJ, Kraków), Joachim Escher (Univ. Hannover), Friedrich Götze (Univ. Bielefeld), Joachim Hilgert (Univ. Paderborn), Grzegorz Karch (Univ. Wrocław), Adrian Langer (Univ. Warszawa), Tomasz Schoen (UAM Poznań), Katrin Tent (Univ. Münster), Barbara Wohlmut (Tech. Univ. München), Grzegorz Zwara (UMK, Toruń).
Information: For more information and for the program of the meeting as it becomes progressively available, please consult the webpage http://dmv.ptm.org.pl/.

17–20 **Third International Conference of Numerical Analysis and Approximation Theory (NAAT2014)**, Babes - Bolyai University, Faculty of Mathematics and Computer Science, Department of Mathematics, Cluj-Napoca, Romania. (Apr. 2014, p. 432)
Description: The conference is an opportunity for meeting and sharing ideas among researchers whose interest lies in function approximation, linear approximation processes, numerical analysis, statistics, stochastic processes.
Confirmed keynote speakers: Francesco Altomare (University of Bari, Italy), Francisco - Javier Muoz - Delgado (University of Jaen, Spain), Gradimir Milovanović; (Mathematical Institute of the Serbian Academy of Sciences and Arts, Serbia), Maria Neuss - Radu (University of Erlangen-Nürenberg, Germany), Gregory M. Nielson (Arizona State University, USA), Iuliu Sorin Pop (Eindhoven University of Technology, Netherlands), Björn Schmalfuss (Friedrich-Schiller-University, Jena, Germany).
Information: http://naat.math.ubbcluj.ro/.

18–20 **Riemann, Einstein and geometry**, Institut de Recherche Mathématique Avancée, University of Strasbourg, France. (Oct. 2013, p. 1204)
Description: The conference is part of a series of bi-annual conferences "Encounter between Mathematicians and Theoretical Physicists" and it is addressed to a large audience.
Organizers: Althanase Papadopoulos (Strasbourg) and Sumio Yamada (Tokyo).
Invited speakers: Jean-Pierre Bourguignon (Paris), Mihalis Dafermos (Princeton), Erwann Delay (Avignon), Jacques Franchi (Strasbourg), Hubert Goenner (Göttingen), Eric Gourgoulhon (Observatoire de Paris), Oussama Hijazi (Nancy), Gerhard Huisken (Tübingen), Emmanuel Humbert (Tours), Marc Mars (Salamanca), Andre Neves (Imperial College, London), Richard Schoen (Stanford) and Tetsuya Shiromizu (Kyoto).
Language: English. Some of the talks will be survey talks intended for a general audience. Graduate students and young mathematicians are welcome.
Registration: Is required (and free of charge) at this link. Hotel booking can be asked for through the registration link. For practical and other questions please email the organizers: Althanase Papadopoulos, xemailathanase.papadopoulos@math.unistra.fr|; Sumio Yamada, yamada@math.gakushuin.ac.jp.
Information: http://www-irma.u-strasbg.fr/article1377.html.

18–21 **The 22-nd Conference on Applied and Industrial Mathematics CAIM 2014**, University Vasile Alecsandri, Bacau, Romania. (Jun/Jul. 2014, p. 662)
Description: The sections of the conference are: Real, complex, functional and numerical analysis; partial differential equations with applications in mechanics, biology, etc.; ordinary differential equations, dynamical systems; probability theory, mathematical statistics, operation research; algebra, logic, geometry (with applications); mathematical modeling; computer science; education.
Information: http://www.romai.ro/conferintele_romai/caim2014_en.html.

* 19–21 **Cincinnati Symposium on Probability Theory and Applications 2014**, University of Cincinnati, Cincinnati, Ohio.
Description: Symposium will focus on current research in limit theorems for dependent structures, specifically focusing on recent advances in martingale approximations, long-range dependence phenomena and infinite ergodic theory, and spectra of large random matrices. The Symposium will have seven hour-long talks and seven half-hour talks, as well as a poster session.
Information: http://math.uc.edu/probability/.

* 20 **Conference on Credit Risk and Systemic Risk**, Boston University Mathematical Finance Program, Boston, Massachusetts.
Description: This event will bring together leading experts in the field. Presentations will provide perspective on issues pertaining to credit risk modeling and valuation, systemic risk and contagion, portfolio optimization with default, credit risk management and related computational and statistical methods.
Information: http://www.bu.edu/mathfinanceconference/.

20–21 **Sectional Meeting**, University of Wisconsin-Eau Claire, Eau Claire, Wisconsin. (Sept. 2013, p. 1112)
Description: 2014 Central Fall Section Meeting.
Information: http://www.ams.org/meetings/sectional/sectional.html.

21–26 **12th International Conference of The Mathematics Education into the 21st Century Project: The Future of Mathematics Education in a Connected World**, Hunguest Hotel Sun Resort, Herceg Novi, Montenegro. (Dec. 2013, p. 1497)
Description: This long running series of conferences (since 1999) brings together many innovative movers and shakers from around the world, and is renowned for its friendly and productive atmosphere. We now welcome proposals for papers and workshops in all areas of innovation in mathematics, science, computing and statistics education. There will be four working days including a half day excursion to the nearby UNESCO World Heritage old town of Dubrovnik. The hotel is in a beautiful bay on the Balkan Adriatic coast and is easily accessible from Dubrovnik and Tivot airports.
Information: http://www.hunguesthotels.hu/en/hotel/herceg_novi/hunguest_hotel_sun_resort/.

22–25 **5th International Workshop on Computational Topology in Image Context**, Timisoara, Romania. (Jun/Jul. 2014, p. 662)
Description: The general aim of CTIC workshops is to gather researchers dealing with the study of topological invariants from the computational point of view, and/or who want to use topological information in image applications. The specific aim of CTIC 2014 is to focus on the interplay between various methods of image processing and in particular on multi-dimensional and multi-variate image processing and on the efficient application of these new techniques in medical imagery. The workshop intends to provide an opportunity for participants, from different fields related to computational geometry, discrete geometry, geometrical modeling, algebraic topology and image processing to exchange ideas.
Information: http://ctic2014.synasc.ro/.

* 22–25 **International Conference on Applied and Geometrical Analysis**, Samarkand State University, Uzbekistan.
Conference organizers: 1. Samarkand State University, Uzbekistan; 2. National University of Uzbekistan, Tashkent, Uzbekistan; 3. Institute of Mathematics SB RAS, Novosibirsk, Russia; 4. Institute of Computational Mathematics and Mathematical Geophysics SB RAS, Novosibirsk, Russia; 5. Institute of Computational Technologies SB RAS, Novosibirsk, Russia National Research Novosibirsk State University, Russia; 6. Novosibirsk State Technical University, Russia. The Conference includes sightseeing Samarkand, also a trip to the city of Bukhara. Invited papers will be published in reputable peer-reviewed scientific journals. The conference abstracts will be published with ISBN assignment and registration system in RISC by the beginning of conference.
Languages: The working languages are English and Russian. The conference proceedings will be published in refereed journals worldwide.
Information: For registration visit: http://conf.abs.uz; email: azimkxon@gmail.com.

22–25 **Workshop on Statistical Inference for Lévy Processes**, Lorentz Center, Leiden, The Netherlands.
Invited speakers: Denis Belomestny; Loïc Chaumont; José Manuel Corcuera; Valentine Genon-Catalot; Marc Hoffmann; Jean Jacod; Cecilia Mancini; Yuliya Mishura; Antonis Papapantoleon; Philip Protter; Markus Reiß; Viktor Todorov; Mathias Vetter.

Registration: There is no registration fee, but the number of participants is limited. For more information, particularities and registration, see the website.
Information: http://tinyurl.com/ph86pbw.

22–26 **Boston University/Keio University workshop on Dynamical Systems**, Boston University, Boston, Massachuetts. (Jun/Jul. 2014, p. 662)
Description: This is the fourth in a series of annual workshops run jointly by Boston University (US) and Keio University (Japan) and aimed at exposing young researchers to topics of interest in the two departments. This year's focus will be Dynamical Systems, and the talks will be accessible to graduate students in that area. Morning sessions will involve talks by faculty, and afternoon sessions will involve talks by graduate students and postdocs. NSF funding is available to partially support the participation of graduate students and those whose Ph.D. was awarded in 2011 or later.
Information: http://math.bu.edu/keio2014/index.html.

22–26 **Logic and Applications - LAP 2014**, Inter-University Center, Dubrovnik, Croatia. (Jun/Jul. 2014, p. 662)
Description: The conference brings together researchers from various fields of logic with applications in computer science.
Topics: Of interest include, but are not restricted to: Formal systems of classical and non-classical logic, category theory, proof theory, lambda calculus; type theory; process algebras and calculi; behavioural types, systems of reasoning in the presence of incomplete, imprecise and/or contradictory information, computational complexity, interactive theorem provers. Student sessions will be organized. The first conference Proof Systems: Sustavi dokazivanja was held in Dubrovnik on June 28, 2012, co-located with the conference LICS 2012. The second conference Logic and Applications 2013: LAP 2013 was held in Dubrovnik, September 16–20, 2013.
Information: http://imft.ftn.uns.ac.rs/math/cms/LAP2014.

22–26 **Workshop on Tensor Valuations in Stochastic Geometry and Imaging**, Sandbjerg Estate, Soenderborg, Denmark. (Aug. 2014, p. 794)
Description: This workshop is dedicated to the mathematical theory and the application of tensor valuations in stochastic geometry and imaging. The workshop is a result of our desire to bring together researchers from stochastic geometry and imaging, who have an interest in the underlying mathematical theory of tensor valuations, along with mathematicians who have an interest in the (potential) application areas of tensor valuations. Also in recent years, there have been very important advances in the mathematical theory of tensor valuations, for instance, concerning the algebraic structure of tensor valuations and the characterization of local tensor measures. At the same time, tensor valuations are starting to be used in a number of research areas, primarily with the purpose of quantifying the morphology and anisotropy of complex spatial structures. At the workshop, overview lectures will be given by experts in the field. The workshop will also have shorter research talks.
Information: http://csgb.dk/activities/2014/tensor/.

22–30 **Summer school and conference on Finsler geometry and it applications**, University of the Aegean, Island of Samos, Greece. (Jun/Jul. 2014, p. 662)
Description: Summer school and conference on Finsler geometry and its applications, including metric geometry and Teichmüller theory. Ph.D. students and young researchers are welcome. There will be a series of courses given by Norbert A'Campo (Basel), Dimitri Burago (Penn State), Yuri Burago (Moscow), Bill Goldman (Maryland), Olivier Guichard (Strasbourg), Viktor Schroeder (Zürich), and Sumio Yamada (Tokyo). There will also be talks by other participants.
Registration: There is no registration fee and the organizers will help in finding lodging in Samos during the conference. To register, contact the organizers A. Papadopoulos and G. Tsapogas, email: papadop@math.unistra.fr and email: georgios.tsapogas@gmail.com.
Information: http://myria.math.aegean.gr/conferences/finsler14/.

23–25 **3rd International Conference on Mathematical Applications in Engineering 2014**, Kuala Lumpur, Malaysia. (Mar. 2014, p. 316)
Description: We are pleased to invite you and all your colleagues to participate in our great event, the 3rd International Conference on Mathematical Applications in Engineering 2014 (ICMAE.14).
Main objective: Of organizing this conference is to provide an international technical forum for engineers, academicians, scientists and researchers to present results of ongoing research in the field of Mathematical Applications in Engineering. The primary focus of the conference is to create an effective medium for institutions and industries to share ideas, innovations and problem solving techniques. For your information the past two conferences (ICMAE 2010, ICMAE2012) were sponsored by many good scientific journals and selected papers were published in those journals, which we are planning to do this time as well.
Information: http://www.iium.edu.my/icmae/14/.

* 25 **International Workshop on Nonlinear Analysis and Applications to Economics (Dedicated to Professor Dušan Repovš on his 60th birthday**, Department of Mathematics, University of Craiova, Romania.
Description: Nonlinear Analysis is nowadays one of the most collaborative and active scientific research fields as it has been increasingly involving the participation of experts from other disciplines. The aim of this Workshop on Applied Nonlinear Analysis is to present some successful achievements in this rapidly collaborative field, in strong relationship with relevant models in economics. The workshop is dedicated to Professor Dušan Repovš (University of Ljubljana) on his 60th birthday and for his honorary degree of Doctor Honoris Causa of the University of Craiova.
Invited Speakers: Massimiliano Ferrara (Univ. of Reggio Calabria), Giovanni Molica Bisci (Univ. of Reggio Calabria), Raffaella Servadei (Univ. of Calabria), Nicu Marcu (Univ. of Craiova).
Local Organizer: Vicentiu Radulescu.
Information: http://www.math.ucv.ro/~repovs2014.

26–28 **Entropy and Singular Solutions for Conservation Laws; Pressureless Gas Dynamics and Other Applications**, West Virginia University, Morgantown, West Virginia. (Aug. 2014, p. 794)
Description: For most of the significant equations of mathematical physics, it is impossible to show the existence of classical solutions even starting out from smooth initial values. On the other hand, if we consider distributional weak solutions, they fail to be unique. To overcome this obstacle, we use the entropy criterion as one of the admissibility criteria compatible with the Second Law of Thermodynamics, to help us single out a unique physically meaningful solution. Recently, the entropy criterion has also been used in connection with systems of pressureless gases to ensure uniqueness of solutions. This arises as a consequence of a deeper connection between scalar Conservation Laws (with rather general flux functions) and Pressureless Gas systems. Despite classical results on existence, uniqueness and stability of entropy solutions for Conservation Laws, there are applications that require the accommodation of more general, uncommon flux functions.
Information: http://math.wvu.edu/entropy2014/.

29–October 1 **MBI Boot Camp: How to Simulate and Analyze Your Cancer Models with COPASI**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p. 662)
Description: Mathematical models typically start out in simple form. One writes down a few differential equations, estimates the parameters, explores the output, and checks to see if it can predict behavior reasonably well. After that, the process begins to take on

a life of its own. Since the model is greatly abstracted and simplified, it captures some aspects of the system, but fails in others, so new variables and more inputs are added. Alternative mechanisms are investigated. At some point, the question arises: How can one tell if this is a good model?
Aim: The aim of this bootcamp is to provide tools that provide good cancer models. We will frame the question in a way that respects both the biology and the underlying mathematics. Two organizers of the bootcamp, Pedro Mendes and Stefan Hoops, have spent the last twenty years creating a bridge between these paradigms, in the form of a software package called COPASI (COmplex PAthway SImulator). COPASI is a simulation software that allows one to translate the biochemical interactions between species into dynamical systems represented by the sets of either stochastic or deterministic equations. COPASI developers have created a user-friendly graphical interface, which can help researchers to apply sophisticated analytical tools to their models. This workshop provides an introduction to the ease and power of the software.
Information: `http://mbi.osu.edu/event/?id=757`; phone: 614-292-3648.

29–October 3 **AIM Workshop: Quantum curves, Hitchin systems, and the Eynard-Orantin theory**, American Institute of Mathematics, Palo Alto, California. (May 2014, p. 555)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to establishing a mathematical theory of quantum curves.
Information: `http://aimath.org/workshops/upcoming/quantumcurves`.

29–October 3 **ICERM Semester Program Workshop: Approximation, Integration, and Optimization**, Brown University, Providence, Rhode Island. (Jun/Jul. 2014, p. 662)
Description: The workshop is devoted to the following problem of fundamental importance throughout science and engineering: how to approximate, integrate, or optimize multivariate functions. The workshop will bring together leading experts in approximation, compressed sensing and optimization.
Information: `http://icerm.brown.edu/sp-f14-w2/`.

29–October 3 **International Conference on Numerical and Mathematical Modeling of Flow and Transport in Porous Media**, Centre for Advanced Academic Studies (CAAS), 20000 Dubrovnik, Croatia. (Jan. 2014, p. 92)
Description: The aim of the conference is to bring together researchers, scientists, engineers, and students to exchange and share their experiences, new ideas, and research results about modeling, analysis and simulation of flow and transport in porous media and application to problems including subsurface hydrology, petroleum exploration, contaminant remediation, carbon sequestration and nuclear waste storage.
Information: `http://www.caas.unizg.hr`; `http://nm2porousmedia.math.pmf.unizg.hr/index.html`.

October 2014

5–11 **International Conference on Algebraic Methods in Dynamical Systems (Conference in honour of the 60th birthday of Juan J. Morales-Ruiz)**, Universidad del Norte, Barranquilla, Colombia. (Jan. 2014, p. 92)
Main topics: Linear Differential Galois Theory, Non-linear Differential Galois Theory, Difference Galois Theory, Integrability of Dynamical Systems, Integrability of Partial Differential Equations, Integrability in Quantum Mechanics, Painlevé Transcendents.
Scientific committee: Jean-Pierre Ramis, President (Université Paul Sabatier, France), José Manuel Aroca (Universidad de Valladolid, Spain), Andrzej Maciejewski (University of Zielona. Gora, Poland), Hiroshi Umemura (Nagoya University, Japan), and Alexander Veselov (Loughborough University, United Kingdom).
Organizing committee: Primitivo Acosta-Humánez (Universidad del Norte, Colombia), David Blázquez-Sanz (Universidad Nacional de Colombia, secional Medellín), Camilo Sanabria (Universidad de los Andes, Colombia), and Sergi Simón (University of Portsmouth, United Kingdom).
Information: `http://www.scm.org.co/eventos/AMDS2014/`; `http://www.scm.org.co/eventos/AMDS2014/`; email: `amds.bcn@gmail.com`; +575 3 509 509 ext. 4844.

6–9 **Methods of Noncommutative Geometry in Analysis and Topology**, Leibniz University Hannover, Hannover, Germany. (Jun/Jul. 2014, p. 663)
Description: The event will gather experts in the noncommutative geometry community, with Kasparov's bivariant K-theory as the unifying theme. A focal point of the workshop will be the Baum-Connes conjecture, which for three decades has been a central problem in this field, bringing together geometry, topology, and analysis. This has lead to both new fundamental ideas as well as interactions with other fields of mathematics. Notable applications encompass index theory, mathematical physics, dynamical systems and the classification of C*-algebras. There will be a poster session to promote the interaction between junior researchers and experts in the field.
Information: `http://www.math-conf.uni-hannover.de/methodsncg14/de/`.

9–10 **The Eighth International Conference on Provable Security (ProvSec 2014)**, The University of Hong Kong, Hong Kong. (Aug. 2014, p. 794)
Description: Provable security is an important research area in modern cryptography. Cryptographic primitives or protocols without a rigorous proof cannot be regarded as secure in practice. In fact, there are many schemes that were originally thought of as secure but eventually broken, which clearly indicates the need of formal security assurance. With provable security, we are confident in using cryptographic schemes and protocols in various real-world applications. Meanwhile, schemes with provable security sometimes give only theoretical feasibility rather than a practical construction, and correctness of the proofs may be difficult to verify. ProvSec conference thus provides a platform for researchers, scholars and practitioners to exchange new ideas for solving these problems in the provable security area.
Information: `http://home.ie.cuhk.edu.hk/~provsec14`.

* 9–10 **International Conference on Quantitative Finance, Insurance and Risk-Management In honor of Profs. Michel Crouhy and Nicole El Karoui**, Marrakech, Morocco.
Description: This Conference is in honor of Professors Michel Crouhy and Nicole El Karoui, two of the foremost contributors to quantitative finance and risk-management, and examples of honorable scientists and very devoted researchers.

12–14 **Information Security, the Seventeenth International Conference (ISC 2014)**, The University of Hong Kong, Hong Kong. (Aug. 2014, p. 794)
Description: The Information Security Conference (ISC) is an annual international conference covering research in theory and applications of Information Security. ISC aims to attract high quality papers in all technical aspects of information security.
Information: `http://isc14.ie.cuhk.edu.hk`.

13–17 **AIM Workshop: Positivity, graphical models, and modeling of complex multivariate dependencies**, American Institute of Mathematics, Palo Alto, California. (Apr. 2014, p. 432)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to studying functions that preserve Loewner properties on (distinguished submanifolds of) the cone of positive semidefinite matrices.
Information: `http://aimath.org/workshops/upcoming/modelmultivar`.

13–17 **Fundamental Groups and Periods**, Institute for Advanced Study, Princeton, New Jersey. (Aug. 2014, p. 794)
Description: A workshop held as part of the yearlong program "Topology of Algebraic Varieties" at the Institute for Advanced Study. It is largely a mystery which groups can be the fundamental group of a smooth complex projective varieties. Hodge theory gives many restrictions on the possible fundamental groups, but there is a big gap between the known examples and the known restrictions. One goal of the workshop is to present the latest work on the possible fundamental groups of algebraic varieties. A second theme is the study of periods, the numbers obtained as integrals of algebraic functions. Multiple zeta values are special periods which are intimately related with the category of mixed Tate motives over the integers.
Information: http://www.topalg2014.org/home/activities/workshop-1.

13–17 **MBI Workshop 2: Metastasis and Angiogenesis**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p 663)
Description: This workshop will address the mathematical and computational issues that arise from models of angiogenesis and metastasis. Such models are frequently hybrid models, that describe cells (either those building the vessel or those involved in metastasis) at a detailed level that treats their biochemical and mechanical responses to their environment, and couple this cell-based description with partial differential equations that describe the mechanics of the surrounding tissue and the reaction and transport of growth factors and chemotactic signals. Major topics to be treated are how to model the movement of single cells through the extracellular matrix, how to describe in sufficient detail the process by which new vessels grow toward a tumor, how to cope with the computational problems raised by such hybrid models, and what the implications are for our understanding of the underlying basic science and how that understanding can be translated into improved therapeutic regimens.
Information: http://mbi.osu.edu/event/?id=496; phone: 614-292-3648.

* 16–18 **International Conference on Special Functions & Applications - ICSFA 2014**, Thapar University, Patiala, India.
Description: ICSFA 2014 is XIII Annual Conference of the Society for Special Functions and their Applications (SSFA) hosted by School of Mathematics and Computer Applications, Thapar University. The Conference will provide a common platform for interaction, exchange of ideas and latest developments in the field of Special Functions and various related fields of mathematical sciences. The day-to-day activities during the conference are designed to be interactive, involving sessions like plenary lectures, invited talks and paper presentation sessions, covering a wide range of topics including Special Functions, Lie Theory, Orthogonal Polynomials, Fractional Calculus, Number Theory, Combinatorics, q-theory, etc.
Information: http://www.ssfaindia.webs.com/conf.htm.

17–19 **Conference "Inverse Problems and Spectral Theory" in honor of the 65th anniversary of Peter Kuchment**, Texas A&M University, College Station, Texas. (Aug. 2014, p. 795)
Description: The conference will feature 40-minute talks by invited speakers and a poster session for contributed presentations. A limited amount of financial support for travel is available on a competitive basis. Strong preference will be given to young researchers (less than 5 years after Ph.D.), postdoctoral fellows, and graduate students. Women and members of underrepresented groups are especially encouraged to apply. Further information and updates about the conference are available at: http://www.math.tamu.edu/~berko/ipst/index.html.
Information: http://www.math.tamu.edu/~berko/ipst/index.html.

17–19 **Georgia Algebraic Geometry Symposium 2014**, University of Georgia, Athens, Georgia. (Jun/Jul. 2014, p. 663)
Description: General conference on the latest topics in algebraic geometry.
Funding: Is available for graduate students and young researchers.
Speakers: Ana-Maria Castravet (Ohio), Christopher Hacon (Utah), Jun-Muk Hwang (KIAS, Seoul), Robert Lazarsfeld (Stony Brook), Diane Maclagan (Warwick, UK), Davesh Maulik (Columbia), Mircea Mustata (Michigan), Karl Schwede (Penn State).
Information: http://gags.torsor.org/conf2014/.

* 17–19 **Informal Analysis and Probability Seminar**, University of Michigan, Ann Arbor, Michigan.
Description: This conference will feature lecture series by Olivier Guedon (Concentration Phenomena in High-Dimensional Analysis) and Fedor Nazarov (The Logarithmic Bound for the Average Number of Real Zeroes of Random Polynomials with I.I.D. Coefficients). The lectures are designed to be accessible to graduate students. The conference is being co-organized by the Analysis/Probability group at the Univeristy of Michigan, and the Analysis group at Kent State University.
Information: For registration and further information regarding funding, see: http://dept.math.lsa.umich.edu/conferences/informalAnalysis/.

17–19 **Yamabe Memorial Symposium 2014: Current Topics in the Geometry of 3-Manifolds**, School of Mathematics, University of Minnesota, Minneapolis, Minnesota 55455 (Jun/Jul. 2014, p. 663)
Description: The eight speakers will be: Ian Agol, UC Berkeley; Mladen Bestvina, Utah; Jeremy Kahn, CUNY-Graduate Center; Ursula Hammenstaedt, Bonn; Ciprian Manolescu, UCLA; Mahan Mj, RKM Vivekanda University, India; Vlad Markovic, Cambridge; Stefano Vidussi, UCRiverside.
Sponsor: The Symposium is sponsored by NSF with additional support from the UMN School of Math. and the Yamabe endowment.
Financial support: Is available, especially for grad students, postdocs, and young researchers. An application/registration form is on the Symposium website. Applicants who are members of the GEAR Network (see http://math.illinois.edu/GEAR/GEARNodes.pdf) or are grad students or postdocs associated with GEAR members may be able to use GEAR resources to facilitate Symposium attendance. For information see: http://gear/math.illinois.edu/programs.
Deadline: For applications for Symposium funding is Wednesday August 6, 2014. Later applications will be considered if funds allow. But all interested mathematician are invited to attend.
Information: http://www.math.umn.edu/yamabe/.

18–19 **Sectional Meeting**, Dalhousie University, Halifax, Canada. (Sept. 2013, p. 1112)
Description: 2014 Fall Eastern Sectional Meeting.
Information: http://www.ams.org/meetings/sectional/sectional.html.

20–24 **Autumn school on nonlinear geometry of Banach spaces and applications**, Métabief, France. (Mar. 2014, p. 317)
Description: In the framework of the special trimester "Geometric and non-commutative methods in functional analysis" at Université Franche-Comté (Besançon, France) we organize this "Autumn school on nonlinear geometry of Banach spaces and applications" in the nearby village of Métabief in the Jura mountains. The school will propose 5 short courses delivered by mathematicians working in this domain. We hope to bring together researchers and students with common interest in the field. There will be many opportunities for informal discussions.
Information: http://trimestres-lmb.univ-fcomte.fr/fa.

22–24 **International Conference in Modeling Health Advances 2014**, UC Berkeley, San Francisco Bay Area, California. (Apr. 2014, p. 432)
Description: The purpose of this conference is to bring all the people working in the area of epidemiology under one roof and

encourage mutual interaction. The conference ICMHA'14 is held under the World Congress on Engineering and Computer Science WCECS 2014. The WCECS 2014 is organized by the International Association of Engineers (IAENG), a non-profit international association for the engineers and the computer scientists. The congress has the focus on the frontier topics in the theoretical and applied engineering and computer science subjects. The last IAENG conference has attracted more than five hundred participants from over 30 countries. All submitted papers will be under peer review and accepted papers will be published in the conference proceeding (ISBN: 978-988-19252-0-6). The abstracts will be indexed and available at major academic databases. The accepted papers will also be considered for publication in the special issues of the journal Engineering Letters.
Information: `http://www.iaeng.org/WCECS2014/ICMHA2014.html`.

22–24 **28th Midwest Conference on Combinatorics and Combinatorial Computing**, University of Nevada, Las Vegas (UNLV), Las Vegas, Nevada. (Feb. 2014, p. 214)
Description: The Midwest Conferences on Combinatorics and Combinatorial Computing (MCCCC) are of small size (50 to 70 participants) and have been growing slowly. Papers cover a spectrum of pure and applied combinatorics, including graph theory, design theory, enumeration, and combinatorial computing. For 28th MCCCC, the invited speakers are: Brian Alspach; Saad El-Zanati; Futaba Fujie-Okamoto; Joseph Gallian; Margaret Readdy; Ian Wanless. Contributed papers (15–20 minutes talks) are very welcomed.
Information: `http://www.mcccc.info`.

23–25 **The Tenth Mississippi State Conference on Differential Equations & Computational Simulations**, Mississippi State University, Starkville, Mississippi. (Jun/Jul. 2014, p. 663)
Description: This interdisciplinary conference will provide a joint forum where mathematicians, scientists and engineers from industries, federal laboratories and academia can exchange research and development ideas. An overall goal of this conference is to promote research and education in mathematical and computational analysis of theoretical and applied differential equations. In addition to the ten principal lectures, there will be sessions for twenty minute contributed talks. This conference is dedicated to Ratnasingham Shivaji in celebration of his 60th birthday, his outstanding contributions to differential equations, and his service to Mississippi State University. Conference participants are encouraged to submit full length manuscripts after the conference. Reviewed manuscripts will be published as a special issue of the *Electronic Journal of Differential Equations*.
Deadline: For pre-registration and abstract submission is September 5, 2014.
Information: `http://www.ccs.msstate.edu/deconf/de2014/`.

23–26 **Ahlfors-Bers Colloquium VI**, Yale University, New Haven, Connecticut. (Oct. 2013, p. 1204)
Description: This conference is the sixth in a series of triennial colloquia devoted to the mathematical legacy of Lars Ahlfors and Lipman Bers. The core heritage is in geometric function theory, quasiconformal mapping, Teichmüller theory and Kleinian groups, hyperbolic manifolds, and partial differential equations including Schramm/Stochastic-Loewneer-Evolution/Equations. Today we see the influence of Ahlfors and Bers on algebraic geometry, mathematical physics, dynamics, probability, geometric group theory, number theory and topology.

25–26 **Sectional Meeting**, San Francisco State University, San Francisco, California. (Sept. 2013, p. 1112)
Description: 2014 Fall Western Section Meeting.
Information: `http://www.ams.org/meetings/sectional/sectional.html`.

27–31 **AIM Workshop: Configuration spaces of linkages**, American Institute of Mathematics, Palo Alto, California. (Apr. 2014, p. 433)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the mathematical study of configuration spaces of linkages consisting of rigid bars connected by revolute joints embedded in an ambient space of fixed dimension.
Information: `http://aimath.org/workshops/upcoming/linkages`.

27–31 **Conference on Geometric Functional Analysis and its Applications**, Université de Franche-Comté, Besann, France. (Mar. 2014, p. 316)
Description: To bring together researchers and students with common interest in this field. The conference will propose many plenary lectures and the participants will have the opportunity to deliver a short talk.
Information: `http://trimestres-lmb.univ-fcomte.fr/fa`.

27–31 **ICERM Semester Program Workshop: Discrepancy Theory**, Brown University, Providence, Rhode Island. (Jun/Jul. 2014, p. 663)
Description: The participants of this workshop will share a wide range of views on topics related to discrepancy with an eye towards the recent developments in the subject. The workshop will bring together different communities working on various aspects of discrepancy theory. The exchange of ideas and approaches, the cross-fertilization of viewpoints, sharing the visions of near and far term goals of the field will be the highlight of the conference.
Information: `http://icerm.brown.edu/sp-f14-w3/`.

November 2014

1–December 31 **Scalar Curvature in Manifold Topology and Conformal Geometry**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jun/Jul. 2014, p. 664)
Description: The purpose of the program is to bring together researchers working on the areas to communicate ideas and dig out the connections as well as stimulate possible research collaboration. Activities 1. Workshop on Positive Curvature and Index Theory: November 17–21, 2014 2. Workshop on Partial Differential Equation and its Applications: December 8–12, 2014. 3. Winter School on Scalar Curvature and Related Problems: December 16–19, 2014. There will be four mini-courses. 4. Public Lecture.
Information: `http://www2.ims.nus.edu.sg/Programs/014scalar/index.php`.

2–3 **5th International Conference on Mathematics and Natural Sciences 2014**, Institut Teknologi Bandung, Bandung, Indonesia. (Aug. 2014, p. 795)
Description: The 5th International Conference on Mathematics and Natural Sciences (ICMNS) is organized jointly by Faculty of Mathematics and Natural Sciences (FMIPA), School of Life Sciences and Technology, and School of Pharmacy at Institut Teknologi Bandung, Indonesia.
Aim: The main aim of this conference is to promote multi- and interdisciplinary researches in sciences and related technology and its applications. The scope of the conference is in the fields of, but not limited to: food sciences, health and medical sciences, biosciences and biotechnology, environmental sciences, pharmaceutical sciences, physical sciences, material sciences, mathematics and its applications, computer science and computational science, earth and space sciences, sustainable energy. Accepted papers will be published in the American Institute of Physics (AIP) Conference Proceedings (indexed by SCOPUS).
Information: `http://icmns.fmipa.itb.ac.id/pages/home.php`.

3–7 **AIM Workshop: Combinatorics and complexity of Kronecker coefficients**, American Institute of Mathematics, Palo Alto, California. (Apr. 2014, p. 433)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the study of Kronecker coefficients which describe the

decomposition of tensor products of irreducible representations of a symmetric group into irreducible representations.
Information: `http://aimath.org/workshops/upcoming/kroncoeff`.

3–7 **MBI Current Topic Workshop on Axonal Transport and Neuronal Mechanics**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Apr. 2014, p. 433)
Description: The goal of this workshop is to bring together leading cell biologists, engineers, physicists, and mathematicians to openly discuss exciting new findings, long-standing questions, and the future of our field. The timeliness of this meeting and its relevance to the mission of the MBI is most evident from three recent reviews by the organizers (Bressloff and Newby, 2013; Franze et al., 2013; Suter and Miller, 2011). In brief these reviews discuss the emerging role of forces in axonal elongation, mathematical models that have been developed to study the contribution of axonal transport to elongation, and the importance of developing mathematical models to study neuromechanics.
Information: `http://mbi.osu.edu/event/?id=817`; phone: 614-292-3648.

5–8 **Fifth Ya.B. Lopatinskii International Conference of Young Scientists on Differential Equations and Its Applications**, Donetsk National University, Donetsk, Ukraine. (Mar. 2014, p. 316)
Description: This is bringing together young and some venerable researchers in above areas in order to get acquainted, to communicate and to understand what directions are actual and perspective. The word “young” in the title means a general direction of the conference but doesn’t mean any age limitations for participants.
Main topics: General theory of boundary-value problems for partial differential equations (PDE), investigation of boundary-value problems for special classes of PDE, nonlinear boundary-value problems, operator methods in the theory of PDE, mathematical physics, ordinary differential equations and dynamical systems, applications of PDE.
Information: `http://math.donnu.edu.ua/en-us/science/conferences/ICL2014`.

6–9 **International Conference on Recent Advances in Pure and Applied Mathematics (ICRAPAM 2014)**, Club Sera Hotel, Antalya, Turkey. (Jun/Jul. 2014, p. 664)
Description: ICRAPAM 2014 is an international forum for mathematicians, scientists and engineers to present their latest research and development results in all areas of Pure and Applied Mathematics and their possible advanced applications in real life. The Conference has a distinguished Organizing Committee and Scientific Committee with extensive academic qualifications, ensuring that the conference maintains high scientific standards and has a broad international coverage. All the papers are subject to rigorous peer-review by at least two members of scientific committee or additional reviewers. The technical program will consist of keynote speakers by eminent specialists, oral presentation of the contributed papers and posters of the work-in-progress. Full versions of the accepted abstracts will be published in the journals listed on the conference website.
Information: `http://www.icrapam.org`.

8–9 **Sectional Meeting**, University of North Carolina, Greensboro, North Carolina. (Sept. 2013, p. 1112)
Description: 2014 Fall Southeastern Section Meeting.
Information: `http://www.ams.org/meetings/sectional/sectional.html`.

9–14 **LISA ‘14: 28th Large Installation System Administration Conference**, Sheraton Seattle Hotel, Seattle, Washington. (Jun/Jul 2014, p. 664)
Description: USENIX’s Large Installation System Administration (LISA) conference — now in its 28th year — is the premier meeting place for professionals who make computing work across a variety of industries. If you.re an IT operations professional, site-reliability engineer, system administrator, architect, software engineer, researcher, or otherwise involved in ensuring that IT services are effectively delivered to others — this is your conference, and we’d love to have you here.
Information: `http://www.usenix.org/conference/lisa14`.

11–January 25 **Inverse Moment Problems: The Crossroads of Analysis, Algebra, Discrete Geometry and Combinatorics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Sept. 2013, p. 1112)
Description: Applications of moments of measures in polynomial optimization led to a number of breakthroughs in optimization and real algebraic geometry, as well as to better understanding of ways to encode measures. Other similar threads are recently seen in the theory of integration on polytopes and counting of integer points in polytopes, as well as in quantum computing. The aim of the program is to futher investigate relations between these topics and inverse moment problems, i.e., questions of reconstructing measures from a set of its moments, which are traditionally attacked by purely analytic tools. Activities will include two 4–5 day research conferences, one quantum computing workshop, and one graduate student winter school/workshops.
Information: `http://www2.ims.nus.edu.sg/Programs/014inverse/index.php`.

13–15 **SIAM Conference on Financial Mathematics and Engineering (FM14)**, The Palmer House, A Hilton Hotel, Chicago, Illinois. (May 2014, p. 555)
Description: The Activity Group on Financial Mathematics and Engineering focuses on research and practice in financial mathematics, computation, and engineering. Its goals are to foster collaborations among mathematical scientists, statisticians, computer scientists, computational scientists, and researchers and practitioners in finance and economics, and to foster collaborations in the use of mathematical and computational tools in quantitative finance in the public and private sector. The activity group promotes and facilitates the development of financial mathematics and engineering as an academic discipline.
Information: `http://www.siam.org/meetings/fm14/`.

14–15 **Blackwell-Tapia Conference and Awards Ceremony**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 795)
Description: IPAM is honored to host the 2014 Blackwell-Tapia Conference and Awards Ceremony. The conference and prize honors David Blackwell and Richard Tapia, two seminal figures who inspired a generation of African-American, Native American and Latino/Latina students to pursue careers in mathematics. The conference will offer a mix of activities including scientific talks, poster presentations, panel discussions, ample opportunities for discussion and interaction, and the awarding of the Blackwell-Tapia Prize. Participants will come from all career stages and will represent institutions of all sizes across the country.
Support: Applications for travel support are due September 15, 2014. Please consult the webpage for more information.
Information: `http://www.ipam.ucla.edu/programs/BTAP2014/`.

14–17 **Conference on Mathematics and its Applications-2014**, Kuwait University, Kuwait City, Kuwait. (May 2014, p. 555)
Description: The Conference on Mathematics and its Applications-2014 (CMA-2014) is broad-based spanning Algebra, Analysis, Discrete Mathematics, and Inverse Problems and Imaging.
Aim: Is to highlight the latest advances in different areas of mathematics and emphasis their applications to other disciplines. The conference will gather renowned scholars in mathematics from around the world and provide a forum to exchange ideas and discuss

research findings, as well as to form new inter-disciplinary connections among the participants.
Information: `http://cma2014.science.ku.edu.kw`.

17–21 **AIM Workshop: Bounded gaps between primes**, American Institute of Mathematics, Palo Alto, California. (May 2014, p. 556)
Description: This workshop, sponsored by AIM and the NSF, will focus on the remarkable progress made in the last year on gaps between prime numbers.
Information: `http://aimath.org/workshops/upcoming/primegaps2`.

17–21 **Categorical Structures in Harmonic Analysis**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul 2014, p. 664)
Description: The workshop will focus on the role of categorical structures in number theory and harmonic analysis, with an emphasis on the setting of the Langlands program. Celebrated examples of this theme range from Lusztig's character sheaves to Ngo's proof of the Fundamental Lemma. The workshop will be a forum for researchers from a diverse collection of fields to compare problems and strategies for solutions.
Information: `http://www.msri.org/workshops/708`.

17–21 **MBI Workshop on Cancer and the Immune System**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p. 664)
Description: The present workshop will bring together cancer biologists and mathematical modelers to review the state of present knowledge and explore future directions. It will also provide an environment that will encourage communication and new contacts among the biologists and mathematicians. Formal lecture and informal discussions will articulate future directions where mathematical models can significantly enhance understanding of the complex relations between tumor cells and the immune cells, and suggest novel approaches to therapy.
Information: `http://mbi.osu.edu/event/?id=498`; phone: 614-292-3648.

24–26 **The 3rd International Conference on Complex Dynamical Systems and Their Applications: New Mathematical Concepts and Applications in Life Sciences**, TOBB University of Economics and Technology University (TOBB ETU), Ankara, Turkey. (Aug. 2014, p. 795)
Description: Within CDSC 2014 we will honor Professor Marat Akhmet on the occasion of his 60th birthday. The aims of this conference are to promote, encourage and bring together researchers in the different research areas (Mathematics, Engineering, Medicine, Physics, Biology, etc.), and to unite our energy and possibilities in this direction. Also, we aim to establish a platform at which the novel research ideas of this area will be shared. CDSC became a regular annual organization since 2012.
Information: `http://cdss2014.org/`.

24–28 **IV International scientific conference of students and young scientists "Theoretical and Applied Aspects of Cybernetics" (TAAC-2014)**, Cybernetics Faculty of Taras Shevchenko National University of Kyiv, Kyiv, Ukraine. (Aug. 2014, p. 795)
Description: The scientific program of the conference includes the following sections: Computer science, applied mathematics, artificial intelligence, software engineering. Before today three International Conferences of Students and Young Scientists Theoretical and Applied Aspects of Cybernetics were held at the Faculty of Cybernetics of Taras Shevchenko National University of Kyiv in 2011, 2012, and 2013. Participants from more than 40 universities and 5 research institutes of Ukraine, Russia, Belorussia, Kazakhstan, Poland, Latvia, Lithuania, Estonia, Hungary, Slovakia, Czech Republic, Romania, Moldova, Turkey, Great Britain, Bulgaria, Georgia, Finland, and India attended these conferences.
Information: `http://taac.org.ua`.

26–29 **International Congress on Music and Mathematics**, University of Guadalajara, Puerto Vallarta, Mexico. (May 2014, p. 556)
Description: In the context of the 20th anniversary of the University Center for Exact Sciences and Engineering (CUCEI-UdeG, Mexico), and the 40th anniversary of the National Center for Music Research, Documentation and Information (CENIDIM.INBA, Mexico), this Congress will focus on the relationship between music and mathematics, both applied and pure, understood as systems, techniques, technologies, theories, and creative work. International and interdisciplinary contributions are highly appreciated. The Congress will examine the essentials of analogous thought and its meaning and functioning in the broadest sense of .abstract forms in music. A wider view on music and mathematics will be also considered. The venue will bring together scholars, researchers, students and artists from many disciplines, converging within the announced topics. We welcome innovative and unexpected proposals on topics that address diverse aspects of music an mathematics.
Information: `http://icmm.cucei.udg.mx/`.

26–30 **The 19th Asian Technology Conference in Mathematics (ATCM 2014)**, State University of Yogyakarta, Yogyakarta, Indonesia. (Mar. 2014, p. 316)
Description: The ATCM 2014 is an international conference to be held in Mumbai, India, that will continue addressing technology-based issues in all Mathematical Sciences. Thanks to advanced technological tools such as computer algebra systems (CAS), interactive and dynamic geometry, and hand-held devices, the effectiveness of our teaching and learning, and the horizon of our research in mathematics and its applications continue to grow rapidly. The aim of this conference is to provide a forum for educators, researchers, teachers and experts in exchanging information regarding enhancing technology to enrich mathematics learning, teaching and research at all levels. English is the official language of the conference. ATCM averagely attracts 300 participants representing over 30 countries around the world. Be sure to submit your abstracts or full papers in time.
Information: `http://atcm.mathandtech.org`.

27–29 **Annual meeting of the French research network (GdR) in Noncommutative Geometry**, Besancon, France. (Mar. 2014, p. 317)
Description: This 3-day workshop is an annual meeting of the French Non-commutative Geometry network, with international participation. The topics include also quantum groups, geometric group theory, operator algebras, operator spaces. The workshop is a part of a trimester in Functional Analysis of the University of Franche-Comte (Besann). The trimester includes also other events, in particular a School on Operator Spaces, Non-commutative Probability and Quantum Groups (December 1-12, Metabief, close to Besann) and a conference on Operator spaces and Quantum Probability (December 15-19, Besann).
Information: `http://trimestres-lmb.univ-fcomte.fr/Noncommutative-Geometry-meeting.html`.

December 2014

1–5 **AIM Workshop: Beyond Kadison-Singer - paving and consequences**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul. 2014, p. 664)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to broadening the recent proof of the Kadison-Singer Problem and to exploring its consequences.
Information: `http://aimath.org/workshops/upcoming/beyondks`.

1–5 **38th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing (ACCMCC)**, Victoria University of Wellington, Wellington, New Zealand. (Mar. 2014, p. 317)

Description: Contributed talks will be sought from all areas of discrete and combinatorial mathematics and related areas of computer science.
Invited speakers: Mike Atkinson (University of Otago); Simeon Ball (Universitat Politècnica de Catalunya); Alice Devillers (University of Western Australia); Jaroslav Nesetril (Charles University); Sergey Norin (McGill University); James Oxley (Louisiana State University); Andrew Thomason (University of Cambridge); Mark Wilson (University of Auckland); Stefan van Zwam (Princeton University).
Queries: Should be sent to the head of the organising committee, Dillon Mayhew (dillon.mayhew@msor.vuw.ac.nz).
Information: http://msor.victoria.ac.nz/Events/38ACCMCC.

1–5 **Automorphic forms, Shimura varieties, Galois representations and L-functions**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 664)
Description: L-functions attached to Galois representations coming from algebraic geometry contain subtle arithmetic information (conjectures of Birch and Swinnerton-Dyer, Deligne, Beilinson, Bloch and Kato, Fontaine and Perrin-Riou). Langlands has predicted the existence of a correspondence relating these L-functions to L-functions of automorphic forms which are much better understood. The workshop will focus on recent developments related to Langlands correspondence (construction of Galois representations attached to automorphic forms via the cohomology of Shimura varieties, modularity of Galois representations...) and arithmetic of special values of L-functions. It will be dedicated to Michael Harris as a tribute to his enormous influence on the themes of the workshop.
Information: http://www.msri.org/workshops/719.

1–5 **International Conference on Applied Mathematics — in honour of Professor Roderick S. C. Wong's 70th Birthday**, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong. (May 2014, p. 556)
Description: The objectives of the conference are to review and discuss some of the latest trends in various fields of applied mathematics. In particular, with a special emphasis on asymptotic and special functions, partial differential equations, computational mathematics, approximation theory, mathematical physics, mathematical biology and financial mathematics. The conference is dedicated to Professor Roderick in recognition of his mathematical achievements and his contributions in the mathematical society. During the conference, the William Benter Prize in Applied Mathematics 2014 will be awarded, and the recipient will give a plenary lecture. The aim of the Prize is to recognize outstanding mathematical contributions that have had a direct and fundamental impact on scientific, business, finance and engineering applications.
Information: http://www6.cityu.edu.hk/rcms/icam2014/index.htm.

1–5 (NEW DATE) **International Conference on Pure and Applied Mathematics, Goroka 2014: ICPAM-GOROKA (2014)**, University of Goroka, Goroka, Eastern Highlands Province, Papua, New Guinea.
Description: ICPAM-GOROKA 2014, aims at bringing together experts in different fields of pure and applied mathematics, as well as researchers, undergraduates and postgraduate students from around the world to discuss mathematical questions, exchange high level knowledge of methods and investigate diverse applications of Pure and Applied Mathematics to astronomy, biology, business, banking, chemistry, computer science, education, engineering, geosciences, health care, medicine, physics, security, the military, etc. Academia and industries are invited to participate.
Information: http://icpam-goroka2014.blogspot.com.

1–12 **Winter School on Operator Spaces, Non-commutative Probability and Quantum Groups**, Métabief, France. (Feb. 2014, p. 214)
Description: This two-week school will include 6 courses on quantum groups, operator spaces and non-commutative probability. The venue is located in a village in Jura mountains, France, close to the Swiss border. This school is a part of a trimester in Functional Analysis of the University of Franche-Comte (Besann). The trimester includes also other events, in particular a workshop on Non-commutative Geometry (November 27–29, Besann) and a conference on Operator spaces and Quantum Probability (December 15–19, Besann).
Information: http://trimestres-lmb.univ-fcomte.fr/Christmas-School.html.

6–31 **The Info-Metrics Annual Prize in Memory of Halbert L. White Jr.**, Washington, DC. (Feb. 2014, p. 214)
Description: The Info-Metrics Institute is pleased to announce the creation of the Halbert L. White Jr. prize in memory of one of the Institute's founding board members who passed away on March 31, 2012. The prize is intended to reward outstanding academic research by an early career scholar in the field of info-metrics and carries an award of $2000 to be conferred either to an individual or shared among joint recipients. A maximum of one prize will be awarded each year. The award ceremony will occur at the first Info-Metrics meeting (conference or workshop) following the announcement of the award recipient. The annual Info-Metrics prize will be given for the best recent published work, in any academic discipline, that is deemed likely to bring important advances to multiple academic disciplines in the area of info-metrics (the science and practice of inference and quantitative information processing). The first prize will be given in 2014.
Information: http://www.american.edu/cas/economics/info-metrics/prize.cfm.

8–10 **IMA Conference on Game Theory and its Applications**, St. Anne's College, Oxford, United Kingdom. (Jun/Jul 2014, p. 665)
Topics: Include the following and are invited to be presented in oral and poster sessions: Search Games with Human and Animal Agents; Equilibrium Computation; Game Theory for Sustainability; Game Theory and Cyber-Security; Game Theory for Auctions and Markets; Gameification.
Call for Papers: Papers will be accepted for the conference based on a 500-word abstract for oral or poster presentation. Abstracts should be submitted by Friday, September 5, 2014 by e-mail to: conferences@ima.org.uk. Successful authors will be notified by Friday, September 26, 2014. Please state whether your title is intended for oral or poster presentation.
Organizing Committee: Rahul Savani (University of Liverpool)–Chair; Steve Alpern (Warwick University), Co-chair; Dragan Pleskonjic (GTECH); Gopal Ramchurn (University of Southampton).
Information: http://ima.org.uk/conferences/conferences_calendar/game_theory_and_its_applications.html.

8–12 **AIM Workshop: Transversality in contact homology**, American Institute of Mathematics, Palo Alto, California. (May 2014, p. 556)
Description: This workshop, sponsored by AIM and the NSF, will bring together specialists in symplectic and contact topology with the goals of clarifying the gaps in current arguments concerning the definition of contact homology and of moving forward to fill these gaps and build precise foundations for the cylindrical, linearized, local, and possibly other versions of contact homology.
Information: http://aimath.org/workshops/upcoming/transcontacthom.

8–12 **8th Australia – New Zealand Mathematics Convention**, University of Melbourne, Melbourne, Australia. (Apr. 2014, p. 433)
Description: The Australia – New Zealand Mathematics Convention is held every six years. It is the combined meeting of the Australian and New Zealand Mathematical Societies and it will also include the 2014 annual meeting of ANZAMP - the Australian and New Zealand Association of Mathematical Physics.
Information: http://www.austms2014.ms.unimelb.edu.au.

9–10 **First call for the training programme "Collaborative Mathematical Research"**, Centre de Recerca Matematica, Bellaterra, Barcelona, Spain. (Mar. 2014, p. 317)
Description: First call for the training programme "Collaborative Mathematical Research".
Information: http://www.crm.cat/en/ResearchTraining/CollabMathResearch/Pages/Description.aspx.

9–19 **Recent Advances in Operator Theory and Operator Algebras-2014**, Bangalore, India. (Dec. 2013, p. 1497)
Description: This conference is a continuation of the earlier conferences and workshops on operator theory and operator algebras held in Indian Statistical Institute, Bangalore. The main goal of the workshop and the conference is to bring together the leading worldwide experts and young researchers, including postdocs and advanced doctoral students working in operator theory, operator algebra and related topics. The topics of interest include, but are not limited to: operator algebras, operator theory, function theory, multivariable operator theory, free probability, groups and dynamical system. The meeting will start with a workshop December 9–13, 2014, followed by a conference December 15–19, 2014. The purpose of the workshop is to bring experts and students as well as researchers together to discuss the most recent developments
Information: http://www.isibang.ac.in/~jay/OTOA2014/OTOA14/OTOA14.html.

9–20 **Vertex algebras, W-algebras, and applications**, Centro di Ricerca Matematica Ennio De Giorigi, Pisa, Italy. (Jun/Jul. 2014, p. 665)
Description: In Winter 2014-2015, a trimester on "Perspectives in Lie Theory" will be held at Centro de Giorgi. The first session of this trimester will be devoted to "Vertex algebras, W-algebras, and applications". This session will include a seminar, time for discussions and collaboration, and three minicourses held by Tomoyuki Arakawa (Kyoto University), Victor Kac (MIT), and Fedya Malikov (University of Southern California). http://www.crm.sns.it/event/293/. More information can be found at: http://www.crm.sns.it/event/293/activities.html#title.

10–12 **I Brazilian Congress of Young Researchers in Pure and Applied Mathematics**, Mathematics and Statistics Institute, University of São Paulo, São Paulo, Brazil. (Aug. 2014, p. 795)
Description: In Brazil, due to its continental dimensions with several universities distant from major research centers, many new Ph.D. graduates join these universities and end up distancing themselves from their original research groups. This often hinders the development of their research and, consequently, their ongoing professional career. For this reason, young researchers decided to create an appropriate framework to share research results, thus giving rise to "I Brazilian Congress of Young Researchers in Pure and Applied Mathematics".
Information: http://jovens.ime.usp.br/jovens/en.

11–20 **Foundations of Computational Mathematics Conference**, Universidad de la República, Montevideo, Uruguay. (Feb. 2014, p. 214)
Description: The conference, organized by the Society for Foundations of Computational Mathematics, is eighth in a sequence that commenced with the Park City, Rio de Janeiro, Oxford, Minneapolis, Santander, Hong Kong and Budapest FoCM meetings. The conference format consists of plenary invited lectures in the mornings and theme-centered parallel workshops in the afternoons. Each workshop extends over three days and the conference will consist of three periods, comprises of different themes. We encourage the participants to attend the full conference.
Information: http://www.fing.edu.uy/~jana/www2/focm_2014.html.

15–17 **10th IMA International Conference on Mathematics in Signal Processing**, Austin Court, Birmingham, United Kingdom. (Jun/Jul. 2014, p. 665)
Description: Signal processing constitutes an important area for the application of mathematical concepts and techniques fuelled, for example, by developments in mobile communications, networks, multimedia system, genomics and bioengineering, neural signal processing, and big data processing. The subject is still advancing rapidly in areas such as non-linear signal processing and systems, compressive sampling, digital communication systems, iterative estimation, blind deconvolution/signal separation, broadband systems, compressed sensing and novel sampling schemes. The aim of the conference is to bring together mathematicians, statisticians and engineers with a view to exploring recent developments and identifying fruitful avenues for further research. It is hoped that the meeting will help to attract more mathematicians into this important and challenging field.
Information: http://www.ima.org.uk/.

16–17 **1st International Conference on Security Standardisation Research**, Royal Holloway, University of London (RHUL), Egham Hill, Egham, United Kingdom. (Jun/Jul. 2014, p. 665)
Description: Over the last two decades a very wide range of standards have been developed covering a wide range of aspects of cyber security. These documents have been published by national and international formal standardisation bodies, as well as by industry consortia. Many of these standards have become very widely used. Despite their wide use, there will always be a need to revise existing security standards and to add new standards to cover new domains. The purpose of this conference is to discuss the many research problems deriving from studies of existing standards, the development of revisions to existing standards, and the exploration of completely new areas of standardisation. This conference is intended to cover the full spectrum of research on security standard.
Information: http://www.ssr2014.com.

19–21 **International Conference on Current Developments in Mathematics and Mathematical Sciences (ICCDMMS-2014)**, Calcutta Mathematical Society, AE-374, Sector-1, Salt Lake City, Kolkata-700064 West Bengal, India. (Apr. 2014, p. 433)
Description: The main objective of ICCDMMS-2014 is to promote mathematical research and to focus the recent advances in mathematics and mathematical sciences along with their applications. The conference aims to provide an ideal platform for the young researchers throughout the world to interact with senior scientists, to exchange their views and ideas and to initiate possible scientific collaboration in different domains.
Talks: The programme will consist of plenary invited talks as well as contributed presentations. Thrust areas of ICCDMMS-2014: i) Algebra, ii) Analysis, iii) Geometry and Topology, iv) Continuum Mechanics, v) Mathematical and Theoretical Physics, vi) Financial Mathematics, vii) Complex Phenomena and Dynamical Systems, viii) Space Research and Atmospheric Sciences, ix) Stochastic Processes, x) Numerical Techniques and Simulations, xi) Soft Computing, xii) Number Theory, xiii) Information Theory, xiv) General Relativity and Cosmology.
Information: Contact email: cmsconf@gmail.com; Contact No.: +91-33-2337 8882; http://www.calmathsoc.org/.

19–21 **2014 Fourth International Conference on Emerging Applications of Information Technology (EAIT 2014)**, Indian Statistical Institute, Kolkata, India. (May 2014, p. 556)
Description: Encouraged by the earlier responses and keeping the tradition CSI Kolkata Chapter is organizing EAIT 2014 during Dec 19-21, 2014. The event will comprise of Pre-Conference Tutorials, plenary sessions, invited lectures by eminent speakers of international repute, session papers and panel discussions. Original unpublished contributions are solicited for presentation at EAIT 2014. Papers cannot be submitted in parallel to any other conference or journal.
Topics: Of interest include but are not limited to: Image Processing, Computer Vision and Pattern Recognition; Machine Learning, Data

Mining and Computational Life Sciences; Management of Data including Big Data and Analytics; Distributed and Mobile Systems including Grid and Cloud infrastructure; Information Security and Privacy. Please check conference website for more details and updates.
Information: http://sites.google.com/site/csieait/.

* 19–21 **Workshop on Mathematical Biology and Nonlinear Analysis**, The University of Miami, Coral Gables, Florida.
Description: This workshop will highlight how methods and ideas from nonlinear analysis have been applied to problems arising in ecology, epidemiology, evolution, and other areas of biology, and how questions from biology have in turn motivated new research into nonlinear problems in dynamical systems, control theory, partial differential equations, and other areas.
Plenary speakers: William Fagan, Suzanne Lenhart, Simon Levin, Paul Rabinowitz, and Hal Smith. There will be special sessions on mathematical biology, nonlinear analysis, and reaction-diffusion equations and dynamical systems. Special session presentations are by invitation only, but all interested researchers are welcome to register and attend the workshop. We particularly encourage graduate students, recent Ph.D.'s and members of underrepresented groups to participate.
Funding: We anticipate a small amount of funding to support travel for young researchers who do not have their own travel funds; email: wmbna@math.miami.edu.
Information: http://math.miami.edu/wmbna.

21–23 **8th International Conference of IMBIC on "Mathematical Sciences for Advancement of Science and Technology (MSAST 2014)"**, IMBIC, Salt Lake City, Kolkata, India. (Jun/Jul. 2014, p. 665)
Description: The main objective of the conference is to bring specialized topics in mathematics, statistics, computer science, information technology, bioinformatics, and closely related interdisciplinary areas to the forefront. Original full papers are invited. All papers are to be screened and accepted papers will be published in the *Proceedings of IMBIC*, Volume 3 (2014), having ISBN 978-81-925832-2-8, except for a few full scientific papers of high quality, which may be published in the highly acclaimed series of monographs of IMBIC. Many scientists from India, USA, Japan, Canada, Sweden, France, Germany, Finland, Australia, Russia, Egypt, Mexico, Algeria, Botswana, Korea, South Africa, and many other countries participated in the earlier conferences.
Contact: All correspondences in respect to the conference are to be addressed to Dr. Avishek Adhikari, Convenor MSAST 2014 & Secretary, IMBIC; email: msast.paper@gmail.com; http://www.isical.ac.in/~avishek_r/.
Information: http://www.imbic.org/forthcoming.html.

* 21–23 **International Conference on Recent Trends in Mathematical Analysis and Its Applications**, Indian Institute of Technology Roorkee, Roorkee-247667 Uttarakhand, India.
Description: This conference aims to bring together the experts and young researchers from all over the world to discuss the recent developments in Mathematical Analysis and to promote exchange of ideas in various applications of Mathematical Analysis in Science and Engineering. This conference will encourage the international collaboration and provide an opportunity to young researchers to learn the current state of research in their related fields. This conference will be organized at the Indian Institute of Technology Roorkee, Roorkee, India.
Information: http://www.iitr.ac.in/icrtmaa14.

January 2015

1–March 31 **High Performance and Parallel Computing for Materials Defects and Multiphase Flows**, Institute for Mathematical Sciences, National University of, Singapore, Singapore. (Jun/Jul. 2014, p. 666)
Description: The program activities will consist of three workshops, tutorial lectures, public lectures, working seminars, and collaborative research. 1. Collaborative Research: January 1–March 31, 2015. 2. Workshop I: January 12–16, 2015. Title: Recent Advances in Parallel and High Performance Computing Techniques and Applications 3. Workshop II: February 9–13, 2015. Title: High Performance and Parallel Computing Methods and Algorithms for Materials Defects 4. Workshop III: March 2–6, 2015. Title: High Performance and Parallel Computing Methods and Algorithms for Multiphase/Complex Fluids. 5. Tutorial and Public Lectures—Distinguished researchers will give tutorial and public lectures on topics in high performance and parallel computing with applications in material defects and complex fluids.
Information: http://www2.ims.nus.edu.sg/Programs/015hiper/index.php.

4–6 **ACM-SIAM Symposium on Discrete Algorithms (SODA15), being held with Analytic Algorithmics and Combinatorics (ANALCO15) and Algorithm Engineering and Experiments (ALENEX15)**, The Westin Gaslamp Quarter, San Diego, California. (Feb. 2014, p. 214)
Description: Information on SODA, ALENEX and ANALCO will be available at http://www.siam.org/meetings/da15/ in May 2014.
Information: http://www.siam.org/meetings/da15/.

5–9 **AIM Workshop: Tumor-immune dynamics**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul. 2014, p. 665)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to mathematical and computational modeling of tumor-immune dynamics.
Information: http://aimath.org/workshops/upcoming/tumorimmune2.

5–June 26 **Periodic and Ergodic Spectral Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 365)
Description: The main objective of the programme is to bring together specialists in three major themes: periodic, almost-periodic, and random operators, to discuss recent developments and deep connections between the methods intrinsic for each of these research areas. Operators on manifolds or graphs and more general ergodic operators will also be considered, as well as problems that lie at the interface of the main topics (e.g. "sheared" periodic operators), and applications in other areas of mathematics (e.g. geometry). At the beginning of the programme, there will be a two-week long instructional conference with six mini-courses of about ten lectures each, which will be designed for students and non-specialists. Further there will be three workshops evenly spread over the period of the programme to cover more advanced results, each centred on one of the main themes. Several workshops will take place during the programme. For full details please see http://www.newton.ac.uk/events.html.
Information: http://www.newton.ac.uk/programmes/PEP/.

12–16 **Multiple Sequence Alignment**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 795)
Description: Despite the importance of MSA estimation and active research, many challenges persist. The research community is addressing them through improved mathematical formalization of MSA estimation; development of sophisticated and biologically meaningful models of sequence evolution that include insertions, deletions, and rearrangements; and design of new methods that have good mathematical properties and empirical performance for large datasets. This workshop will engage researchers from different fields, including mathematicians, statisticians, evolutionary biologists, structural biologists, and computer scientists, with the aim of integrating diverse viewpoints, improving mathematical

foundations, and developing new and more powerful methods for estimating MSAs.
Support: Applications for travel support are due November 17, 2014. Please consult the webpage for more information.
Information: http://www.ipam.ucla.edu/programs/MSA2015/.

12–May 22 **Dynamics on Moduli Spaces of Geometric Structures Program**, Mathematical Sciences Research Institute, Berkeley, California. (Jan. 2014, p. 117)
Description: The program will focus on the deformation theory of geometric structures on manifolds, and the resulting geometry and dynamics. This subject is formally a subfield of differential geometry and topology, with a heavy infusion of Lie theory. Its richness stems from close relations to dynamical systems, algebraic geometry, representation theory, Lie theory, partial differential equations, number theory, and complex analysis.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm9002.

12–July 3 **Random Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 365)
Description: A new frontier has emerged at the interface between probability, geometry, and analysis, with a central target to produce a coherent theory of the geometry of random structures. The principal question is the following: within a given structure, what is the interplay between randomness and geometry? More precisely, does the geometry appear to be random at every scale (i.e. fractal), or do fluctuations "average out" at sufficiently large scales? Can the global geometry be described by taking a suitable scaling limit that allows for concrete computations? The goal of the programme is to gather experts from probability, geometry, analysis and other connected areas, in order to study aspects of this question in some paradigmatic situations. Several workshops will take place during the programme. For full details please see http://www.newton.ac.uk/events.html.
Information: http://www.newton.ac.uk/programmes/RGM/index.html.

15–16 **Connections for Women: Dynamics on Moduli Spaces of Geometric Structures**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 665)
Description: This two-day workshop will consist of short courses given by prominent female mathematicians in the field. These introductory courses will be appropriate for graduate students, post-docs, and researchers in areas related to the program. The workshop will also include a panel discussion featuring successful women at various stages in their mathematical careers.
Information: http://www.msri.org/workshops/739.

19–February 6 **Lie Theory and Representation Theory**, Centro di Ricerca Matematica Ennio De Giorigi, Pisa, Italy. (Jun/Jul. 2014, p. 665)
Description: In Winter 2014-2015, a trimester on "Perspectives in Lie Theory" will be held at Centro de Giorgi. The second session of this trimester will be devoted to the topic "Lie Theory and Representation Theory". This session will include a seminar, time for discussions and collaboration, and three minicourses held by Alexander Premet (University of Manchester), Vera Serganova (University of California, Berkeley) and Geordie Williamson (Max-Planck-Institute, Bonn).
Information: http://www.crm.sns.it/event/293/. More information can be found at: http://www.crm.sns.it/event/293/activities.html#title.

20–23 **AIM Workshop: Inference in high-dimensional regression**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 795)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to exploring recent methodological and theoretical advances in inference for high-dimensional statistical models.
Information: http://aimath.org/workshops/upcoming/inferencehighdim.

20–23 **Introductory Workshop: Dynamics on Moduli Spaces of Geometric**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 665)
Description: The deformation theory of geometric structures on manifolds is a subfield of differential geometry and topology, with a heavy infusion of Lie theory. Its richness stems from close relations to dynamical systems, algebraic geometry, representation theory, Lie theory, partial differential equations, number theory, and complex analysis. The introductory workshop will serve as an overview to the program. It aims to familiarize graduate students, post-docs, and other researchers to the major topics of the program. There will be a number of short courses.
Information: http://www.msri.org/workshops/740.

26–30 **AIM Workshop: Graph Ramsey Theory**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul. 2014, p. 665)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to graph Ramsey theory. The main topics of the workshop are Hypergraph Ramsey numbers, Generalized Ramsey numbers, and Geometric Ramsey theorems.
Information: http://aimath.org/workshops/upcoming/graphramsey.

26–30 **Symmetry and Topology in Quantum Matter**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 795)
Description: Topological phases of matter are remarkable both for their richness of physical phenomena, and for their mathematical description by topological quantum field theories (TQFTs). Recently, the prediction and experimental discovery of topological insulators has spurred physicists to explore the role of symmetry in topological phases, leading to the identification of new classes of phases of matter, and new insights into their classification, properties, and potential physical realizations. This is an area with a history of strong connections between physics and mathematics, and the time is ripe for the emerging understanding of symmetric topological phases to benefit from new mathematical ideas in TQFTs, and vice versa. This interdisciplinary workshop will bring together theoretical physicists and mathematicians to discuss symmetric topological phases and TQFTs, with a goal of forging productive new interactions between these communities.
Deadline: Applications are due December 1, 2014.
Information: http://www.ipam.ucla.edu/programs/stq2015/.

29–30 **Connections for Women: Geometric and Arithmetic Aspects of Homogeneous Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2014, p. 796)
Description: This workshop will consist of several mini-courses given by prominent female mathematicians in the field, intended for graduate students, post-docs, and researchers in areas related to the program. The workshop will also include an informal panel discussion session among female researchers on career issues.
Information: http://www.msri.org/workshops/741.

February 2015

2–6 **MBI Workshop on Tumor Heterogeneity and the Microenvironment**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p. 665)
Description: Most solid tumors present as dense fibrotic masses, which suggests that fibroblasts contribute to tumor growth by infiltrating and depositing extracellular matrix proteins. Fibroblasts act in wound healing, angiogenesis and tissue remodeling by releasing growth factors and proteases such as matrix metalloproteinases. Therefore, if the growing tumor can co-opt such fibroblasts it has

an unlimited source of many of the fundamental elements required for growth and invasion. The two central themes of this workshop are: - Heterogeneity (be it phenotypic, signaling or genotypic), and - Microenvironment (ECM, nutrients, fibroblasts and immune cells). Since a highly heterogeneous tumor has the potential to adapt to any microenvironment, understanding how interactions between the growing tumor and its microenvironment modulate tumor heterogeneity is critical to unraveling the mechanisms of cancer initiation.
Information: http://mbi.osu.edu/event/?id=819; phone: 614-292-3648.

2–March 8 **ICERM Semester Program: Phase Transitions and Emergent Properties**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)
Description: Emergent phenomena are properties of a system of many components which are only evident or even meaningful for the collection as a whole. A typical example is a system of many molecules, whose bulk properties may change from those of a fluid to those of a solid in response to changes in temperature or pressure. The basic mathematical tool for understanding emergent phenomena is the variational principle, most often employed via entropy maximization. The difficulty of analyzing emergent phenomena, however, makes empirical work essential; computations generate conjectures and their results are often our best judge of the truth. The semester will include three workshops that will concentrate on different aspects of current interest, including unusual settings such as complex networks and quasicrystals, the onset of emergence as small systems grow, and the emergence of structure and shape as limits in probabilistic models.
Information: http://icerm.brown.edu/sp-s15.

* 4–6 **Computational Photography and Intelligent Cameras**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: Computational photography is a new area of computer graphics and vision, seeking to create new types of photographs and to allow photographers to acquire better images or images they never could observe before. This involves research into new software algorithms for fusing data from multiple images, video streams, or other types of sensors as well as into new hardware architectures for capturing the data needed for the software and numerical processing. Applications of computational photography paradigms include compressed sensing cameras, extended depth of field/refocussing, high dynamic range images, invertible motion blurs, and plenoptic cameras, and mathematics is an important tool for inventing and optimizing these new cameras. This workshop will serve as a gathering place for all those interested in theories, algorithms, methodologies, hardware designs, and experimental studies in computational photography.
Deadline: Applications are due December 10, 2014. Consult the webpage for more information.
Information: http://www.ipam.ucla.edu/programs/CP2015/.

8–28 **Algebraic topology, geometric and combinatorial group theory**, Centro di Ricerca Matematica Ennio De Giorigi, Pisa, Italy. (Jun/Jul. 2014, p. 665)
Description: In Winter 2014-2015, a trimester on "Perspectives in Lie Theory" will be held at Centro de Giorgi. The third session of this trimester will be devoted to "Algebraic topology, geometric and combinatorial group theory". This session will include a seminar, time for discussions and collaboration, and three minicourses held by Vic Reiner (University of Minnesota), Ulrike Tillmann (University of Oxford), and Karen Vogtmann (University of Warwick).
Information: More information can be found at: http://www.crm.sns.it/event/293/activities.html#title; http://www.crm.sns.it/event/293/.

9–13 **Crystals, Quasicrystals and Random Networks**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)
Description: In this workshop we will focus on two significant variants of this classic picture: quasicrystals, and complex networks/random graphs. The analogue of energy minimizing crystals for quasicrystals are aperiodic tilings, such as the kite and dart tilings of Penrose, and for complex networks the analogue of energy minimizing crystals are (multi-partite) extremal graphs, graphs which minimize the number of subgraphs of some type. The workshop will focus on extremal graphs and aperiodic tilings and on the 'solid' phases they are believed to yield when random defects are introduced. It is hoped that progress can be made by pooling the expertise of researchers interested in the various aspects of these subjects.
Information: http://icerm.brown.edu/sp-s15-w1.

9–13 **Zariski-dense Subgroups**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 796)
Description: This workshop will survey the recent progress in the study of Zariski-dense subgroups (both arithmetic and non-arithmetic) of semi-simple algebraic groups; the impact of this work on adjacent areas such as algebraic groups, division algebras, and Galois cohomology; and applications in further areas such as geometry (isospectral and length-commensurable locally symmetric spaces) and combinatorics (expander graphs). These developments have led to new connections between different areas of mathematics (algebra, number theory, algebraic and Lie groups, differential geometry and topology, and combinatorics), and the workshop will bring together people working in those areas, using the subject of Zariski-dense subgroups as a common thread to build new scientific connections as well as to solve new problems that have recently appeared.
Deadline: Applications for travel support are due December 15, 2014. Please consult the webpage for more information.
Information: http://www.ipam.ucla.edu/programs/ZDS2015/.

16–20 **MBI Workshop on Treatment, Clinical Trials and Resistance of Cancer**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p. 667)
Description: This workshop will focus on two broad topics: Mathematical modeling of cancer treatment strategies and how to model resistance of cancers to drug treatments. Use of mathematical models to compare clinical trial arms and virtually simulate clinical trials outcomes. The workshop will highlight modeling applications that are as close as possible to direct clinical impact including design of multi-institutional clinical trials for patient-specific radiation dose strategies, quantification of patient-specific response to treatment that can be useful in predicting outcomes and treatment design, as well as include discussions of sequencing of drug treatments, optimal scheduling, and modeling of combination therapies which are useful in rapidly mutating diseases, such as cancer and HIV. The workshop will also discuss ways to implement the use of mathematical models in a clinical setting.
Information: http://mbi.osu.edu/event/?id=820; phone: 614-292-3648.

23–27 **Machine Learning for Many-Particle Systems**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 796)
Description: This workshop will address the reaches and limitations of ML as applied to many-particle systems and highlight examples where physical models can be successfully combined with ML algorithms. The workshop aims to create novel synergistic collaborations between researchers in two different fields: modeling of many-particle (quantum and classical) systems and machine learning. Interactions between many constituent particles generally give rise to collective (or emergent) phenomena in matter. Even when the interactions between the particles are well defined and the governing

equations of the system are understood, the collective behavior of the system as a whole does not trivially emerge from these equations.
Deadline: Applications for travel support are due January 1, 2015. Consult the webpage for more information.
Information: `http://www.ipam.ucla.edu/programs/ML2015/`.

25–March 1 **Introductory Workshop**, Uppsala University, Uppsala, Sweden. (Jun/Jul. 2014, p. 667)
Description: Satellite of the Representation theory program at the Institute Mittag-Leffler.
Invited speakers: Alexander Alldridge (Cologne), Henning Haahr Andersen (Arhus), Karin Baur (Graz), Eleonore Faber (Toronto), Vyacheslav Futorny (Sao Paulo), Martin Herschend (Uppsala), Bernard Leclerc (Caen), Marco Mackaay (Algarve), Vanessa Miemietz (UEA), Idun Reiten (Trondheim), Claus Michael Ringel (Jeddah/Shanghai), Anne-Laure Thiel (Uppsala), Michela Varagnolo (Cergy-Pontoise), Eric Vasserot (Paris VII), Yu Zhou (Bielefeld).
Organizers: Aslak Bakke Buan and Volodymyr Mazorchuk.
Deadline: January 10, 2015.
Information: `http://www.math.uu.se/IW2015/`; email: `iw2015@math.uu.se`.

March 2015

9–12 **Broad Perspectives and New Directions in Financial Mathematics**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 796)
Description: This IPAM "long program" will address the stability of the network of financial institutions, the impact of high frequency and algorithmic trading, the financialization of the commodity markets, and the huge challenges raised by the size and the speed of trade data. This program will bring together academic mathematicians, economists, regulators, and experts from the finance industry to seed research — even if speculative — in these areas. The program will open with tutorials, and will be punctuated by four major workshops and a culminating workshop. Long program participants will participate for extended periods up to the entire length of the program. Applications for individual workshops are separate and are posted on individual workshop home pages. Applications for the long program will be accepted through December 9, 2014, but decisions will be made starting in July. Please consult the webpage for more information.
Information: `http://www.ipam.ucla.edu/programs/fm2015/`.

14–18 (UPDATED) **SIAM Conference on Computational Science and Engineering (CSE15)**, The Calvin L. Rampton Salt Palace Convention Center, Salt Lake City, Utah. (Jun/Jul. 2014, p. 667)
Description: Call for Participation Now Available! The SIAM CS&E conference seeks to enable in-depth technical discussions on a wide variety of major computational efforts on large problems in science and engineering, foster the interdisciplinary culture required to meet these large-scale challenges, and promote the training of the next generation of computational scientists. We especially encourage submissions of posters to CSE15, where we will have expanded poster sessions, including demos and thematic groups of posters (or poster minisymposia), as well as poster prizes. New at CSE15: Poster Minisymposia (including demos). A minisymposium of posters (that is, a minisymposterium) consists of a collection of three or more posters by different presenters grouped around a central theme. The posters will be co-located in the poster viewing area.
Deadlines: Submission: July 31, 2014. Abstracts for contributed and minisymposium speakers August 21, 2014: Abstracts for contributed posters and minisymposterium posters (thematic groups). Travel Fund Application: August 7, 2014: SIAM Student Travel Award and Post-doc/Early Career Travel Award Applications Twitter hashtag: #SIAMCSE15 Contact SIAM Conference Department at `http://meetings@siam.org` with any questions about the conference.
Information: `http://www.siam.org/meetings/cse15/index.php`.

* 16–20 **6th International Conference on High Performance Scientific Computing**, Hanoi, Vietnam.
Description: The conference is jointly organized by Heidelberg Institute of Theoretical Studies (HITS), Institute of Mathematics, Vietnam Academy of Science and Technology, Interdisciplinary Center for Scientific Computing (IWR), University of Heidelberg, and Vietnam Institute for Advanced Study in Mathematics.
Topics: Mathematical modeling, numerical simulation, methods for optimization and control, parallel computing (architectures, algorithms, tools and environments), software development applications of scientific computing (in physics, mechanics, hydrology, chemistry, biology, medicine, transport, logistics, site location, communication, scheduling, industry, business, finance...). The conference proceedings with selected high-quality contributions will be published by Springer.
Information: `http://hpsc.iwr.uni-heidelberg.de/HPSCHanoi2015/`.

16–20 **Small Clusters, Polymer Vesicles and Unusual Minima**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)
Description: This workshop will explore emergent phenomena in the context of small clusters, supramolecular self-assembly and the shape of self-assembled structures such as polymer vesicles. The emphasis will be on surprises which arise when common conditions are not satisfied, for instance when the number of components is small, or they are highly non-spherical, or there are several types of components. Interactions vary from hard sphere repulsion to competition between coarse-grained liquid-crystalline ordering competing with shape deformation.
Information: `http://icerm.brown.edu/sp-s15-w2`.

18–20 **IAENG International Conference on Scientific Computing 2015**, Royal Garden Hotel, Hong Kong. (Aug. 2014, p. 796)
Description: The IAENG International Conference on Scientific Computing (ICSC'15) will take place in Hong Kong, 18-20 March, 2015. The conference ICSC'15 is held under the International MultiConference of Engineers and Computer Scientists 2015. The IMECS 2015 is organized by the International Association of Engineers (IAENG), a non-profit international association for the engineers and the computer scientists.
Information: `http://www.iaeng.org/IMECS2015/ICSC2015.html`.

23–27 **AIM Workshop: Dynamical algebraic combinatorics**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 796)
Description: This workshop, sponsored by AIM and the NSF, will focus on dynamical systems arising from algebraic combinatorics.
Information: `http://aimath.org/workshops/upcoming/dynalgcomb`.

23–27 **MBI Workshop on Targeting Cancer Cell Proliferation and Metabolism Networks**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p. 667)
Description: This workshop will encompass a mix of experimentalists and mathematicians. Ideally, the former will be engaged on the production of large datasets on cancer cell proliferation, both at the cell population and single-cell level, and in response to microenvironment perturbations including anti-proliferative drugs. The latter will focus on mathematical models of proliferation and metabolism at several scales, including genetic, signaling and cellular, including a focus on the ability of cancer cell populations to regenerate and reprogram in response to hostile microenvironment and to targeted treatment, ultimately persisting in their proliferative state. Multi-scale models connecting the growth of cultured cancer cells and/or individual tumors to epidemiological data will also be

considered. Although tumor growth and cancer cell proliferation have been modeled mathematically for decades, adequate datasets have been scarce and fragmentary due to experimental limitations.
Information: http://mbi.osu.edu/event/?id=821; phone: 614-292-3648.

27 **Philosophy of Information and Information Processing**, Pembroke College, Oxford, United Kingdom. (Jun/Jul. 2014, p. 667)
Description: The overall objective of this workshop is to study open questions within the philosophy of information and information processing, with an emphasis on the value of observed information and its measurement. Interest in the philosophy, meaning and value of information goes back half a century but has rapidly increased recently with many new directions of research into the meaning, quantification and measures of information and its complexity. Theoretic advances in these directions will have a huge impact on a wide range of real world applications.
Information: http://www.american.edu/cas/economics/info-metrics/workshop/workshop-2015-spring.cfm.

30–31 **3rd IMA International Conference on Flood Risk**, Swansea University, Wales, United Kingdom. (Jun/Jul. 2014, p. 667)
Description: Recent coastal and inland flooding events such as occurred in the UK, have highlighted the difficulties in forecasting individual and sequences of extreme events. The widespread and catastrophic flooding following the Japanese earthquake in March 2011 heightened the global public awareness of the limitations of existing flood defence infrastructure and flood warning systems. The conference will provide a forum at which engineers, mathematicians and statisticians can meet to exchange views on this important technical area. The emphasis will be on new developments in the mathematical and statistical techniques applicable for assessing flood risk. The conference will be of interest to flood defence practitioners; flood defence managers; statisticians, mathematicians and civil engineers.
Information: http://www.ima.org.uk/conferences/conferences_calendar.cfm.html.

April 2015

13–17 **Dynamics on Moduli Spaces**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 667)
Description: The Research Workshop of the "Dynamics on moduli spaces of geometric structures" will concentrate on some of the following general interrelated themes: (1) Geometric structures on the spaces of geometric structures which extend and generalize classical constructions on Teichmüller metric and its geodesic flow, Fenchel-Nielsen coordinates, Fock-Goncharov Thurson-Penner coordinates, and the symplectic and Poisson geometries (2) Relations with harmonic maps, Riemann surfaces, complex geometry: specifically Higgs bundles, holomorphic differentials (quadratic, cubic, etc.) as parameters for representations of the fundamental group, hyperkähler and complex symplectic geometry of moduli spaces, lifts of Teichmüller geodesic flows to flat bundles of character varieties (3) Asymptotic properties of higher Teichmüller spaces, including generalized measured geodesic laminations, Culler-Morgan-Shalen group.
Information: http://www.msri.org/workshops/743.

13–17 **Limit Shapes**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)
Description: Since the days of Boltzmann, it has been well accepted that natural phenomena, when described using tools of statistical mechanics, are governed by various "laws of large numbers." For practitioners of the field this usually means that certain empirical means converge to constants when the limit of a large system is taken. However, evidence has been amassed that such laws apply also to geometric features of these systems and, in particular, to many naturally-defined shapes. The last decade has seen a true explosion of "limit-shape" results. New tools of combinatorics, random matrices and representation theory have given us new models for which limit shapes can be determined and further studied. The goal of the workshop is to attempt to confront this "ZOO" of combinatorial examples with older foundational work and develop a better understanding of the general limit shape phenomenon.
Information: http://icerm.brown.edu/sp-s15-w3.

13–17 **MBI Workshop on Stem Cells, Development, and Cancer**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul. 2014, p. 667)
Description: What is the relationship between normal tissue stem cells and tumor-initiating cells (e.g., cancer stem cells)? Which signaling and other regulatory networks are altered in tumors relative to the normal tissues, and how do they function within the tumor? Finally, there is growing evidence that therapies aimed at the major cell types in tumors may sometimes make things worse, by leading to an expansion in the fraction of cancer stem cells. How can this be avoided? This workshop will address these and other questions through discussions among mathematical and computational modelers and experimentalists. In particular, the strong connections between normal development, tumor growth and the use of novel treatment strategies will be discussed.
Information: http://mbi.osu.edu/event/?id=822; phone: 614-292-3648.

May 2015

6–10 **Representation Theory Workshop**, Uppsala University, Uppsala, Sweden. (Jun/Jul. 2014, p. 668)
Description: Satellite of the Representation Theory program at the Institute Mittag-Leffler.
Invited speakers: Aslak Bakke Buan (Trondheim), Vyjayanthi Chari (Riverside), Shun-Jen Cheng (Taipei), Kevin Coulembier (Ghent), Jonathan Kujawa (Oklahoma), Shrawan Kumar (Chapel Hill), Gus Lehrer (Sydney), George Lusztig (MIT), Steffen Oppermann (Trondheim), Ivan Penkov (Bremen), Loic Poulain d'Andecy (Amsterdam), Antonio Sartori (Bonn), Vera Serganova (Berkeley), Weiqiang Wang (Virginia), Kaiming Zhao (Waterloo).
Organizers: Henning Haahr Andersen and Volodymyr Mazorchuk.
Registration deadline: March 24, 2015.
Information: http://www.math.uu.se/rtw2015/; email: rtw2015@math.uu.se.

11–15 **Advances in Homogeneous Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 668)
Description: The Advances in Homogeneous Dynamics workshop will feature the speakers whose work is at the forefront of the field. There will be a panel discussion accompanied by an open problem session to lay out possible directions for the research in homogeneous dynamics. Talks will be in a broad range of topics and this will help to build more connections between researchers interested in dynamical systems, number theory, and geometry. For example we hope that the involvement of the participants of the other program held at MSRI during the same academic year (Dynamics on Moduli Spaces of Geometric Structures, Spring 2015) would create new connections between the topics. There will be shorter talks presented by early-career researchers
Information: http://www.msri.org/workshops/738.

17–21 **SIAM Conference on Applications of Dynamical Systems (DS15)**, Snowbird Ski and Summer Resort, Snowbird, Utah. (May 2014, p. 556)
Description: The application of dynamical systems theory to areas outside of mathematics continues to be a vibrant, exciting and fruitful endeavor. These application areas are diverse and multidisciplinary, ranging over all areas of applied science and engineering, including biology, chemistry, physics, finance, and industrial applied mathematics. This conference strives to achieve a blend

of application-oriented material and the mathematics that informs and supports it. The goals of the meeting are a cross-fertilization of ideas from different application areas, and increased communication between the mathematicians who develop dynamical systems techniques and applied scientists who use them.
Information: http://www.siam.org/meetings/ds15/|.

18–22 **AIM Workshop: Carleson theorems and multilinear operators**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 796)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to a selection of questions at the intersection of Carleson operators and multilinear operators.
Information: http://aimath.org/workshops/upcoming/multilinops.

* 18–22 **International Conference on Differential & Difference Equations and Applications 2015**, Military Academy, Amadora, Portugal.
Description: The main aim of the conference is to promote, encourage, cooperate, and bring together researchers in the fields of differential & difference equations. All areas of differential & difference equations will be represented with special emphasis on applications. It is anticipated that the conference will attract over 200 participants with 10 plenary speakers, 20 main speakers, and more than 200 lectures. It will be a mathematically enriching and socially exciting event.
Information: http://sites.google.com/site/sandrapinelas/icddea-2015.

27–30 **Seventh International Conference on Dynamic Systems and Applications & Fifth International Conference on Neural, Parallel, and Scientific Computations**, Department of Mathematics, Morehouse College, Atlanta, Georgia. (Aug. 2014, p. 797)
Description: This is a joint international conference on selected topics of Dynamic Systems and Applications & Neural, Parallel, and Scientific Computations.
Information: http://www.dynamicpublishers.com.

28–31 **3rd International Conference on "Applied Mathematics & Approximation Theory-AMAT 2015"**, Ankara, Turkey. (May 2014, p. 557)
Description: All subareas and topics of Applied Mathematics and Approximation Theory are welcome.
Plenary Speakers: George A. Anastassiou (University of Memphis, USA); Jerry L. Bona (University Illinois at Chicago, USA); Alexander Goncharov (Bilkent University, Turkey); Weimin Han (University of Iowa, USA); Varga Kalantarov (Ko University, Turkey); Gitta Kutyniok (Technische Universitt, Germany); Choonkil Park (Hanyang University, South Korea); Tamaz Vashakmadze (Tbilisi State University, Georgia).
Organizers: George A. Anastassiou (University of Memphis, USA) and Oktay Duman (TOBB Economics and Technology University, Ankara, Turkey).
Contact: email: amat2015@etu.edu.tr; amat2015conference@gmail.com.
Information: http://amat2015.etu.edu.tr/.

June 2015

* 1–5 **AIM Workshop: Stochastic methods for non-equilibrium dynamical systems**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the study of the statistical properties of dynamical systems of physical interest.
Information: http://aimath.org/workshops/upcoming/noneqdynsys.

8–12 **AIM Workshop: Mathematical aspects of physics with non-self-adjoint operators**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 797)
Description: This workshop, sponsored by AIM and the NSF, will emphasize the state-of-the-art techniques for the mathematically rigorous analysis of non-self-adjoint phenomena encountered in main stream and newly developing fields of physics.
Information: http://aimath.org/workshops/upcoming/nonselfadjoint.

15–19 **Connections in Discrete Mathematics**, Simon Fraser University, Vancouver, Canada. (Jun/Jul. 2014, p. 668)
Description: Discrete mathematics plays a central role in modern mathematics. This is in large part due to the work of Ron Graham. His work has spanned over five decades and includes over 300 published papers, 5 books, countless talks and editorial assignments, service as president of the AMS and the MAA, and the many connections that he has made in the mathematics community. His research encompasses number theory, graph theory, discrete geometry, Ramsey theory, combinatorics, algorithms, and more; often revealing surprising interconnections between these topics. To celebrate the life and work of Ron Graham, this conference will bring together prominent researchers in number theory, graph theory, combinatorics, probability, discrete geometry, and so on, to explore the connections between these areas of mathematics. In addition to plenary and invited talks we will have contributed talks. We particularly encourage graduate students and early career mathematicians to participate.
Information: http://sites.google.com/site/connectionsindiscretemath/.

22–24 **3rd International Conference on "Graph Modelling in Engineering"**, University of Bielsko-Biala, Bielsko-Biala, Poland. (Jun/Jul. 2014, p. 668)
Description: On behalf of Professor Józef Wojnarowski, the father of graph-based modelling of mechanical systems in Poland, we would like to invite you to participate in our conference.
Upon the initiative of Professor Józef Wojnarowski, discussed among the members of Polish Committee on TMM, we would like to continue the tradition of two previous conferences which had been organized by the Silesian TU in Gliwice in 1993 and 1999.
Goal: Of our conference is to unite the society of scientists whose works are dedicated to an application of graphs into mechanical engineering and related fields of knowledge.
Scope: The scope is wide but narrower than other conferences on mathematical modeling or industrial mathematics. It is dedicated to an application not only graph theory but also discrete mathematics, combinatorics, number theory, network theory and some other related disciplines of mathematics. The tools, methods, algorithms and structures of these fields of mathematics could be utilized in versatile areas of mechanical engineering, mechanics, mechatronics and connected engineer and industry related areas. The full scope of the conference is given in the adequate subpage.
In our opinion, the proposed scope gives a unique opportunity to join together all areas of graph-related applications which are usually considered separately as e.g., bond-graphs, Petri nets or graph grammars which, in fact, are closely and almost fully related to graph theory.
Please, take into consideration that our proposal is rare on the market of contemporary conferences interwining all possible graph-related science and technical applications. We do hope that rebirthing of such a forum would be fruitful for all participants.
Bielsko-Biala is an open, nice city with a multi-cultural, multi-nationality and multi-religious tradition which gives a friendly atmosphere for our meeting.
Information: email: szawislak@ath.bielsko.pl; email: gm2015@ath.eu.

* 22–26 **International conference "Dynamical Systems and Their Applications"**, Institute of Mathematics of National Academy of Sciences of Ukraine, Kiyv, Ukraine.
Description: The conference is devoted to a wide range of issues of the modern theory of dynamical systems, among which are to-

pological dynamics, ergodic theory, the theory of attractors and chaos, combinatorial and symbolic dynamics, the theory of fractals, bifurcation and stability theory, infinite-dimensional dynamical systems, and various kinds of applications, especially in mathematical physics. Emphasis is expected to be paid to combinatorial dynamics, originating from the widely known Sharkovskiy's theorem on the coexistence of cycles.
Information: `http://cds2015.imath.kiev.ua/`.

July 2015

6–10 **Classical and quantum hyperbolic geometry and topology/ Topologie et géométrie hyperbolique classique et quantique**, Université Paris-Sud, Orsay, France. (Jun/Jul. 2014, p. 668)
Description: This conference is in honnor of Francis Bonahon (University of Southern California); The main themes are low-dimensional topology, hyperbolic geometry, quantum Teichmüller theory, topological quantum field theory, higher Teichmüller theory.
Information: `http://www.math.u-psud.fr/~paulin/Bonahon2015.html`.

6–10 **10th IMACS Seminar on Monte Carlo Methods**, Johannes Kepler University Linz and Radon Institute for Computational and Applied Mathematics, Linz, Austria. (Oct. 2013, p. 1205)
Description: The IMACS Seminar on Monte Carlo Methods is a bi-annual event that previously took place in Brussels, Varna, Salzburg, Berlin, Tallahassee, Reading, Brussels, Borovets, and Annecy-le-Vieux.
Topics: Algorithms for high-dimensional problems and complexity, computational stochastic differential equations, generation of random numbers, low discrepancy point sets and sequences, Markov Chain Monte Carlo, multilevel Monte Carlo.
Information: `http://www.mcm2015.jku.at`.

8–10 **SIAM Conference on Control and Its Applications (CT15)**, Maison de la Mutualit, Paris, France. (Jun/Jul. 2014, p. 668)
Description: The field of control theory is central to a wide range of aerospace, energy, automotive and advanced technological systems and is increasingly recognized as fundamental for emerging fields ranging from nanotechnology, smart grid to cell regulation. Moreover, in addition to its traditional ubiquity in process regulation for the physical sciences and engineering, control concepts now pervade the biological, computer, and social sciences. This conference will showcase a wide range of topics in control and systems theory. The topics and applications include control of PDEs, computational mathematics for control and optimization, real-time optimization and data assimilation, cooperative control for unmanned autonomous vehicles, differential games, cellular and biological regulation, control of hybrid systems, control techniques for financial mathematics, biomedical control, risk sensitive control and filtering, control of smart systems, flow control and quantum control.
Information: `http://www.siam.org/meetings/ct15/`.

13–17 **12th International Conference on Finite Fields and Their Applications (Fq12)**, Skidmore College, Saratoga Springs, New York. (Feb. 2014, p. 214)
Description: The bi-annual series of "Fq" conferences returns to the USA for the first time since 1993. The Fq12 conference will feature 8 invited lectures and approximately 80 contributed talks on all aspects, theoretical and applied, of mathematics and computer science which are related to finite fields. Truly an international event, recent conferences in the series have attracted researchers from about 30 different countries. See the Fq12 website for more information.
Information: `http://www.skidmore.edu/fq12`.

13–December 18 **Coupling Geometric PDEs with Physics for Cell Morphology, Motility and Pattern Formation**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2014, p. 318)
Description: The aim of this six-month research programme is to create a unique forum to strengthen and develop research links between state-of-the-art experimental "wet" sciences (biology, medicine, bio-physics) and theoretical "dry" sciences (pure, applied and computational mathematics, theoretical physics, statistics). In this programme we will discuss and present in a hands-on format current experimental methodology for cell motility and pattern formation. We will emphasise interactions between experimentalists and theoreticians, with the dual goals of understanding how current mathematical techniques from physics, differential geometry, mathematical modelling and numerical analysis can help to understand current problems in the areas of cell motility and pattern formation, and what new mathematical techniques may emerge in the process. Several workshops will take place during the programme. For full details please see www.newton.ac.uk/events.html.
Information: `http://www.newton.ac.uk/programmes/CGP/`.

14–17 **International Conference on Nonlinear Operators, Differential Equations and Applications, ICNODEA-2015**, Babes-Bolyai University, Cluj-Napoca, Romania. (Aug. 2014, p. 797)
Description: The conference will explore new developments in the theory of nonlinear operators and its applications to integral, differential and partial differential equations and inclusions. A special emphasis will be on applications in biology, medicine, economics, physics and engineering.
Conference Sessions: Nonlinear ODEs and Applications; Topological and Variational Methods for Nonlinear PDEs; Mathematical Models in Applied Sciences; Fixed Point Theory.
Keynote Speakers: Ravi P. Agarwal, Gabiele Bonanno, Alberto Cabada, Wojtek Kryszewski, Dumitru Motreanu, Themistocles M. Rassias, Mircea Sofonea.
Organizers: Radu Precup, Adrian Petrusel, Adriana Buica, Marcel Serban, Szilárd András.
Information: `http://www.cs.ubbcluj.ro/~icnodeacj/index.htm`.

20–24 **The 11th International Conference on Fixed Point Theory and its Applications**, Galatasaray University, Istanbul, Turkey. (Dec. 2013, p. 1497)
Description: The purpose of the conference is to bring together leading experts and researchers in fixed point theory and to assess new developments, ideas and methods in this important and dynamic field. A special emphasis will be put on applications in related areas, as well as other sciences, such as the natural sciences, medicine, economics and engineering. The conference will continue the tradition of the previous fixed point theory meetings which were held in Marseille (1989), Halifax (1991), Seville (1995), Kazimierz Dolny (1997), Haifa (2001), Valencia (2003), Guanajuato (2005), Chiang Mai (2007), Changhua (2009) and Cluj-Napoca (2012).
Information: `http://www.icfpta.org/`.

20–August 14 **Metric and Analytic Aspects of Moduli Spaces**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2014, p. 318)
Description: The term `moduli space' has its origins in the classification of conformal structures on two-dimensional surfaces. Closed surfaces are classified topologically by their genus, but for fixed genus, the set of inequivalent conformal structures is essentially a smooth finite- dimensional manifold, a first example of a moduli space. In more recent times, many other instances of mathematical structures of this type have come to light, above all in gauge theory. They continue to have, a major impact in modern geometry, topology and mathematical physics.
Goal: The goal of the programme is to explore moduli spaces from the metric and analytical points of view. We shall survey the current state of the art with a focus on four themes: 4-dimensional hyper-Kaehler manifolds; compactification of moduli spaces; analysis on moduli spaces; new constructions and challenges. There will be a

5-day workshop during the second week of the programme. For full details please see http://www.newton.ac.uk/events.html.
Information: http://www.newton.ac.uk/programmes/MAM/.

August 2015

3–7 **AIM Workshop: First passage percolation and related models**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 797)
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the study of first passage percolation on the d-dimensional integer lattice and related models.
Information: http://aimath.org/workshops/upcoming/firstpercolation.

3–7 **Differential and combinatorial aspects of singularities**, TU Kaiserslautern, Germany. (Aug. 2014, p. 797)
Description: This conference will focus on aspects of singularity theory and complex algebraic geometry, including D-module theory, homological methods, (logarithmic) derivations and differential forms, topology of hypersurface singularities and arrangements of hyperplanes.
Information: http://www.mathematik.uni-kl.de/agag/workshops/singconf2015.

19–December 18 **Mathematical, Foundational and Computational Aspects of the Higher Infinite**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.
Description: Current set-theoretic research on infinity focuses on the following three broad areas: large Cardinals and inner model theory, descriptive set-theoretic methods and classification problems, and infinite combinatorics. The programme HIF will connect these three main strands of set-theoretic research and other fields of set theory to the wider scope of mathematics, to research in the foundations of mathematics, including some philosophical issues, and to research on computational issues of infinity, e.g. in theoretical computer science and constructive mathematics. Three workshops are planned during the programme: The first one (August 24–28, 2015) will be the 5th European Set Theory Conference. The second workshop, entitled "New challenges in iterated forcing" will be a Satellite Meeting held at the University of East Anglia in Norwich (November 2–6, 2015). A final workshop will take place on December 14–18, 2015. For full details please see http://www.newton.ac.uk/events.html.
Information: http://www.newton.ac.uk/programmes/HIF/.

September 2015

1–August 31 **Call for Research Programmes 2015-2016**, Centre de Recerca Matematica, Bellaterra, Barcelona, Spain.
Description: The CRM invites proposals for Research Programmes during the academic year 2015–2016 in any branch of mathematics and its applications. CRM Research Programmes consist of periods ranging between two to five months of intensive research in a given area of mathematics and its applications. Researchers from different institutions are brought together to work on open problems and to analyze the state and perspectives of their area.
Deadlines for submission of proposals: November 29, 2013, for preliminary proposals and October 25, 2013, for final proposals.
Information: http://www.crm.cat/en/Pages/DetallCrida.aspx?ItemID=7.

1–4 **IMA Conference on Numerical Methods for Simulation**, Mathematical Institute, University of Oxford, UK. (Aug. 2014, p. 797)
Description: Developments in numerical methods underpin simulations in many ways, for example, in any area where high-dimensional problems are governed by differential equations. Computational fluid dynamics has driven many developments in this area; however there is a wide range of application areas where the problems, and indeed solution techniques may be similar. Numerical methods are important in diverse areas such as geophysical modelling, fluid-structure interaction, high-dimensional dynamical systems, weather prediction, climate modelling, oil reservoir simulation, and so on. The conference will bring together application specialists, applied mathematicians, numerical analysts and computational scientists who develop and use numerical simulations. Applications which focus on data assimilation, inverse problems, uncertainties or control, which contain as a major component a high-dimensional forward model, will also be represented.
Information: http://www.ima.org.uk/conferences/conferences_calendar.cfm.html.

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

September 2015

* 9–11 **IMA Conference on Mathematics of Robotics**, St. Anne's College, Oxford, United Kingdom.
Description: The IMA Conference on the Mathematics of Robotics aims to bring together researchers working on all areas of robotics which have a significant mathematical content. The idea is to highlight the mathematical depth and sophistication of techniques applicable to robotics and to foster cooperation between researchers working in different areas of robotics.
Information: http://ima.org.uk/.

9–December 4 **ICERM Semester Program: Computational Aspects of the Langlands Program**, Brown University, Providence, Rhode Island. (Jun/Jul. 2014, p. 669)
Description: During the semester we will focus on three specific aspects of the Langlands program. First, we will look at elliptic curves over number fields and genus 2 curves over the rationals and will consider their relationship to modular forms. Second, we will consider computational aspects of modular forms in higher rank. Specifically, we will examine K3 surfaces and their connections to modular forms on orthogonal groups. Our third topic concerns analytic aspects of L-functions, building upon and complementing the algebraic, arithmetic, and geometric data.
Information: http://icerm.brown.edu/sp-f15/.

14–18 **The European Numerical Mathematics and Advanced Applications (ENUMATH) Conference**, Institute of Applied Mathematics, Middle East Technical University, Ankara, Turkey. (Dec. 2013, p. 1497)
Description: The European Numerical Mathematics and Advanced Applications (ENUMATH) conferences are a forum for discussion of basic aspects and new trends in numerical mathematics and challenging scientific and industrial applications on the highest level of international expertise. They started in Paris in 1995 and were subsequently held at the universities of Heidelberg (1997), Jyvaskyla (1999), Ischia Porto (2001), Prague (2003), Santiago de Compostela (2005), Graz (2007), Uppsala (2009), Leicester (2011), Lausanne (2013).
Information: http://enumath2015.iam.metu.edu.tr/.

21–26 **International Conference in Mathematics Education**, Catania, Sicily, Italy. (Aug. 2014, p. 797)
Description: The 12th International Conference of the Mathematics Education into the 21st Century Project will be held this year from Sep. 21-26 in Montenegro. Already more than 160 people have registered and it promises to be a very successful and productive meeting. The First Announcement and Call for Papers, with full details of the conference and a registration form, as well as background on our Project and Conferences, can be downloaded at: http://www.cdnalma.poznan.pl/static/alan/FAMontenegro6.doc. We are starting to plan our next conference, to be held in a beautiful hotel convention centre overlooking the sea close to Catania, Sicily,

Italy, in late September, 2015. It will feature papers and workshops on all aspects of innovation in Mathematics, Science, Statistics and Computer Education.
Information: Would you be kind enough to give us some personal feedback as follows? It is probable/possible/impossible (please choose one) that I can attend the Catania Conference in late September 2015. Dr. Alan Rogerson, International Coordinator of the Mathematics Education into the 21st Century Project.

December 2015

1–5 **BioInfoSummer 2014: Summer symposium in bioinformatics**, Monash University (Caufield Campus), Melbourne, Australia. (Jun/Jul. 2014, p. 669)
Description: Bioinformatics is an exciting, fast-moving area analysing and simulating the structures and processes of biological systems. BioInfoSummer introduces students, researchers and others working in related areas to the discipline. The program features: Introduction to biology and bioinformatics; evolutionary biology; systems biology; next generation sequencing; and coding and algorithms for bioinformatics.
Information: `http://www.amsi.org.au/BIS`.

January 2016

14–15 **Connections for Women: Differential Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 669)
Description: The purpose of this meeting is to help junior female researchers to become familiar with the focus topics of the main MSRI program, and also for the junior researchers to have an opportunity to get acquainted with more senior women researchers in differential geometry.
Information: `http://www.msri.org/workshops/702`.

18–22 **Introductory Workshop: Modern Riemannian Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 669)
Description: The week will be devoted to an introduction to modern techniques in Riemannian geometry. This is intended to help graduate students and younger researchers get a headstart, in order to increase their participation during the main semester programs and research lectures. To increase outreach, the week will focus on Riemannian geometry and should be largely accessible. Some mini-courses on topics of recent interest will be included. The workshop will also have semi-expository lectures dealing with aspects of spaces with curvature bounded from below, since such spaces will occur throughout the semester. We expect that many Berkeley mathematicians and students will participate in the introductory workshop.
Information: `http://www.msri.org/workshops/703`.

February 2016

15–June 17 **Melt in the Mantle**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Apr. 2014, p. 433)
Description: The Earth's mantle is almost entirely solid, but on geological timescales it convects vigorously, the well-known surface expression of this being plate tectonics. Although the basic thermodynamics of melt generation in these settings is well understood, how the melt is transported to the surface is not, despite several decades of work on the problem. Sophisticated mathematical techniques are needed to map an understanding of physics at the smallest scales to plate-tectonic scales. Seismology offers a way to image melt in the mantle, but development of new tools in inverse theory is required to extract that information. Models are cast as a series of coupled non-linear PDEs, which require advanced numerical techniques to solve. This programme will bring together a broad spectrum of mathematicians and solid Earth scientists to tackle these and other challenges in the area. Several workshops will take place during the programme. For full details please see www.newton.ac.uk/events.html.
Information: `http://www.newton.ac.uk/programmes/MIM/`.

March 2016

21–25 **Kähler Geometry, Einstein Metrics, and Generalizations**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul. 2014, p. 669)
Description: The workshop will integrate elements from complex differential geometry with Einstein metrics and their generalizations. The topics will include • Existence of Kähler-Einstein metrics and extremal Kähler metrics. Notions of stability in algebraic geometry such as Chow stability, K-stability, b-stability, and polytope stability. Kähler-Einstein metrics with conical singularities along a divisor. • Calabi-Yau metrics and collapsed limit spaces. Connections with physics and mirror symmetry. • Einstein metrics and their moduli spaces, ϵ-regularity, noncompact examples such as ALE, ALF, and Poincaré-Einstein metrics. Generalizations of the Einstein condition, such as Bach-flat metrics and Ricci solitons. • Sasaki-Einstein metrics and metrics with special holonomy. New examples and classification problems.
Information: `http://www.msri.org/workshops/704`.

May 2016

2–6 **Geometric Flows in Riemannian and Complex Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul.. 2014, p. 669)
Description: The workshop will concentrate on parabolic methods in both Riemannian and complex geometry. The topics will include • Ricci flow. Analytic questions about Ricci flow in three dimensions. Possible applications of Ricci flow to 4-manifold topology. Ricci flow in higher dimensions under curvature assumptions. • Kähler-Ricci Flow. Applications to the Kähler-Einstein problem. Connections to the minimal model program. Study of Kähler-Ricci solitons and limits of Kähler-Ricci flow. • Mean curvature flow. Singularity analysis. Generic mean curvature flow. • Other geometric flows such as Calabi flow and pluriclosed flow.
Information: `http://www.msri.org/workshops/705`.

July 2016

11–December 21 **Theoretical Foundations for Statistical Network Analysis**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Apr. 2014, p. 433)
Description: The core of this 6-month programme is understanding and quantifying mathematical structure in network models. Networks are ubiquitous in modern science and society. In fact, whenever we observe entities and relationships between them, we have network data. The behaviour of almost all networks, natural or engineered, physical or information-based, involves a strong component of randomness and is typically not fully or directly observed. Considerable open challenges remain in proving properties both of generative mechanisms for such networks, as well as of methods for inference. This motivates the development of theoretical foundations for statistical network analysis. Several workshops will take place during the programme, including an opening, midterm and closing workshop, as well as a Satellite Meeting and an Open for Business industry day. For full details please see `http://www.newton.ac.uk/events.html`.
Information: `http://www.newton.ac.uk/programmes/SNA/`.

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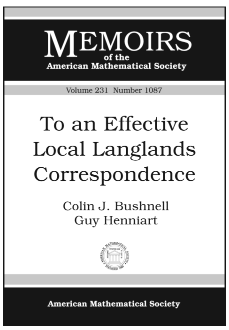
Algebra and Algebraic Geometry



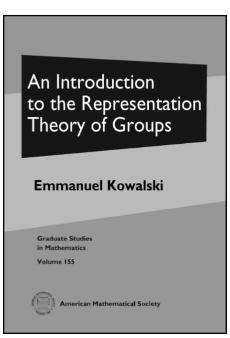
To an Effective Local Langlands Correspondence

Colin J. Bushnell, *King's College London, United Kingdom*, and **Guy Henniart**, *Université Paris-Sud, Orsay, France*

Contents: Introduction; Representations of Weil groups; Simple characters and tame parameters; Action of tame characters; Cuspidal representations; Algebraic induction maps; Some properties of the Langlands correspondence; A naïve correspondence and the Langlands correspondence; Totally ramified representations; Unramified automorphic induction; Discrepancy at a prime element; Symplectic signs; Main Theorem and examples; Bibliography.

Memoirs of the American Mathematical Society, Volume 231, Number 1087

September 2014, 88 pages, Softcover, ISBN: 978-0-8218-9417-0, LC 2014015533, 2010 *Mathematics Subject Classification:* 22E50, **Individual member US$42.60**, List US$71, Institutional member US$56.80, Order code MEMO/231/1087



An Introduction to the Representation Theory of Groups

Emmanuel Kowalski, *ETH, Zurich, Switzerland*

Representation theory is an important part of modern mathematics, not only as a subject in its own right but also as a tool for many applications. It provides a means for exploiting symmetry, making it particularly useful in number theory, algebraic geometry, and differential geometry, as well as classical and modern physics.

The goal of this book is to present, in a motivated manner, the basic formalism of representation theory as well as some important applications. The style is intended to allow the reader to gain access to the insights and ideas of representation theory—not only to verify that a certain result is true, but also to explain why it is important and why the proof is natural.

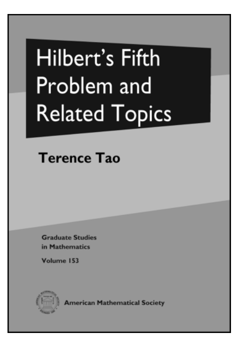
The presentation emphasizes the fact that the ideas of representation theory appear, sometimes in slightly different ways, in many contexts. Thus the book discusses in some detail the fundamental notions of representation theory for arbitrary groups. It then considers the special case of complex representations of finite groups and discusses the representations of compact groups, in both cases with some important applications. There is a short introduction to algebraic groups as well as an introduction to unitary representations of some noncompact groups.

The text includes many exercises and examples.

Contents: Introduction and motivation; The language of representation theory; Variants; Linear representations of finite groups; Abstract representation theory of compact groups; Applications of representations of compact groups; Other groups: a few examples; Some useful facts; Bibliography; Index.

Graduate Studies in Mathematics, Volume 155

September 2014, 434 pages, Hardcover, ISBN: 978-1-4704-0966-1, LC 2014012974, 2010 *Mathematics Subject Classification:* 20-01, 20Cxx, 22A25, **AMS members US$63.20**, List US$79, Order code GSM/155



Hilbert's Fifth Problem and Related Topics

Terence Tao, *University of California, Los Angeles, CA*

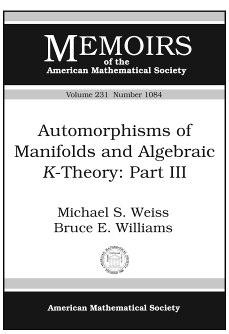
In the fifth of his famous list of 23 problems, Hilbert asked if every topological group which was locally Euclidean was in fact a Lie group. Through the work of Gleason, Montgomery-Zippin, Yamabe, and others, this question was solved affirmatively; more generally, a satisfactory description of the (mesoscopic) structure of locally compact groups was established. Subsequently, this structure theory was used to prove Gromov's theorem on groups of polynomial growth, and more recently in the work of Hrushovski, Breuillard, Green, and the author on the structure of approximate groups.

In this graduate text, all of this material is presented in a unified manner, starting with the analytic structural theory of real Lie groups and Lie algebras (emphasising the role of one-parameter groups and the Baker-Campbell-Hausdorff formula), then presenting a proof of the Gleason-Yamabe structure theorem for locally compact groups (emphasising the role of Gleason metrics), from which the solution to Hilbert's fifth problem follows as a corollary. After reviewing some model-theoretic preliminaries (most notably the theory of ultraproducts), the combinatorial applications of the Gleason-Yamabe theorem to approximate groups and groups of polynomial growth are then given. A large number of relevant exercises and other supplementary material are also provided.

Contents: *Hilbert's fifth problem:* Introduction; Lie groups, Lie algebras, and the Baker-Campbell-Hausdorff formula; Building Lie structure from representations and metrics; Haar measure, the Peter-Weyl theorem, and compact or abelian groups; Building metrics on groups, and the Gleason-Yamabe theorem; The structure of locally compact groups; Ultraproducts as a bridge between hard analysis and soft analysis; Models of ultra approximate groups; The microscopic structure of approximate groups; Applications of the structural theory of approximate groups; *Related articles:* The Jordan-Schur theorem; Nilpotent groups and nilprogressions; Ado's theorem; Associativity of the Baker-Campbell-Hausdorff-Dynkin law; Local groups; Central extensions of Lie groups, and cocycle averaging; The Hilbert-Smith conjecture; The Peter-Weyl theorem and nonabelian Fourier analysis; Polynomial bounds via nonstandard analysis; Loeb measure and the triangle removal lemma; Two notes on Lie groups; Bibliography; Index.

Graduate Studies in Mathematics, Volume 153

August 2014, 338 pages, Hardcover, ISBN: 978-1-4704-1564-8, LC 2014009022, 2010 *Mathematics Subject Classification:* 22D05, 22E05, 22E15, 11B30, 20F65, **AMS members US$55.20**, List US$69, Order code GSM/153



Automorphisms of Manifolds and Algebraic *K*-Theory: Part III

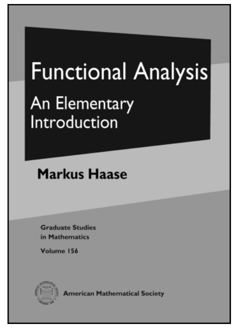
Michael S. Weiss, *Mathematisches Institut, Universität Münster, Germany*, and **Bruce E. Williams**, *University of Notre Dame, Indiana*

Contents: Introduction; Outline of proof; Visible L-theory revisited; The hyperquadratic L–theory of a point; Excision and restriction in controlled L–theory; Control and visible L-theory; Control, stabilization and change of decoration; Spherical fibrations and twisted duality; Homotopy invariant characteristics and signatures; Excisive characteristics and signatures; Algebraic approximations to structure spaces: Set-up; Algebraic approximations to structure spaces: Constructions; Algebraic models for structure spaces: Proofs; Appendix A. Homeomorphism groups of some stratified spaces; Appendix B. Controlled homeomorphism groups; Appendix C. K-theory of pairs and diagrams; Appendix D. Corrections and elaborations; Bibliography.

Memoirs of the American Mathematical Society, Volume 231, Number 1084

September 2014, 110 pages, Softcover, ISBN: 978-1-4704-0981-4, LC 2014015617, 2010 *Mathematics Subject Classification:* 57N15, 57N65; 19D10, **Individual member US$42.60**, List US$71, Institutional member US$56.80, Order code MEMO/231/1084

Analysis



Functional Analysis

An Elementary Introduction

Markus Haase, *Delft University of Technology, The Netherlands*

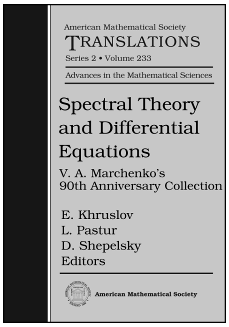
This book introduces functional analysis at an elementary level without assuming any background in real analysis, for example on metric spaces or Lebesgue integration. It focuses on concepts and methods relevant in applied contexts such as variational methods on Hilbert spaces, Neumann series, eigenvalue expansions for compact self-adjoint operators, weak differentiation and Sobolev spaces on intervals, and model applications to differential and integral equations. Beyond that, the final chapters on the uniform boundedness theorem, the open mapping theorem and the Hahn–Banach theorem provide a stepping-stone to more advanced texts.

The exposition is clear and rigorous, featuring full and detailed proofs. Many examples illustrate the new notions and results. Each chapter concludes with a large collection of exercises, some of which are referred to in the margin of the text, tailor-made in order to guide the student digesting the new material. Optional sections and chapters supplement the mandatory parts and allow for modular teaching spanning from basic to honors track level.

Contents: Inner product spaces; Normed spaces; Distance and approximation; Continuity and compactness; Banach spaces; The contraction principle; The Lebesgue spaces; Hilbert space fundamentals; Approximation theory and Fourier analysis; Sobolev spaces and the Poisson problem; Operator theory I; Operator theory II; Spectral theory of compact self-adjoint operators; Applications of the spectral theorem; Baire's theorem and its consequences; Duality and the Hahn-Banach theorem; Historical remarks; Background; The completion of a metric space; Bernstein's proof of Weierstrass' theorem; Smooth cutoff functions; Some topics from Fourier analysis; General orthonormal systems; Bibliography; Symbol index; Subject index; Author index.

Graduate Studies in Mathematics, Volume 156

October 2014, approximately 379 pages, Hardcover, ISBN: 978-0-8218-9171-1, LC 2014015166, 2010 *Mathematics Subject Classification:* 46-01, 46Cxx, 46N20, 35Jxx, 35Pxx, **AMS members US$63.20**, List US$79, Order code GSM/156



Spectral Theory and Differential Equations

V. A. Marchenko's 90th Anniversary Collection

E. Khruslov, **L. Pastur**, and **D. Shepelsky**, *B. Verkin Institute for Low Temperature Physics and Engineering, Kharkov, Ukraine*, Editors

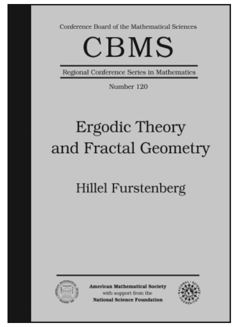
This volume is dedicated to V. A. Marchenko on the occasion of his 90th birthday. It contains refereed original papers and survey articles written by his colleagues and former students of international stature and focuses on the areas to which he made important contributions: spectral theory of differential and difference operators and related topics of mathematical physics, including inverse problems of spectral theory, homogenization theory, and the theory of integrable systems. The papers in the volume provide a comprehensive account of many of the most significant recent developments in that broad spectrum of areas.

Contents: **V. M. Adamyan**, **G. J. Martin**, and **B. S. Pavlov**, Local inverse scattering problem as a tool of perturbation analysis for resonance systems; **H.-D. Alber**, The continuous theory of dislocations for a material containing dislocations to one Burgers vector only; **A. I. Aptekarev**, Spectral problems of high order recurrences; **A. Boutet de Monvel**, **I. Loutsenko**, and **O. Yermolayeva**, On the multifractal spectrum of the whole-plane Lévy-Loewner evolution; **A. Boutet de Monvel** and **L. Zielinski**, Asymptotic behavior of large eigenvalues of a modified Jaynes-Cummings model; **S. Yu. Dobrokhotov**, **G. Makrakis**, and **V. E. Nazaikinskii**, Fourier integrals and a new representation of Maslov's canonical operator near caustics; **J. Eckhardt**, **A. Kostenko**, and **G. Teschl**, Inverse uniqueness results for one-dimensional weighted Dirac operators; **A. Eremenko** and **A. Gabrielov**, Spectral loci of Sturm-Liouville operators with polynomial potentials; **O. Guédon**, **A. Lytova**, **A. Pajor**, and **L. Pastur**, The central limit theorem for linear eigenvalue statistics of the sum of independent matrices of rank one; **T. Kappeler**, **P. Lohrmann**, and **P. Topalov**, On the spectrum of nonself-adjoint Zakharov-Shabat operators on $\mathbb{R}$; **E. Y. Khruslov**, **M. V. Goncharenko**, and **N. K. Radyakin**, Homogenized model of oscillations of elastic medium with small caverns filled with viscous incompressible fluid; **V. Y. Novokshenov** and **A. A. Shchelkonogov**, Double scaling limit in Painlevé IV equation and asymptotics of the Okamoto polynomials; **A. M. Savchuk** and **A. A. Shkalikov**, Recovering of a potential of the Sturm-Liouville problem from finite sets of spectral data; **R. Weder**, High-velocity estimates, inverse scattering and topological effects.

American Mathematical Society Translations—Series 2 (*Advances in the Mathematical Sciences*), Volume 233

October 2014, approximately 252 pages, Hardcover, ISBN: 978-1-4704-1683-6, 2010 *Mathematics Subject Classification:* 34B20, 34L25, 34L40, 34M60, 35B27, 47B36, 60B20, 60J67, 81Q20, 81U40, **AMS members US$104.80**, List US$131, Order code TRANS2/233

Differential Equations



Ergodic Theory and Fractal Geometry

Hillel Furstenberg, *The Hebrew University of Jerusalem, Israel*

Fractals are beautiful and complex geometric objects. Their study, pioneered by Benoît Mandelbrot, is of interest in mathematics, physics and computer science. Their inherent structure, based on their self-similarity, makes the study of their geometry amenable to dynamical approaches. In this book, a theory along these lines is developed by Hillel Furstenberg, one of the foremost experts in ergodic theory, leading to deep results connecting fractal geometry, multiple recurrence, and Ramsey theory. In particular, the notions of fractal dimension and self-similarity are interpreted in terms of ergodic averages and periodicity of classical dynamics; moreover, the methods have deep implications in combinatorics. The exposition is well-structured and clearly written, suitable for graduate students as well as for young researchers with basic familiarity in analysis and probability theory.

—***Endre Szemerédi, Rényi Institute of Mathematics, Budapest***

Fractal geometry represents a radical departure from classical geometry, which focuses on smooth objects that "straighten out" under magnification. Fractals, which take their name from the shape of fractured objects, can be characterized as retaining their lack of smoothness under magnification. The properties of fractals come to light under repeated magnification, which we refer to informally as "zooming in". This zooming-in process has its parallels in dynamics, and the varying "scenery" corresponds to the evolution of dynamical variables.

The present monograph focuses on applications of one branch of dynamics—ergodic theory—to the geometry of fractals. Much attention is given to the all-important notion of fractal dimension, which is shown to be intimately related to the study of ergodic averages. It has been long known that dynamical systems serve as a rich source of fractal examples. The primary goal in this monograph is to demonstrate how the minute structure of fractals is unfolded when seen in the light of related dynamics.

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

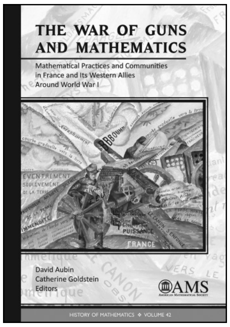
A co-publication of the AMS and CBMS.

Contents: Introduction to fractals; Dimension; Trees and fractals; Invariant sets; Probability trees; Galleries; Probability trees revisited; Elements of ergodic theory; Galleries of trees; General remarks on Markov systems; Markov operator $\mathcal{T}$ and measure preserving transformation T; Probability trees and galleries; Ergodic theorem and the proof of the main theorem; An application: The k-lane property; Dimension and energy; Dimension conservation; Ergodic theorem for sequences of functions; Dimension conservation for homogeneous fractals: The main steps in the proof; Verifying the conditions of the ergodic theorem for sequences of functions; Bibliography; Index.

CBMS Regional Conference Series in Mathematics, Number 120

September 2014, 69 pages, Softcover, ISBN: 978-1-4704-1034-6, LC 2014010556, 2010 *Mathematics Subject Classification:* 28A80, 37A30; 30D05, 37F45, 47A35, **AMS members US$25.60**, List US$32, Order code CBMS/120

General Interest



The War of Guns and Mathematics

Mathematical Practices and Communities in France and Its Western Allies around World War I

David Aubin, *Sorbonne Universités, université Pierre et Marie Curie, Institut de mathématiques de Jussieu-Paris Rive Gauche, France*, and **Catherine Goldstein**, *CNRS, Institut de mathématiques de Jussieu-Paris Rive Gauche, France*, Editors

For a long time, World War I has been shortchanged by the historiography of science. Until recently, World War II was usually considered as the defining event for the formation of the modern relationship between science and society. In this context, the effects of the First World War, by contrast, were often limited to the massive deaths of promising young scientists.

By focusing on a few key places (Paris, Cambridge, Rome, Chicago, Brno, and others), the present book gathers studies representing a broad spectrum of positions adopted by mathematicians about the conflict, from militant pacifism to military, scientific, or ideological mobilization. The use of mathematics for war is thoroughly examined.

This book suggests a new vision of the long-term influence of World War I on mathematics and mathematicians. Continuities and discontinuities in the structure and organization of the mathematical sciences are discussed, as well as their images in various milieux. Topics of research and the values with which they were defended are scrutinized. This book, in particular, proposes a more in-depth evaluation of the issue of modernity and modernization in mathematics.

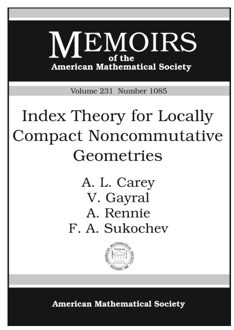
The issue of scientific international relations after the war is revisited by a close look at the situation in a few Allied countries (France, Britain, Italy, and the USA), as well as in a new country created by the war, Czechoslovakia. The historiography has emphasized the place of Germany as the leading mathematical country before WWI and the absurdity of its postwar ostracism by the Allies. The studies presented here help explain how dramatically different prewar situations, prolonged interaction during the war, and new international postwar organizations led to attempts at redrafting models for mathematical developments.

Contents: **D. Aubin** and **C. Goldstein**, Placing World War I in the history of mathematics; *Starting Up:* **J. Barrow-Green**, Cambridge mathematicians' responses to the First World War; **D. Aubin**, **H. Gispert**, and **C. Goldstein**, The total war of Paris mathematicians; *Joining In:* **P. Nastasi** and **R. Tazzioli**, Italian mathematicians and the First World War: Intellectual debates and institutional innovations; **T. Archibald**, **D. Dumbaugh**, and **D. Kent**, A mobilized community: Mathematicians in the United States during the First World War; *Moving On:* **J.-L. Chabert** and **C. Gilain**, Debating the place of mathematics at the École polytechnique around World War I; **D. Aubin**, "I'm just a mathematician": Why and how mathematicians collaborated with military ballisticians at Gâvre; *Crossing Through:* **L. Mazliak** and **P. Šišma**, The Moravian crossroad: Mathematics and mathematicians in Brno between German traditions and Czech hopes; **L. Rollet** and **P. Nabonnand**, Why aerodynamics failed to take off in Nancy: An unexpected casualty of World War I; Index.

History of Mathematics, Volume 42

November 2014, approximately 424 pages, Hardcover, ISBN: 978-1-4704-1469-6, LC 2014012563, 2010 *Mathematics Subject Classification:* 01-02, 01A60, 65-03, 70-03, 97-03, **AMS members US$100.80**, List US$126, Order code HMATH/42

Geometry and Topology



Index Theory for Locally Compact Noncommutative Geometries

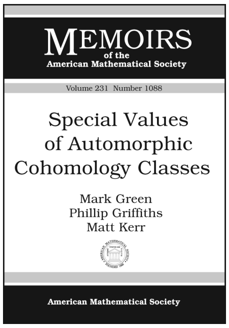
A. L. Carey, *Mathematical Sciences Institute, Australian National University, Canberra, Australia*, **V. Gayral**, *Université de Reims, France*, **A. Rennie**, *University of Wollongong, Australia*, and **F. A. Sukochev**, *University of New South Wales, Kensington, Australia*

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

Contents: Introduction; Pseudodifferential calculus and summability; Index pairings for semifinite spectral triples; The local index formula for semifinite spectral triples; Applications to index theorems on open manifolds; Noncommutative examples; Appendix A. Estimates and technical lemmas; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 231, Number 1085

September 2014, 130 pages, Softcover, ISBN: 978-0-8218-9838-3, LC 2014015549, 2010 *Mathematics Subject Classification:* 46H30, 46L51, 46L80, 46L87, 19K35, 19K56, 58J05, 58J20, 58J30, 58J32, 58J42, **Individual member US$45.60**, List US$76, Institutional member US$60.80, Order code MEMO/231/1085



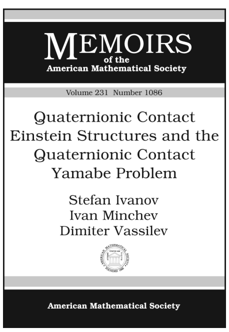
Special Values of Automorphic Cohomology Classes

Mark Green, *University of California, Los Angeles*, **Phillip Griffiths**, *Institute for Advanced Study, Princeton, New Jersey*, and **Matt Kerr**, *Washington University in St. Louis, Missouri*

Contents: Introduction; Geometry of the Mumford Tate domains; Homogeneous line bundles over the Mumford Tate domains; Correspondence and cycle spaces; Penrose transforms; The Penrose transform in the automorphic case and the main result; Bibliography.

Memoirs of the American Mathematical Society, Volume 231, Number 1088

September 2014, 145 pages, Softcover, ISBN: 978-0-8218-9857-4, LC 2014015548, 2010 *Mathematics Subject Classification:* 14M17, 22E45, 22E46, 32M10, 32G20, **Individual member US$47.40**, List US$79, Institutional member US$63.20, Order code MEMO/231/1088



Quaternionic Contact Einstein Structures and the Quaternionic Contact Yamabe Problem

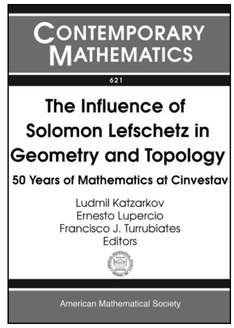
Stefan Ivanov, *Univ. of Sofia and Institute of Mathematics, Bulgarian Academy of Sciences, Bulgaria*, **Ivan Minchev**, *University of Sofia, Bulgaria*, and **Dimiter Vassilev**, *University of New Mexico, Albuquerque*

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

Contents: Introduction; Quaternionic contact structures and the Biquard connection; The torsion and curvature of the Biquard connection; QC-Einstein quaternionic contact structures; Conformal transformations of a qc-structure; Special functions and pseudo-Einstein quaternionic contact structures; Infinitesimal automorphisms; Quaternionic contact Yamabe problem; Biibliography; Index.

Memoirs of the American Mathematical Society, Volume 231, Number 1086

September 2014, 82 pages, Softcover, ISBN: 978-0-8218-9843-7, LC 2014015536, 2010 *Mathematics Subject Classification:* 53C17, **Individual member US$39**, List US$65, Institutional member US$52, Order code MEMO/231/1086



The Influence of Solomon Lefschetz in Geometry and Topology

50 Years of Mathematics at CINVESTAV

Ludmil Katzarkov, *University of Miami, Coral Gables, FL, and Universität Wien, Austria*, **Ernesto Lupercio**, *Cinvestav-Mexico, Mexico*, and **Francisco J. Turrubiates**, *Instituto Politécnico Nacional México, Mexico*, Editors

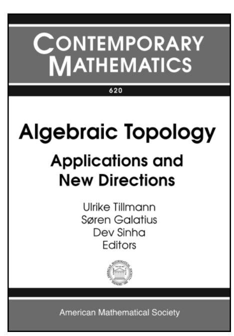
The influence of Solomon Lefschetz (1884–1972) in geometry and topology 40 years after his death has been very profound. Lefschetz's influence in Mexican mathematics has been even greater. In this volume, celebrating 50 years of mathematics at Cinvestav-México, many of the fields of geometry and topology are represented by some of the leaders of their respective fields.

This volume opens with Michael Atiyah reminiscing about his encounters with Lefschetz and México. Topics covered in this volume include symplectic flexibility, Chern–Simons theory and the theory of classical theta functions, toric topology, the Beilinson conjecture for finite-dimensional associative algebras, partial monoids and Dold–Thom functors, the weak b-principle, orbit configuration spaces, equivariant extensions of differential forms for noncompact Lie groups, dynamical systems and categories, and the Nahm pole boundary condition.

Contents: **M. Atiyah**, Solomon Lefschetz and Mexico; **Y. Eliashberg**, Recent progress in symplectic flexibility; **H. García-Compeán**, **P. Paniagua**, and **B. Uribe**, Equivariant extensions of differential forms for noncompact Lie groups; **R. Gelca** and **A. Uribe**, From classical theta functions to topological quantum field theory; **S. Gitler**, Toric topology; **D. Kaledin**, Beilinson conjecture for finite-dimensional associative algebras; **J. Mostovoy**, Partial monoids and Dold–Thom functors; **R. Sadykov**, The weak b-principle; **M. A. Xicoténcatl**, Orbit configuration spaces; **G. Dimitrov**, **F. Haiden**, **L. Katzarkov**, and **M. Kontsevich**, Dynamical systems and categories; **R. Mazzeo** and **E. Witten**, The Nahm pole boundary condition.

Contemporary Mathematics, Volume 621

September 2014, 226 pages, Softcover, ISBN: 978-0-8218-9494-1, LC 2013049429, 2010 *Mathematics Subject Classification:* 14-06, 53-06, 55-06, **AMS members US$72.80**, List US$91, Order code CONM/621



Algebraic Topology: Applications and New Directions

Ulrike Tillmann, *Oxford University, United Kingdom*, **Søren Galatius**, *Stanford University, CA*, and **Dev Sinha**, *University of Oregon, Eugene, OR*, Editors

This volume contains the proceedings of the Stanford Symposium on Algebraic Topology: Applications and New Directions, held from July 23–27, 2012, at Stanford University, Stanford, California. The symposium was held in honor of Gunnar Carlsson, Ralph Cohen and Ib Madsen, who celebrated their 60th and 70th birthdays that year. It showcased current research in Algebraic Topology reflecting the celebrants' broad interests and profound influence on the subject.

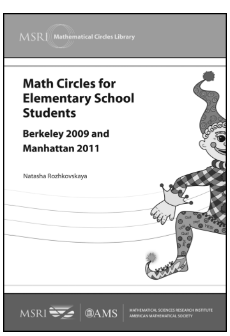
The topics varied broadly from stable equivariant homotopy theory to persistent homology and application in data analysis, covering topological aspects of quantum physics such as string topology and geometric quantization, examining homology stability in algebraic and geometric contexts, including algebraic K-theory and the theory of operads.

Contents: T. Church, **J. S. Ellenberg**, and **B. Farb**, Representation stability in cohomology and asymptotics for families of varieties over finite fields; **T. Church**, **B. Farb**, and **A. Putman**, A stability conjecture for the unstable cohomology of $\mathrm{SL}_n\mathbb{Z}$, mapping class groups, and $\mathrm{Aut}(F_n)$; **W. Dwyer** and **K. Hess**, The Boardman-Vogt tensor product of operadic bimodules; **S. Galatius** and **O. Randal-Williams**, Detecting and realising characteristic classes of manifold bundles; **B. Goldfarb** and **T. K. Lance**, Controlled algebraic G-theory, II; **I. Hambleton** and **E. K. Pedersen**, More examples of discrete co-compact group actions; **L. Hesselholt**, On the K-theory of planar cuspical curves and a new family of polytopes; **M. A. Hill** and **M. J. Hopkins**, Equivariant multiplicative closure; **M. Kahle**, Topology of random simplicial complexes: A survey; **L. Katzarkov**, **E. Lupercio**, **L. Meersseman**, and **A. Verjovsky**, The definition of a non-commutative toric variety; **N. Kitchloo**, The stable symplectic category and quantization; **G. Segal**, A geometric perspective on quantum field theory; **M. Vejdemo-Johansson**, Sketches of a platypus: A survey of persistent homology and its algebraic foundations; **K. Wickelgren**, Cartier's first theorem for Witt vectors on $\mathbb{Z}^n_{\geq 0} - 0$.

Contemporary Mathematics, Volume 620

June 2014, 328 pages, Softcover, ISBN: 978-0-8218-9474-3, LC 2013048259, 2010 *Mathematics Subject Classification:* 14M25, 18D50, 19D55, 55R40, 55Q91, 57R56, 57R17, 60D05, **AMS members US$91.20**, List US$114, Order code CONM/620

Math Education



Math Circles for Elementary School Students

Natasha Rozhkovskaya, *Kansas State University, Manhattan, KS*

The main part of this book describes the first semester of the existence of a successful and now highly popular program for elementary school students at the Berkeley Math Circle. The topics discussed in the book introduce the participants to the basics of many important areas of modern mathematics, including logic, symmetry, probability theory, knot theory, cryptography, fractals, and number theory. Each chapter in the first part of this book consists of two parts. It starts with generously illustrated sets of problems and hands-on activities. This part is addressed to young readers who can try to solve problems on their own or to discuss them with adults. The second part of each chapter is addressed to teachers and parents. It includes comments on the topics of the lesson, relates those topics to discussions in other chapters, and describes the actual reaction of math circle participants to the proposed activities.

The supplementary problems that were discussed at workshops of Math Circle at Kansas State University are given in the second part of the book.

The book is richly illustrated, which makes it attractive to its young audience.

In the interest of fostering a greater awareness and appreciation of mathematics and its connections to other disciplines and everyday life, MSRI and the AMS are publishing books in the Mathematical Circles Library series as a service to young people, their parents and teachers, and the mathematics profession.

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

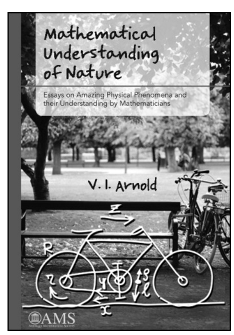
Titles in this series are co-published with the Mathematical Sciences Research Institute (MSRI).

Contents: *Part I: Berkeley Math Circle:* Preface: Berkeley 2009; Lesson 1; Lesson 2; Lesson 3; Lesson 4; Lesson 5; Lesson 6; Lesson 7; Lesson 8; Lesson 9; Lesson 10; Lesson 11; Lesson 12; Lesson 13; Lesson 14; Lesson 15; *Part II: Manhattan Math Circle:* Preface: Manhattan 2011; Counting rhymes; Arithmetic; More coded pictures; Make your own problem; Cut the square; Siege of the fortress; More logic problems; Estimates; Problems with unknowns; Knots, links, and paths; How old are you?; No solutions; The pigeon hole principle.

MSRI Mathematical Circles Library, Volume 13

October 2014, approximately 163 pages, Softcover, ISBN: 978-1-4704-1695-9, LC 2014016100, 2010 *Mathematics Subject Classification:* 97-00, **All Individuals US$20**, List US$25, Institutional member US$20, Order code MCL/13

Mathematical Physics



Mathematical Understanding of Nature

Essays on Amazing Physical Phenomena and their Understanding by Mathematicians

V. I. Arnold

This collection of 39 short stories gives the reader a unique opportunity to take a look at the scientific philosophy of Vladimir Arnold, one of the most original contemporary researchers. Topics of the stories included range from astronomy, to mirages, to motion of glaciers, to geometry of mirrors and beyond. In each case Arnold's explanation is both deep and simple, which makes the book interesting and accessible to an extremely broad readership. Original illustrations hand drawn by the author help the reader to further understand and appreciate Arnold's view on the relationship between mathematics and science.

Arnold's talent for exposition shines in this collection of short chapters on a miscellany of topics. I could not stop reading until I reached the end of the book. This book will entertain and enrich any curious person, whether a layman or a specialist.

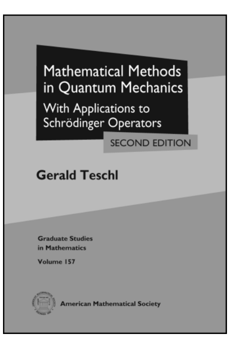
—***Mark Levi, Penn State University, author of "The Mathematical Mechanic"***

This book, which fits all mathematical ages, provides a glimpse into the "laboratory" of one of the most influential mathematicians of our time. Its genre is absolutely unique. A kaleidoscope of intriguing examples illustrating applications of mathematics to real life, intertwines with entertaining and often wildly funny mathematical anecdotes, as well as with profound insights into modern research areas. A brilliant informal exposition, complemented by artful drawings by the author, makes the book a fascinating read.

—***Leonid Polterovich, Tel-Aviv University***

Contents: The eccentricity of the Keplerian orbit of Mars; Rescuing the empennage; Return along a sinusoid; The Dirichlet integral and the Laplace operator; Snell's law of refraction; Water depth and Cartesian science; A drop of water refracting light; Maximal deviation angle of a beam; The rainbow; Mirages; Tide, Gibbs phenomenon, and tomography; Rotation of a liquid; What force drives a bicycle forward?; Hooke and Keplerian ellipses and their conformal transformations; The stability of the inverted pendulum and Kapitsa's sewing machine; Space flight of a photo camera cap; The angular velocity of a clock hand and Feynman's "self-propagating pseudoeducation"; Planetary rings; Symmetry (and Curie's principle); Courant's erroneous theorems; Ill-posed problems of mechanics; Rational fractions of flows; Journey to the center of the earth; Mean frequency of explosions (according to Ya. B. Zel'dovich) and de Sitter's world; The Bernoulli fountains of the Nikologorsky bridge; Shape formation in a three-liter glass jar; Lidov's moon landing problem; The advance and retreat of glaciers; The ergodic theory of geometric progressions; The Malthusian partitioning of the world; Percolation and the hydrodynamics of the universe; Buffon's problem and integral geometry; Average projected area; The mathematical notion of potential; Inversion in cylindrical mirrors in the subway; Adiabatic invariants; Universality of Hack's exponent for river lengths; Resonances in the Shukhov tower, in the Sobolev equation, and in the tanks of spin-stabilized rockets; The theory of rigid body rotation and hydrodynamics.

October 2014, 167 pages, Softcover, ISBN: 978-1-4704-1701-7, LC 2014018911, 2010 *Mathematics Subject Classification:* 70-01, 76-01, 78-01, **AMS members US$23.20**, List US$29, Order code MBK/85



Mathematical Methods in Quantum Mechanics

With Applications to Schrödinger Operators, Second Edition

Gerald Teschl, *University of Vienna, Austria*

Quantum mechanics and the theory of operators on Hilbert space have been deeply linked since their beginnings in the early twentieth century. States of a quantum system correspond to certain elements of the configuration space and observables correspond to certain operators on the space. This book is a brief, but self-contained, introduction to the mathematical methods of quantum mechanics, with a view towards applications to Schrödinger operators.

Part 1 of the book is a concise introduction to the spectral theory of unbounded operators. Only those topics that will be needed for later applications are covered. The spectral theorem is a central topic in this approach and is introduced at an early stage. Part 2 starts with the free Schrödinger equation and computes the free resolvent and time evolution. Position, momentum, and angular momentum are discussed via algebraic methods. Various mathematical methods are developed, which are then used to compute the spectrum of the hydrogen atom. Further topics include the nondegeneracy of the ground state, spectra of atoms, and scattering theory.

This book serves as a self-contained introduction to spectral theory of unbounded operators in Hilbert space with full proofs and minimal prerequisites: Only a solid knowledge of advanced calculus and a one-semester introduction to complex analysis are required. In particular, no functional analysis and no Lebesgue integration theory are assumed. It develops the mathematical tools necessary to prove some key results in nonrelativistic quantum mechanics.

Mathematical Methods in Quantum Mechanics is intended for beginning graduate students in both mathematics and physics and provides a solid foundation for reading more advanced books and current research literature.

This new edition has additions and improvements throughout the book to make the presentation more student friendly.

The book is written in a very clear and compact style. It is well suited for self-study and includes numerous exercises (many with hints).

—***Zentralblatt MATH***

The author presents this material in a very clear and detailed way and supplements it by numerous exercises. This makes the book a nice introduction to this exciting field of mathematics.

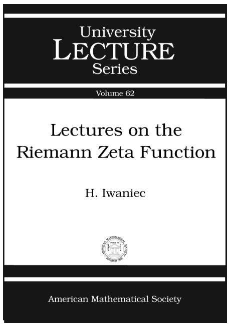
—***Mathematical Reviews***

Contents: *Preliminaries:* A first look at Banach and Hilbert spaces; *Mathematical foundations of quantum mechanics:* Hilbert spaces; Self-adjointness and spectrum; The spectral theorem; Applications of the spectral theorem; Quantum dynamics; Perturbation theory for self-adjoint operators; *Schrödinger operators:* The free Schrödinger operator; Algebraic methods; One-dimensional Schrödinger operators; One-particle Schrödinger operators; Atomic Schrödinger operators; Scattering theory; *Appendix:* Almost everything about Lebesgue integration; Bibliographical notes; Bibliography; Glossary of notation; Index.

Graduate Studies in Mathematics, Volume 157

November 2014, 356 pages, Hardcover, ISBN: 978-1-4704-1704-8, LC 2014019123, 2010 *Mathematics Subject Classification:* 81-01, 81Qxx, 46-01, 34Bxx, 47B25, **AMS members US$53.60**, List US$67, Order code GSM/157

Number Theory



Lectures on the Riemann Zeta Function

H. Iwaniec, *Rutgers University, Piscataway, NJ*

The Riemann zeta function was introduced by L. Euler (1737) in connection with questions about the distribution of prime numbers. Later, B. Riemann (1859) derived deeper results about the prime numbers by considering the zeta function in the complex variable. The famous Riemann Hypothesis, asserting that all of the non-trivial zeros of zeta are on a critical line in the complex plane, is one of the most important unsolved problems in modern mathematics.

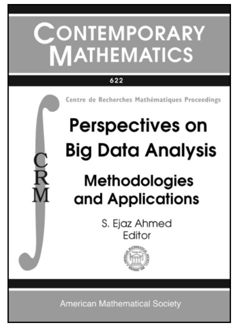
The present book consists of two parts. The first part covers classical material about the zeros of the Riemann zeta function with applications to the distribution of prime numbers, including those made by Riemann himself, F. Carlson, and Hardy–Littlewood. The second part gives a complete presentation of Levinson's method for zeros on the critical line, which allows one to prove, in particular, that more than one-third of non-trivial zeros of zeta are on the critical line. This approach and some results concerning integrals of Dirichlet polynomials are new. There are also technical lemmas which can be useful in a broader context.

Contents: *Classical topics:* Panorama of arithmetic functions; Sums of basic arithmetic functions; Tchebyshev's prime seeds; Elementary prime number theorem; The Riemann memoir; The analytic continuation; The functional equation; The product formula over the zeros; The asymptotic formula for $N(T)$; The asymptotic formula for $\psi(x)$; The zero-free region and the PNT; Approximate functional equations; The Dirichlet polynomials; Zeros off the critical line; Zeros on the critical line; *The critical zeros after Levinson:* Introduction; Detecting critical zeros; Conrey's construction; The argument variations; Attaching a mollifier; The Littlewood lemma; The principal inequality; Positive proportion of the critical zeros; The first moment of Dirichlet polynomials; The second moment of Dirichlet polynomials; The diagonal terms; The off-diagonal terms; Conclusion; Computations and the optimal mollifier; Smooth bump functions; The gamma function; Bibliography; Index.

University Lecture Series, Volume 62

October 2014, 119 pages, Softcover, ISBN: 978-1-4704-1851-9, LC 2014021164, 2010 *Mathematics Subject Classification:* 11N05; 11N37, **AMS members US$32**, List US$40, Order code ULECT/62

Probability and Statistics



Perspectives on Big Data Analysis

Methodologies and Applications

S. Ejaz Ahmed, *Brock University, St. Catharines, Ontario, Canada*, Editor

This volume contains the proceedings of the International Workshop on Perspectives on High-dimensional Data Analysis II, held May 30–June 1, 2012, at the Centre de Recherches Mathématiques, Université de Montréal, Montréal, Quebec, Canada.

This book collates applications and methodological developments in high-dimensional statistics dealing with interesting and challenging problems concerning the analysis of complex, high-dimensional data with a focus on model selection and data reduction. The chapters contained in this book deal with submodel selection and parameter estimation for an array of interesting models. The book also presents some surprising results on high-dimensional data analysis, especially when signals cannot be effectively separated from the noise, it provides a critical assessment of penalty estimation when the model may not be sparse, and it suggests alternative estimation strategies. Readers can apply the suggested methodologies to a host of applications and also can extend these methodologies in a variety of directions. This volume conveys some of the surprises, puzzles and success stories in big data analysis and related fields.

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

This book is co-published with the Centre de Recherches Mathématiques.

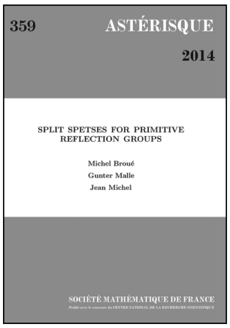
Contents: **F. Yang**, **K. Doksum**, and **K.-W. Tsui**, Principal component analysis (PCA) for high-dimensional data. PCA is dead. Long live PCA; **N. D. Singpurwalla** and **J. Landon**, Solving a system of high-dimensional equations by MCMC; **J. Kang** and **T. D. Johnson**, A slice sampler for the hierarchical Poisson/gamma random field model; **A. McGillivray** and **A. Khalili**, A new penalized quasi-likelihood approach for estimating the number of states in a hidden Markov model; **X. Gao** and **S. E. Ahmed**, Efficient adaptive estimation strategies in high-dimensional partially linear regression models; **H. Ishwaran** and **J. S. Rao**, Geometry and properties of generalized ridge regression in high dimensions; **G. Diao**, **B. Hanlon**, and **A. N. Vidyashankar**, Multiple testing for high-dimensional data; **F. Konietschke**, **Y. R. Gel**, and **E. Brunner**, On multiple contrast tests and simultaneous confidence intervals in high-dimensional repeated measures designs; **Z. Yang**, **H. Xie**, and **X. Huo**, Data-driven smoothing can preserve good asymptotic properties; **P. Du**, **P. Wu**, and **H. Liang**, Variable selection for ultra-high-dimensional logistic models; **S. Hossain** and **S. E. Ahmed**, Shrinkage estimation and selection for a logistic regression model; **P. K. Tadavani**, **B. Alipanahi**, and **A. Ghodsi**, Manifold unfolding by isometric patch alignment with an application in protein structure determination.

Contemporary Mathematics, Volume 622

August 2014, 191 pages, Softcover, ISBN: 978-1-4704-1042-1, LC 2014000814, 2010 *Mathematics Subject Classification:* 68T99, 62H25, 62J07, 62F05, 62G05, 62M05, 62G08, 60-XX, 62G99, 62H15, **AMS members US$62.40**, List US$78, Order code CONM/622

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Split Spetses for Primitive Reflection Groups

Michel Broué, *Université Paris VII, France*, **Gunter Malle**, *TU Kaiserslautern, Germany*, and **Jean Michel**, *Université Paris VII, France*

Let W be an exceptional spetsial irreducible reflection group acting on a complex vector space V, *i.e.*, a group G_n for

$$n \in 4, 6, 8, 14, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 37$$

in the Shephard-Todd notation.

The authors describe how to determine some data associated to the corresponding (split) "spets" $\mathbb{G} = (V, W)$, given complete knowledge of the same data for all proper subspetses (the method is thus inductive).

The data determined here are the set $\mathrm{Uch}(\mathbb{G})$ of "unipotent characters" of $\mathbb{G}$ and its repartition into families, as well as the associated set of Frobenius eigenvalues. The determination of the Fourier matrices linking unipotent characters and "unipotent character sheaves" will be given in another paper.

The approach works for all split reflection cosets for primitive irreducible reflection groups. The result is that all the above data exist and are unique (note that the cuspidal unipotent degrees are only determined up to sign).

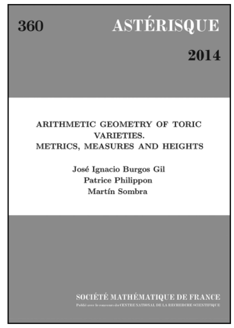
The authors keep track of the complete list of axioms used. In order to do that, they explain in detail some general axioms of "spetses", generalizing (and sometimes correcting) along the way.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: *From Weyl groups to complex reflection groups:* Reflection groups, braid groups, Hecke algebras; Complements on finite reductive groups; Spetsial Φ-cyclotomic Hecke algebras; Axioms for spetses; Determination of $\mathrm{Uch}(\mathbb{G})$: the algorithm; Appendix A; Appendix B; Bibliography; Index.

Astérisque, Number 359

March 2014, 146 pages, Softcover, ISBN: 978-2-85629-781-0, 2010 *Mathematics Subject Classification:* 20G05; 20C33, 20F36, 20F55, **AMS members US$50.40**, List US$63, Order code AST/359



Arithmetic Geometry of Toric Varieties

Metrics, Measures and Heights

José Ignacio Burgos Gil, *Instituto de Ciencias Matemáticas, UAM, Madrid, Spain*, **Partice Philippon**, *Institut de Mathématiques de Jussieu, UMR, Paris, France*, and **Martín Sombra**, *ICREA and Universitat de Barcelona, Spain*

The authors show that the height of a toric variety with respect to a toric metrized line bundle can be expressed as the integral over a polytope of a certain adelic family of concave functions.

To state and prove this result, the authors study the Arakelov geometry of toric varieties. In particular, they consider models over a discrete valuation ring, metrized line bundles, and their associated measures and heights. They show that these notions can be translated in terms of convex analysis and are closely related to objects such as polyhedral complexes, concave functions, real Monge-Ampére measures, and Legendre-Fenchel duality.

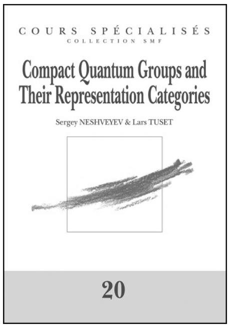
The authors also present a closed formula for the integral over a polytope of a function of one variable composed with a linear form. This formula allows them to compute the height of toric varieties with respect to some interesting metrics arising from polytopes and compute the height of toric projective curves with respect to the Fubini-Study metric and the height of some toric bundles.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Conventions and notations; Metrized line bundles and their associated heights; The Legendre-Fenchel duality; Toric varieties; Metrics and measures on toric varieties; Height of toric varieties; Metrics from polytopes; Variations on Fubini-Study metrics; Bibliography; List of Symbols; Index.

Astérisque, Number 360

May 2014, 222 pages, Softcover, ISBN: 978-2-85629-783-4, 2010 *Mathematics Subject Classification:* 14M25; 14G40, 52A41, **AMS members US$62.40**, List US$78, Order code AST/360



Compact Quantum Groups and Their Representation Categories

Sergey Neshveyev, *University of Oslo, Norway*, and **Lars Tuset**, *Department of Computer Science of Oslo, Norway, and Askershus University College of Applied Sciences, Norway*

The book provides an introduction to the theory of compact quantum groups, emphasizing the role of the categorical point of view in constructing and analyzing concrete examples. The general theory is developed in the first two chapters and is illustrated with a detailed analysis of free orthogonal quantum groups and the Drinfeld-Jimbo q-deformations of compact semisimple Lie groups. The next two chapters are more specialized and concentrate on the Drinfeld-Kohno theorem, presented from the operator algebraic point of view. This book should be accessible to students with a basic knowledge of operator algebras and semisimple Lie groups.

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

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.

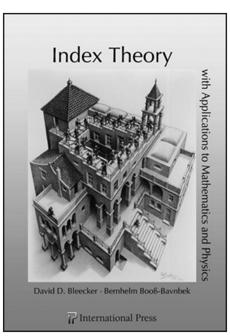
This book is co-published with Fondation Sciences Mathématiques de Paris.

Contents: Compact quantum groups; C^*-tensor categories; Cohomology of quantum groups; Drinfeld twists; Bibliography; List of symbols; Index.

Cours Spécialisés—Collection SMF, Number 20

May 2014, 168 pages, Softcover, ISBN: 978-2-85629-777-3, 2010 *Mathematics Subject Classification:* 20G42; 46L65, 18D10, 17B37, **AMS members US$60**, List US$75, Order code COSP/20

Analysis



Index Theory with Applications to Mathematics and Physics

David D. Bleecker, *University of Hawaii at Manoa, Honolulu*, and **Bernhelm Booß-Bavnbek**, *Roskilde Universitet, Denmark*

This book describes, explains, and explores the Index Theorem of Atiyah and Singer, one of the truly great accomplishments of twentieth-century mathematics whose influence continues to grow, fifty years after its discovery. The Index Theorem has given birth to many mathematical research areas and exposed profound connections between analysis, geometry, topology, algebra, and mathematical physics. Hardly any topic of modern mathematics stands independent of its influence.

In this ambitious new work, the authors give two proofs of the Atiyah–Singer Index Theorem in impressive detail: one based on K-theory and the other on the heat kernel approach. As a preparation for this, the authors explain all the background information on such diverse topics as Fredholm operators, pseudo-differential operators, analysis on manifolds, principal bundles and curvature, and K-theory carefully and with concern for the reader. Many applications of the theorem are given, as well as an account of some of the most important recent developments in the subject, with emphasis on gauge theoretic physical models and low-dimensional topology.

The 18 chapters and two appendices of the book introduce different topics and aspects, often beginning from scratch, without presuming full knowledge of all the preceding chapters. Learning paths, through a restricted selection of topics and sections, are suggested and facilitated. The chapters are written for students of mathematics and physics: some for the upper-undergraduate level, some for the graduate level, and some as an inspiration and support for researchers.

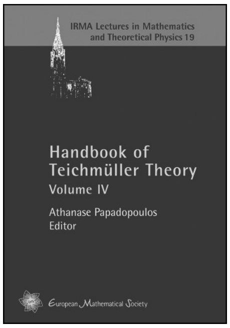
Index Theory with Applications to Mathematics and Physics is a textbook, a reference book, a survey, and much more. Written in a lively fashion, it contains a wealth of basic examples and exercises. The authors have included many discussion sections that are both entertaining and informative and which illuminate the thinking behind the more general theory. A detailed bibliography and index facilitate the orientation.

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

Contents: *Part I. Operators with Index and Homotopy Theory:* Fredholm operators; Analytic methods. Compact operators; Fredholm operator topology; Wiener-Hopf operators; *Part II. Analysis on Manifolds:* Partial Differential equations in euclidean space; Differential operators over manifolds; Sobolev spaces (crash course); Pseudo-differential operators; Elliptic operators over closed manifolds; *Part III. The Atiyah–Singer Index Formula:* Introduction to topological K-Theory; The Index formula in the Euclidean case; The Index theorem for closed manifolds; Classical applications (survey); *Part IV. Index Theory in Physics and the Local Index Theorem:* Physical motivation and overview; Geometric preliminaries; Gauge theoretic instantons; The local index theorem for twisted Dirac operators; Seiberg–Witten theory; Appendix A. Fourier series and integrals–fundamental principles; Appendix B. Vector bundles; Bibliography; Index of notation; Index of names/authors; Subject index.

International Press

October 2013, 792 pages, Hardcover, ISBN: 978-1-57146-264-0, 2010 *Mathematics Subject Classification:* 58-02, 58C15, 58C30, 58C40, 58D27, 58J32, 58J40, 58J50, 58J52, 58Z05, 83C05, 83C47, **AMS members US$76**, List US$95, Order code INPR/96



Handbook of Teichmüller Theory: Volume IV

Athanase Papadopoulos, *Université de Strasbourg, France*, Editor

For several decades, Teichmüller theory has been one of the most active research areas in mathematics, with a very wide range of points of view, including Riemann surface theory, hyperbolic geometry, low-dimensional topology, several complex variables, algebraic geometry, arithmetic, partial differential equations, dynamical systems, representation theory, symplectic geometry, geometric group theory, and mathematical physics.

This book is the fourth volume in a Handbook of Teichmüller Theory project that started as an attempt to present, in a most comprehensive and systematic way, the various aspects of this theory with its relations to all the fields mentioned. The handbook is addressed to researchers as well as graduate students.

This volume is divided into five parts:

- Part A: The metric and the analytic theory
- Part B: Representation theory and generalized structures
- Part C: Dynamics
- Part D: The quantum theory
- Part E: Sources

Parts A, B, and D are sequels to parts on the same theme in previous volumes. Part E contains the translation together with a commentary of an important paper by Teichmüller that is almost unknown, even to specialists. Making the original ideas of and motivations for a theory clear is crucial for many reasons, and making this translation, together with the commentary that follows, available will give readers a broader perspective on Teichmüller theory.

The various volumes in this collection are written by experts who have a broad view on the subject. In general, the chapters are expository, while some of them contain new and important results.

For the table of contents, go to http://www.ams.org/bookstore.

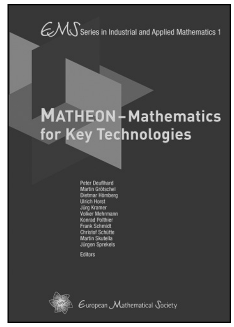
This item will also be of interest to those working in geometry and topology.

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

IRMA Lectures in Mathematics and Theoretical Physics, Volume 19

June 2014, 838 pages, Hardcover, ISBN: 978-3-03719-117-0, 2010 *Mathematics Subject Classification:* 30-00, 32-00, 57-00, 32G13, 32G15, 30F60, **AMS members US$102.40**, List US$128, Order code EMSILMTP/19

General Interest



MATHEON–Mathematics for Key Technologies

Peter Deuflhard and **Martin Grötschel**, *Zuse Institute, Berlin, Germany*, **Dietmar Hömberg**, *Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany*, **Ulrich Horst** and **Jürg Kramer**, *Humboldt University, Berlin, Germany*, **Volker Mehrmann**, *Technical University of Berlin, Germany*, **Konrad Polthier**, *Freie Universitaet Berlin, Germany*, **Frank Schmidt** and **Christof Schütte**, *Zuse Institute, Berlin, Germany*, **Martin Skutella**, *Technical University of Berlin, Germany*, and **Jürgen Sprekels**, *Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany*, Editors

Mathematics: intellectual endeavor, production factor, key technology, key to key technologies?

Mathematics is all of these; the last three of its facets are not well known, though. They have been the focus of the research and development in the Berlin-based DFG Research Center MATHEON in the last twelve years. Through these activities, MATHEON has become an international trademark. Its mission and its strategies for carrying out creative, application-driven research in mathematics and cooperating in the solution of complex problems in key technologies are by now a role model for the development of many other centers.

Modern key technologies have become highly sophisticated, integrating aspects of engineering, computer, business and other sciences. At the same time, the innovation cycles get shorter and shorter. These simultaneous challenges can be mastered only by qualitatively and quantitatively rigorous methods. And that is where mathematics is indispensable.

Flexible mathematical models, as well as fast and accurate methods for numerical simulation and optimization, open new possibilities to handle the indicated complexities, to react quickly, and to explore new options. Researchers in mathematical fields such as optimization, discrete mathematics, numerical analysis, scientific computing, applied analysis and stochastic analysis have to work hand in hand with scientists and engineers to fully exploit this potential and to strengthen the transversal role of mathematics in solving the challenging problems in key technologies.

This book presents in seven chapters the research highlights of the research work carried out in the MATHEON application areas: Life Sciences, Networks, Production, Electronic and Photonic Devices, Finance, Visualization, and Education. The chapters summarize many of the contributions, put them in the context of current mathematical research activities, and outline their impact in various key technologies. To make some of the results more easily accessible to the general public, a large number of "showcases" are presented that illustrate a few success stories.

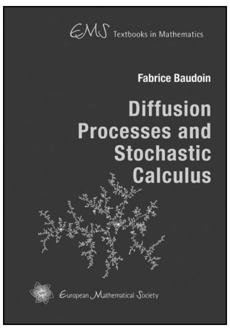
For the table of contents, go to www.ams.org/bookstore.

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

EMS Industrial and Applied Mathematics, Volume 1

May 2014, 466 pages, Hardcover, ISBN: 978-3-03719-137-8, 2010 *Mathematics Subject Classification:* 00-02, 01-02, **AMS members US$51.20**, List US$64, Order code EMSIAM/1

Probability and Statistics



Diffusion Processes and Stochastic Calculus

Fabrice Baudoin, *Purdue University, West Lafayette, IN*

The main purpose of the book is to present, at a graduate level and in a self-contained way, the most important aspects of the theory of continuous stochastic processes in continuous time and to introduce some of its ramifications such as the theory of semigroups, the Malliavin calculus, and the Lyons' rough paths.

This book is intended for students, or even researchers, who wish to learn the basics in a concise but complete and rigorous manner. Several exercises are distributed throughout the text to test the understanding of the reader and each chapter ends with bibliographic comments aimed at those interested in exploring the materials further.

Stochastic calculus was developed in the 1950s and the range of its applications is huge and still growing today. Besides being a fundamental component of modern probability theory, domains of applications include but are not limited to: mathematical finance, biology, physics, and engineering sciences.

The first part of the text is devoted to the general theory of stochastic processes. The author focuses on the existence and regularity results for processes and on the theory of martingales. This allows him to introduce the Brownian motion quickly and study its most fundamental properties.

The second part deals with the study of Markov processes, in particular, diffusions. The author's goal is to stress the connections between these processes and the theory of evolution semigroups.

The third part deals with stochastic integrals, stochastic differential equations and Malliavin calculus.

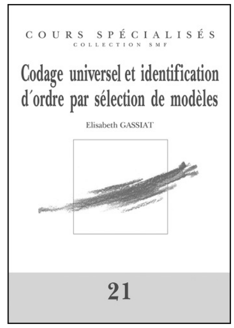
In the fourth and final part, the author presents an introduction to the very new theory of rough paths by Terry Lyons.

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

Contents: Introduction; Stochastic processes; Brownian motion; Markov processes; Symmetric diffusion semigroups; Itô calculus; Stochastic differential equations and Malliavin calculus; An introduction to Lyons' rough paths theory; Appendix A. Unbounded operators; Appendix B. Regularity theory; References; Index.

EMS Textbooks in Mathematics, Volume 16

July 2014, 287 pages, Hardcover, ISBN: 978-3-03719-133-0, 2010 *Mathematics Subject Classification:* 60-01, 60G07, 60J60, 60J65, 60H05, 60H07, **AMS members US$54.40**, List US$68, Order code EMSTEXT/16



Codage Universel et Identification d'ordre par Sélection de Modèles

Elisabeth Gassiat, *University Paris-Sud, Orsay, France*

A note to readers: This book is in French.

These notes are at the interface between information theory and statistics. They highlight how universal coding and adaptive compression are linked with the statistical inference of random processes, by maximum likelihood or Bayesian methods.

The author starts with classic tools for dealing with finite alphabets, then presents the recent theory of universal coding in infinite aphabets. She shows how it is used to solve problems of order identification, in particular for hidden Markov models.

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

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Codage sans perte; Codage universel en alphabet fini; Codage en alphabet infini; Inférence sur l'ordre d'un modèle; Bibliographie; Notations; Index.

Cours Spécialisés—Collection SMF, Number 21

May 2014, 140 pages, Softcover, ISBN: 978-2-85629-782-7, 2010 *Mathematics Subject Classification:* 62B10, 68P30, 62M99, **AMS members US$53.60**, List US$67, Order code COSP/21

Classified Advertisements

Positions available, items for sale, services available, and more

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics
Tenure-Track Assistant Professor

The Department of Mathematics invites applications for a tenure-track Assistant Professor beginning July 1, 2015. A Ph.D. degree or its equivalent and demonstrated promise in research and commitment to teaching are required. The department is seeking candidates in areas of pure mathematics that fit in with the existing areas of the department. To submit your application, go to `http://www.mathjobs.org/jobs/jhu`. Submit the AMS cover sheet, your curriculum vitae, list of publications, and research and teaching statements, and ensure that at least four letters of recommendation, one of which addresses teaching, are submitted by the reference writers. If you are unable to apply online, you may send application materials to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. If you have questions concerning this position, please write to `cpoole@jhu.edu`. Preference will be given to applications received by October 31, 2014. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

000030

JOHNS HOPKINS UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for tenured positions at the Associate and Full Professor levels beginning fall 2015 or later. The department is seeking candidates in areas of pure mathematics that fit in with the existing areas of the department. Preference for the full professor position will be given to candidates in analysis. Applications may be submitted online at `http://www.mathjobs.org/jobs/jhu` or mailed to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. Submit a curriculum vitae, including a list of publications. The department will assume the responsibility of soliciting letters of evaluation and will provide evaluators with a summary of policies on confidentiality of letters. If you have questions concerning these positions, please write to `cpoole@jhu.edu`. Applications received by October 15, 2014, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply

000031

Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2014 rate is $3.50 per word with a minimum two-line headline. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: October 2014 issue–July 29, 2014; November 2014 issue–September 4, 2014; December 2014 issue–September 30, 2014; January 2015 issue–October 29, 2014; February 2015 issue–December 8, 2014; March 2015 issue–January 2, 2015.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Eau Claire, Wisconsin

University of Wisconsin-Eau Claire

September 20–21, 2014

Saturday – Sunday

Meeting #1102

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2014
Program first available on AMS website: August 7, 2014
Program issue of electronic *Notices*: September 2014
Issue of *Abstracts*: Volume 35, 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

Matthew Kahle, Ohio State University, *To be announced*.

Markus Keel, University of Minnesota, *To be announced*.

Svitlana Mayboroda, University of Minnesota, *To be announced*.

Dylan P. Thurston, Indiana University, Bloomington, *Rubber bands, square tilings, and rational maps*.

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 `http://www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebraic Combinatorics, **Pavlo Pylyavskyy**, **Victor Reiner**, and **Dennis Stanton**, University of Minnesota.

Algorithms in Arithmetic Geometry, **Adriana Salerno**, Bates College, and **Ursula Whitcher**, University of Wisconsin-Eau Claire.

Analysis and Geometry on Lie Groups, **Chal Benson** and **Gail Ratcliff**, East Carolina University.

Cohomology and Representation Theory of Groups and Related Structures, **Christopher Bendel**, University of Wisconsin-Stout, and **Christopher Drupieski**, De Paul University.

Commutative Ring Theory, **Michael Axtell**, University of St. Thomas, and **Joe Stickles**, Millikin University.

Directions in Commutative Algebra: Past, Present, Future. Dedicated to the memory of H.-B. Foxby, **Joseph P. Brennan**, University of Central Florida, and **Robert M. Fossum**, University of Illinois at Urbana-Champaign.

Graph and Hypergraph Theory, **Sergei Bezrukov**, University of Wisconsin-Superior, **Dalibor Froncek**, University of Minnesota Duluth, and **Xiaofeng Gu**, **Uwe Leck**, and **Steven Rosenberg**, University of Wisconsin-Superior.

Knot Concordance and 4-Manifolds, **Christopher W. Davis**, University of Wisconsin-Eau Claire, **Taylor Martin**, Sam Houston State University, and **Carolyn Otto**, University of Wisconsin-Eau Claire.

Lie Algebras and Representation Theory, **Michael Lau**, Université Laval, **Ian Musson**, University of Wisconsin-Milwaukee, and **Matthew Ondrus**, Weber State University.

New Trends in Toric Varieties, **Christine Berkesch Zamaere**, University of Minnesota, **Daniel Erman**, University of Wisconsin-Madison, and **Hal Schenck**, University of Illinois Urbana-Champaign.

Number Theory, **Colleen Duffy**, University of Wisconsin-Eau Claire, and **Rafe Jones**, Carleton College.

Patterns in Permutations and Words, and Applications, **Manda Riehl**, University of Wisconsin-Eau Claire, and **Alex Woo**, University of Idaho.

Problem Solving in Extremal Combinatorics and Combinatorial Geometry, **Jeremy Alm**, Illinois College, and **Jacob Manske**, Epic.

Random Spaces, **Matthew Kahle**, Ohio State University, and **Dylan Thurston**, Indiana University.

The Mathematical Education of Future K-12 Teachers, **Charles Bingen** and **Ryan Harrison**, University of Wisconsin-Eau Claire.

Wavelets, Frames, and Time-Frequency Analysis, **Patrick Van Fleet**, University of St. Thomas, and **James S. Walker**, University of Wisconsin-Eau Claire.

von Neumann Algebras and Related Fields, **Stephen Avsec** and **Ken Dykema**, Texas A&M University.

Halifax, Canada

Dalhousie University

October 18–19, 2014

Saturday – Sunday

Meeting #1103

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: August 2014
Program first available on AMS website: September 5, 2014
Program issue of electronic *Notices*: October 2014
Issue of *Abstracts*: Volume 35, Issue 3

Deadlines

For organizers: Expired
For abstracts: August 19, 2014

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

Invited Addresses

François Bergeron, Université du Québec à Montréal, *Algebraic combinatorics and finite reflection groups.*

Sourav Chatterjee, Stanford University, *Nonlinear large deviations.*

William M. Goldman, University of Maryland, *Moduli spaces and the classification of geometric structures on manifolds.*

Sujatha Ramdorai, University of British Columbia, *Galois representations and Iwasawa theory.*

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 `http://www.ams.org/cgi-bin/abstracts/abstract.pl`.

Advances in Harmonic Analysis and Partial Differential Equations (Code: SS 14A), **David Cruz-Uribe**, Trinity College, and **Scott Rodney**, Cape Breton University.

Combinatorial Representation Theory (Code: SS 8A), **Cristina Ballantine**, College of the Holy Cross, **Rosa Orellana**, Dartmouth College, and **Mercedes Rosas**, Universidad de Sevilla.

Commutative Algebra and Its Interactions with Algebraic Geometry (Code: SS 2A), **Susan Marie Cooper**, North Dakota State University, **Sara Faridi**, Dalhousie University, and **William Traves**, U.S. Naval Academy.

Differential Geometry and Mathematical Physics (Code: SS 7A), **Virginie Charette**, Université de Sherbrooke, and **Karin Melnick**, University of Maryland.

Experimental Mathematics in Number Theory, Analysis, and Combinatorics (Code: SS 10A), **Marc Chamberland**, Grinnell College, and **Karl Dilcher**, Dalhousie University.

Games on Graphs (Code: SS 6A), **Jason Brown** and **Jeannette Janssen**, Dalhousie University.

General Relativity (Code: SS 12A), **Jack Gegenberg**, University of New Brunswick.

Generalized Catalan Algebraic Combinatorics (Code: SS 9A), **François Bergeron** and **Franco Saliola**, Université du Québec á Montréal, **Hugh Thomas**, University of New Brunswick, and **Nathan Williams**, Université du Québec á Montréal.

Hopf Algebras (Code: SS 11A), **Yuri Bahturin**, Memorial University of New Foundland, **Margaret Beattie**, Mount Allison University, and **Mitja Mastnak**, Saint Mary's University.

New Directions in Category Theory (Code: SS 5A), **Pieter Hofstra**, University of Ottawa, and **Dorette Pronk**, Dalhousie University.

Sampling Theory (Code: SS 4A), **John J. Benedetto**, University of Maryland, **Jean-Pierre Gabardo**, McMaster University, and **Ozgur Yilmaz**, University of British Columbia.

Special Functions and Their Applications. (Code: SS 3A), **Mourad E. H. Ismail**, University of Central Florida, and **Nasser Saad**, University of Prince Edward Island.

Symbolic Dynamics and Combinatorics on Words (Code: SS 13A), **Srecko Brlek**, Université du Québec á Montréal, and **Reem Yassawi**, Trent University.

p-adic Methods in Arithmetic (Code: SS 1A), **Henri Darmon**, McGill University, **Adrian Iovita**, Concordia University, and **Sujatha Ramdorai**, University of British Columbia.

San Francisco, California

San Francisco State University

October 25–26, 2014
Saturday – Sunday

Meeting #1104

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2014
Program first available on AMS website: September 11, 2014
Program issue of electronic *Notices*: October 2014
Issue of *Abstracts*: Volume 35, Issue 4

Deadlines

For organizers: Expired
For abstracts: September 3, 2014

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

Invited Addresses

Kai Behrend, University of British Columbia, Vancouver, Canada, *Title to be announced*.

Kiran S. Kedlaya, University of California, San Diego, *A brief history of perfectoid spaces*.

Julia Pevtsova, University of Washington, Seattle, *Applications of geometry to modular representation theory*.

Jim Simons, Euclidean Capital, *Mathematics, common sense, and good luck*. (Einstein Lecture, Saturday, October 25, 6:00 p.m.)

Burt Totaro, University of California, Los Angeles, *The fundamental group of an algebraic variety, and hyperbolic complex manifolds*.

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 `http://www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebraic Geometry (Code: SS 1A), **Renzo Cavalieri**, Colorado State University, **Noah Giansiracusa**, University of California, Berkeley, and **Burt Totaro**, University of California, Los Angeles.

Algebraic Statistics (Code: SS 8A), **Elizabeth Gross**, San Jose State University, and **Kaie Kubjas**, Aalto University.

Applications of Knot Theory to the Entanglement of Biopolymers (Code: SS 15A), **Javier Arsuaga**, San Francisco State University, **Michael Szafron**, University of Saskatchewan, and **Mariel Vazquez**, San Francisco State University.

Categorical Methods in Representation Theory (Code: SS 4A), **Eric Friedlander**, University of Southern California, **Srikanth Iyengar**, University of Utah, and **Julia Pevtsova**, University of Washington.

Combinatorics and Algebraic Geometry (Code: SS 9A), **Madhusudan Manjunath**, University of California, Berkeley, and **Farbod Shokrieh**, Cornell University.

Computational Algebraic Geometry and Applications to Science and Engineering (Code: SS 17A), **Daniel Brake** and **Dhagash Mehta**, North Carolina State University, Raleigh.

Developments from MSRI Programs in Commutative Algebra and Noncommutative Algebraic Geometry and Representation Theory (Code: SS 18A), **Kenneth Chan**, University of Washington, and **Jack Jeries**, University of Utah.

Geometry of Submanifolds (Code: SS 3A), **Yun Myung Oh**, Andrews University, **Bogdan D. Suceava**, California State University, Fullerton, and **Mihaela B. Vajiac**, Chapman University.

Hamiltonian Partial Differential Equations (Code: SS 12A), **Marius Beceanu**, University of California, Berkeley, **Magdalena Czubak**, Binghamton University, **Dong Li**, University of British Columbia, and **Xiaoyi Zhang**, University of Iowa.

High-Dimensional Convexity and Applications (Code: SS 14A), **Luis Rademacher**, Ohio State University, **Stanislaw Szarek**, Case Western Reserve University and Université Pierre et Marie Curie-Paris 6, and **Elisabeth Werner**, Case Western Reserve University, Université de Lille 1, UFR de Mathématique.

Homotopy Theory (Code: SS 11A), **Julie Bergner**, University of California, Riverside, and **Angélica Osorno**, Reed College.

Interactions between Knots and Manifolds (Code: SS 10A), **Stanislav Jabuka** and **Swatee Naik**, University of Nevada, Reno, and **Cornelia Van Cott**, University of San Francisco.

Nonlinear Partial Differential Equations (Code: SS 6A), **Nathan Glatt-Holtz**, Virginia Tech, **Geordie Richards**, University of Rochester, and **Vlad Vicol**, Princeton University.

Polyhedral Number Theory (Code: SS 2A), **Matthias Beck**, San Francisco State University, **Martin Henk**, Universität Magdeburg, and **Joseph Gubeladze**, San Francisco State University.

Probabilistic and Statistical Problems in Stochastic Dynamics (Code: SS 7A), **Alexandra Piryatinska**, San Francisco State University.

Recent Progress in Geometric Analysis (Code: SS 5A), **David Bao**, San Francisco State University, and **Ovidiu Munteanu**, University of Connecticut.

Recent Progress in Harmonic Analysis and Several Complex Variables (Code: SS 16A), **Gustavo Hoepfner** and **Paulo Liboni**, Universidade Federal de São Carlos, and **Irina Mitrea**, Temple University.

Topological Combinatorics and Combinatorial Commutative Algebra (Code: SS 13A), **Anton Dochtermann**, University of Miami, **Augustine O'Keefe**, University of Kentucky, and **Alexander Engstrom**, Aalto University.

Greensboro, North Carolina

University of North Carolina at Greensboro

November 8–9, 2014

Saturday – Sunday

Meeting #1105

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: August 2014
Program first available on AMS website: September 25, 2014
Program issue of electronic *Notices*: November 2014
Issue of *Abstracts*: Volume 35, Issue 4

Deadlines

For organizers: Expired
For abstracts: September 23, 2014

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

Invited Addresses

Susanne C. Brenner, Louisiana State University, *Novel finite element methods for optimal control problems with PDE constraints.*

Skip Garibaldi, Emory University, *E_8 and other exceptional groups.*

Stavros Garoufalidis, Georgia Institute of Technology, *Knots and q-series.*

James Sneyd, University of Auckland, *The dynamics of calcium: Oscillations, waves, theories, and experiments* (AMS-NZMS Maclaurin Lecture).

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 http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Algebraic Structures Motivated by Knot Theory (Code: SS 9A), **Jozef H. Przytycki**, George Washington University, and **Radmila Sazdanovic**, North Carolina State University.

Algorithms for Local Fields (Code: SS 14A), **Chad Awtrey**, Elon University, and **Sebastian Pauli**, University of North Carolina at Greensboro.

Automorphic Forms and Related Topics (Code: SS 11A), **Matthew Boylan**, University of South Carolina, **Jayce Getz**, Duke University, and **Dan Yasaki**, University of North Carolina at Greensboro.

Connections in Number Theory (Code: SS 20A), **Joseph Vandehey**, University of Georgia.

Difference Equations and Applications (Code: SS 1A), **Michael A. Radin**, Rochester Institute of Technology, and **Youssef Raffoul**, University of Dayton.

Discontinuous Galerkin Finite Element Methods (Code: SS 13A), **Susanne C. Brenner** and **Joscha Gedicke**, Louisiana State University, and **Thomas Lewis**, University of North Carolina at Greensboro.

Discrete Structures in Classical Geometries (Code: SS 4A), **Philip L. Bowers**, Florida State University.

Exceptional Groups in Physics, Algebra, and Geometry (Code: SS 17A), **Asher Auel**, Yale University, **Anthony Ruozzi**, Emory University, and **George McNinch**, Tufts University.

Galois Theory and Its Interactions with Algebra and Number Theory (Code: SS 12A), **Chad Awtrey**, Elon University, and **Michael Bush**, Washington and Lee University.

Geometric Analysis (Code: SS 6A), **Hubert Bray**, Duke University, and **Andrew Cooper**, North Carolina State University.

Geometry and Combinatorics on Homogeneous Spaces (Code: SS 10A), **Leonardo C. Mihalcea**, Virginia Tech University, and **Richard Rimanyi**, University of North Carolina Chapel Hill.

Knot Theory and Its Applications (Code: SS 7A), **Elizabeth Denne**, Washington & Lee University, and **Laura Taalman**, James Madison University.

Mirror Symmetry (Code: SS 18A), **Matthew Ballard**, University of South Carolina, and **David Favero**, University of Alberta.

Movement in Mathematical Biology (Code: SS 19A), **Jonathan T. Rowell** and **Jan Rychtar**, University of North Carolina at Greensboro.

Multiple Combinatorial Numbers and Associated Identities (Code: SS 16A), **Hasan Coskun**, Texas A&M University Commerce.

Nonlinear Boundary Value Problems (Code: SS 5A), **Maya Chhetri**, University of North Carolina at Greensboro, and **Stephen Robinson**, Wake Forest University.

Partial Differential Equations Related to Fluids (Code: SS 15A), **Dhanapati Adhikari**, Marywood University.

Recent Advances in Numerical Methods for Fluid Flow Problems (Code: SS 2A), **Leo Rebholz**, Clemson University, and **Zhu Wang**, University of South Carolina.

Recent Developments in Graph Theory and Hypergraph Theory (Code: SS 3A), **David Galvin**, University of Notre Dame, and **Clifford Smyth**, University of North Carolina at Greensboro.

Set Theoretic Topology (Code: SS 8A), **Peter J. Nyikos**, University of South Carolina, and **Jerry Vaughan**, University of North Carolina at Greensboro.

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday

Meeting #1106

Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th 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 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2015
Issue of *Abstracts*: Volume 36, Issue 1

Deadlines

For organizers: Expired
For abstracts: September 16, 2014

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

Joint Invited Addresses

Jordan Ellenberg, University of Wisconsin-Madison, *Title to be announced* (AMS-MAA Invited Address).

Donald G. Saari, University of California, Irvine, *From Voting Paradoxes to the Search for "Dark Matter"* (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture).

Richard Tapia, Rice University, *Title to be announced* (AMS-MAA Invited Address).

AMS Invited Addresses

Ian Agol, University of California, Berkley, *Title to be announced*.

Henri Darmon, McGill University, *Title to be announced*.

Susan Holmes, Stanford University, *Title to be announced*.

Michael Hopkins, Harvard University, *Title to be announced* (AMS Colloquium Lectures).

Russell Lyons, Indiana University, *Title to be announced*.

Irena Peeva, Cornell University, *Title to be announced*.

Daniel A. Spielman, Yale University, *Title to be announced* (AMS Josiah Willard Gibbs Lecture).

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 http://jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm.

Some sessions are cosponsored with other organizations. These are noted within the parenthesis at the end of each listing, where applicable.

Accelerated Advances in Multiobjective Optimal Control Problems and Mathematical Programming Based on Generalized Invexity Frameworks (Code: SS 4A), **N. J. Huang**, Sichuan University, **R. N. Mohapatra**, University of Central Florida, **Ram Verma**, Texas State University, and **Alexander Zaslavski**, Israel Institute of Technology.

Advances in Coding Theory (Code: SS 21A), **Felice Manganiello** and **Gretchen L. Matthews**, Clemson University, and **Judy L. Walker**, University of Nebraska.

Algebraic Combinatorics and Representation Theory (Code: SS 36A), **Zajj Daugherty**, Dartmouth College, and **Ben Salisbury**, Central Michigan University.

Algebraic and Geometric Methods in Applied Discrete Mathematics (a Mathematics Research Communities session) (Code: 57A), **Heather Harrington**, University of Oxford, **Mohamed Omar**, Harvey Mudd College, and **Matthew Wright**, IMA, University of Minnesota.

Applications of Dynamical Systems to Biological Models (Code: SS 18A), **Yu Jin**, University of Nebraska-Lincoln, and **Xiang-Sheng Wang**, Southeast Missouri State University.

Beyond First-Order Model Theory (Code: SS 55A), **John T. Baldwin**, University of Illinois at Chicago, **Xavier Caicedo**, Universidad de los Andes, **Rami Grossberg**, Carnegie Mellon University, **Jose Iovino**, University of Texas at San Antonio, and **Boris Zilber**, Oxford University (AMS-ASL).

Classification Problems in Operator Algebras (Code: SS 47A), **Arnaud Brothier**, Vanderbilt University, **Ionut Chifan**, The University of Iowa, **Darren Creutz**, Vanderbilt University, **Remus Nicoara**, University of Tennessee, and **David Penneys**, University of Toronto.

Cluster Algebras (a Mathematics Research Communities session) (Code: SS 56A), **Andrew T. Carroll**, DePaul University, **Ian T. Le**, University of Chicago, and **Greg Muller**, University of Michigan.

Computing Intensive Modeling in Mathematical and Computational Biology (Code: SS 29A), **Timothy D. Comar**, Benedictine University, **Olcay Akman**, Illinois State University, and **Daniel Hrozencik**, Chicago State University.

Continued Fractions (Code: SS 43A), **James Mc Laughlin**, West Chester University, and **Nancy J. Wyshinski**, Trinity College.

Creating Coherence in K–12 Mathematics (Code: SS 50A), **Brigitte Lahme**, Sonoma State University, **William McCallum** and **Cody Patterson**, University of Arizona, **Kristin Umland**, University of New Mexico, and **Ellen Whitesides**, University of Arizona.

Current Trends in Classical Dynamical Systems (Code: SS 25A), **Lennard Bakker** and **Skyler Simmons**, Brigham Young University.

Difference Equations and Applications (Code: SS 3A), **Steven Miller**, Williams College, and **Michael A. Radin**, Rochester Institute of Technology.

Differential Geometry and Statistics (Code: SS 45A), **Susan Holmes**, Stanford University.

Enumerative Combinatorics (Code: SS 30A), **Brian K. Miceli**, Trinity University, and **Jay Pantone** and **Vince Vatter**, University of Florida.

Ergodic Theory and Dynamical Systems (Code: SS 32A), **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Factorization Theory and Its Applications (Code: SS 11A), **Nicholas Baeth**, University of Central Missouri, **Scott Chapman**, Sam Houston State University, **Jim Coykendall**, Clemson University, and **Alfred Geroldinger**, Karl Franzens University.

Fixed Point Theory and Applications (Code: SS 13A), **Clement Boateng Ampadu**.

Fractional, Stochastic, and Hybrid Dynamic Systems with Applications (Code: SS 5A), **John R. Graef**, University of Tennessee at Chattanooga, **G. S. Ladde**, University of South Florida, and **A. S. Vatsala**, University of Louisiana at Lafayette.

Frames and Their Applications (Code: SS 33A), **Radu Balan** and **Kasso Okoudjou**, University of Maryland, and **Rachel Ward**, University of Texas.

Geometries Defined by Differential Forms (Code: SS 38A), **Sergey Grigorian**, University of Texas-Pan American, **Sema Salur**, University of Rochester, and **Albert J. Todd**, University of California, Riverside.

Geosystems Mathematics (Code: SS 54A), **Willi Freeden**, University of Kaiserslautern, **Volker Michel**, University of Siegen, and **M. Zuhair Nashed**, University of Central Florida.

Graphs, Matrices, and Related Problems (Code: SS 23A), **Cheryl Grood** and **Thomas Hunter**, Swarthmore College, and **Sharon McCathern**, Azusa Pacific University.

Groups, Algorithms, and Cryptography (Code: SS 2A), **Bren Cavallo** and **Delaram Kahrobaei**, City University of New York Graduate Center.

Heavy-Tailed Distributions and Processes (Code: SS 52A), **U. Tuncay Alparslan** and **John P. Nolan**, American University.

History of Mathematics (Code: SS 24A), **Sloan Despeaux**, Western Carolina University, **Patti Hunter**, Westmont College, **Deborah Kent**, Drake University, and **Adrian Rice**, Randolph-Macon College (AMS-MAA).

Holomorphic Dynamics in One and Several Variables (Code: SS 51A), **Tanya Firsova**, State University of New York at Stony Brook and Kansas State University, and **Thomas Sharland**, State University of New York at Stony Brook.

Hopf Algebras and Tensor Categories (Code: SS 6A), **Susan Montgomery**, University of Southern California, **Siu-Hung Ng**, Louisiana State University and Iowa State University, and **Sarah Witherspoon**, Texas A&M University.

Inequalities and Quantitative Approximation (Code: SS 1A), **Feng Dai**, University of Alberta, and **Mourad E. H. Ismail**, University of Central Florida.

Inverse Problems (Code: SS 49A), **Peter Muller**, Rensselaer Polytechnic Institute, and **Kaitlyn Voccola**, Colorado State University.

Knot Theory (Code: SS 10A), **Tim Cochran** and **Shelly Harvey**, Rice University.

Limits of Discrete Structures (Code: SS 26A), **Peter Diao**, **Dominique Guillot**, **Apoorva Khare**, and **Bala Rajaratnam**, Stanford University.

Math Teachers Circles and the K–20 Continuum (Code: SS 41A), **Brian Conrey**, American Institute of Mathematics, **Michael Nakamaye** and **Kristin Umland**, University of New Mexico, and **Diana White**, University of Colorado at Denver.

Mathematics in Natural Resource Modeling (Code: SS 44A), **Shandelle M. Henson**, Andrews University, and **Catherine A. Roberts**, College of the Holy Cross.

Mathematics in Poland: Interbellum, World War II, and Immediate Post-War Developments (Code: SS 42A), **Mohammad Javaheri** and **Emelie A. Kenney**, Siena College.

Model Theory and Applications (Code: SS 48A), **David Marker**, University of Illinois at Chicago, **Sergei Starchenko**, University of Notre Dame, and **Carol Wood**, Wesleyan University.

Noncommutative Function Theory (Code: SS 16A), **Paul S. Muhly**, University of Iowa, and **Gelu F. Popescu**, University of Texas at San Antonio.

Operator Algebras and Their Applications: A Tribute to Richard V. Kadison (Code: SS 40A), **Robert S. Doran** and **Efton Park**, Texas Christian University.

Partitions, q-Series, and Modular Forms (Code: SS 37A), **Atul Dixit**, Tulane University, **Tim Huber**, University of Texas-Pan American, **Amita Malik**, University of Illinois, and **Ae Ja Yee**, Pennsylvania State University.

Positivity and Matrix Inequalities (Code: SS 35A), **Dominique Guillot**, **Apoorva Khare**, and **Bala Rajaratnam**, Stanford University.

Probability and Applications (Code: SS 34A), **Rick Kenyon**, Brown University, and **Russell Lyons**, Indiana University.

Progress in Multivariable Operator Theory (Code: SS 20A), **Ron Douglas**, Texas A&M University, and **Constanze Liaw**, Baylor University.

Quantum Markov Chains, Quantum Walks, and Related Topics (Code: SS 7A), **Chaobin Liu**, Bowie State University, **Takuya Machida**, University of California, Berkeley, **Salvador E. Venegas-Andraca**, Tecnologicó de Monterrey, Campus Estado de México, and **Nelson Petulante**, Bowie State University.

Recent Advances in Discrete and Intuitive Geometry (Code: SS 31A), **Andras Bezdek**, Auburn University, **Ted Bisztriczky**, University of Calgary, and **Wlodek Kuperberg**, Auburn University.

Recent Advances in the Analysis and Applications of Modern Splitting Methods (Code: SS 14A), **Abdul Q. M. Khaliq**, Middle Tennessee State University, **Qin Sheng**, Baylor University, and **Bruce Wade**, University of Wisconsin-Milwaukee.

Recent Developments in Algebraic Number Theory (Code: SS 9A), **Wen-Ching Winnie Li**, Pennsylvania State University, **Tong Liu**, Purdue University, and **Ling Long**, Iowa State University and Louisiana State University.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs (Code: SS 17A), **Darren A. Narayan**, Rochester Institute of Technology, **Tamas Forgacs**, California State University Fresno, and

Jobby Jacob, **Carl V. Lutzer**, and **Tamas Wiandt**, Rochester Institute of Technology.

Ricci Curvature for Homogeneous Spaces and Related Topics (Code: SS 8A), **Megan Kerr**, Wellesley College, and **Tracy Payne**, Idaho State University.

Selmer Groups (Code: SS 53A), **Mirela Ciperiani**, University of Texas, and **Henri Darmon**, McGill University.

Set-Valued Optimization and Variational Problems with Applications (Code: SS 22A), **Akhtar A. Khan**, Rochester Institute of Technology, **Mau Nam Nguyen**, Portland State University, **Miguel Sama**, Universidad Nacional de Educacion a Distancia, Madrid, and **Christiane Tammer**, Martin-Luther-University of Halle-Wittenberg.

Studies in Interconnections among Parameters in Graph Theory, Combinatorics, and Discrete Geometry (Code: SS 39A), **Cong X. Kang** and **Eunjeong Yi**, Texas A&M University at Galveston.

Successes and Challenges in Teaching Mathematics (Code: SS 46A), **Ellina Grigorieva**, Texas Woman's University, and **Natali Hritonenko**, Prairie View A&M University.

Syzygies (Code: SS 27A), **Giulio Caviglia**, Purdue University, **Jason McCullough**, Rider University, and **Irena Peeva**, Cornell University.

The Scottish Book (Code: SS 15A), **Krystyna Kuperberg**, Auburn University, **R. Daniel Mauldin**, University of North Texas, and **Jan Mycielski**, University of Colorado.

Theory and Application of Reaction Diffusion Models (Code: SS 12A), **Jerome Goddard II**, Auburn University Montgomery, and **Ratnasingham Shivaji**, University of North Carolina Greensboro.

Topological Measures of Complexity: Inverse Limits, Entropy, and Structure of Attractors (Code: SS 28A), **Loribeth M. Alvin**, University of Denver, **Jan P. Boroński**, National Supercomputing Centre IT4Innovations, Ostrava, **James Keesling**, University of Florida, **Olga Lukina**, University of Illinois at Chicago, and **P. Oprocha**, AGH University of Science and Technology, Krakow.

What's New in Group Theory? (Code: SS 19A), **Arturo Magidin**, University of Louisiana at Lafayette, and **Elizabeth Wilcox**, Oswego State University.

Washington, District of Columbia

Georgetown University

March 7–8, 2015

Saturday – Sunday

Meeting #1107

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: March 2015
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: Expired
For abstracts: January 20, 2015

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

Invited Addresses

Frederico Rodriguez Hertz, Pennsylvania State University, *Title to be announced.*

Nancy Hingston, The College of New Jersey, *Title to be announced.*

Simon Tavaré, Cambridge University, *Title to be announced* (Einstein Public Lecture in Mathematics).

Yitang Zhang, University of New Hampshire, *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 `http://www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebra and Representation Theory (Code: SS 13A), **Ela Celikbas** and **Olgur Celikbas**, University of Connecticut, and **Frank Moore**, Wake Forest University.

Computable Structure Theory (Code: SS 8A), **Rumen Dimitrov**, Western Illinois University, **Valentina Harizanov**, George Washington University, and **Russell Miller**, Queens College and Graduate Center, City University of New York.

Conceptual Mathematical Models in Climate Science (Code: SS 5A), **Hans Engler** and **Hans Kaper**, Georgetown University.

Convexity and Combinatorics (Code: SS 9A), **Jim Lawrence** and **Valeriu Soltan**, George Mason University.

Crossing Numbers of Graphs (Code: SS 3A), **Paul Kainen**, Georgetown University.

Iterated Integrals and Applications (Code: SS 12A), **Ivan Horozov**, Washington University in St. Louis.

Operator Theory on Analytic Function Spaces (Code: SS 11A), **Robert F. Allen**, University of Wisconsin, La Cross, and **Flavia Colonna**, George Mason University.

Qualitative Behavior of Solutions of Partial Differential Equations (Code: SS 7A), **Junping Shi**, College of William and Mary, and **Jiuyi Zhu**, John Hopkins University.

Quantum Algebras, Representations, and Categorifications (Code: SS 2A), **Sean Clark** and **Weiqiang Wang**, University of Virginia.

Somos Sequences and Nonlinear Recurrences (Code: SS 10A), **Andrew Vogt**, Georgetown University.

Spatial Evolutionary Models and Biological Invasions (Code: SS 6A), **Judith Miller**, Georgetown University, and **Yuan Lou**, Ohio State University.

Topology in Biology (Code: SS 4A), **Paul Kainen**, Georgetown University.

Within-Host Disease Modeling (Code: SS 1A), **Stanca Ciupe**, Virginia Polytechnic Institute, and **Sivan Leviyang**, Georgetown University.

East Lansing, Michigan

Michigan State University

March 14–15, 2015

Saturday – Sunday

Meeting #1108

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: January 2015
Program first available on AMS website: January 29, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: August 26, 2014
For abstracts: January 20, 2015

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

Invited Addresses

Philippe Di Francesco, University of Illinois, *Title to be announced*.

Alexander Furman, University of Illinois at Chicago, *Title to be announced*.

Vera Mikyoung Hur, University of Illinois at Urbana-Champaign, *Title to be announced*.

Mihnea Popa, University of Illinois at Chicago, *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 `http://www.ams.org/cgi-bin/abstracts/abstract.pl`.

Approximation Theory in Signal Processing and Computer Science (Code: SS 5A), **Mark Iwen**, Michigan State University, **Rayan Saab**, University of California San Diego, and **Aditya Viswanathan**, Michigan State University.

Arithmetic of Hyperelliptic Curves (Code: SS 3A), **Tony Shaska**, Oakland University.

Complex Analysis in Several Variables and its Applications (Code: SS 11A), **Debraj Chakrabarti**, Central Michigan University, and **Yunus Zeytuncu**, University of Michigan at Dearborn.

Fractals and Tilings (Code: SS 10A), **Sze-Man Ngai**, Georgia Southern University, **Erin Pearse**, California Polytechnic State University, **Yang Wang**, Hong Kong University of Science and Technology, and **Yimin Xiao**, Michigan State University.

Fractional Calculus and Nonlocal Operators (Code: SS 1A), **Mark M. Meerschaert** and **Russell Schwab**, Michigan State University.

Frames, Wavelets and Their Applications (Code: SS 16A), **Palle Jorgensen**, University of Iowa, **Darrin Speegle**, St. Louis University, and **Yang Wang**, Hong Kong University of Science and Technology.

Groups and Representations (Code: SS 9A), **Amanda Schaeffer Fry** and **Jonathan Hall**, Michigan State University, and **Hung Nguyen**, University of Akron.

High-Frequency Problems (Code: SS 14A), **Shlomo Levental** and **Mark Schroder**, Michigan State University.

Homotopy Continuation Methods and Their Applications to Science and Engineering (Code: SS 6A), **Tianran Chen**, Michigan State University, and **Dhagash Mehta**, North Carolina State University.

New Developments in Actuarial Mathematics (Code: SS 15A), **Emiliano A. Valdez**, Michigan State University.

New Developments in Stochastic Analysis, Stochastic Control and Related Fields (Code: SS 7A), **Chao Zhu**, University of Wisconsin-Milwaukee.

Phase Retrieval in Theory and Practice (Code: SS 8A), **Matthew Fickus**, Air Force Institute of Technology, **Mark Iwen**, Michigan State University, and **Dustin Mixon**, Air Force Institute of Technology.

Random Fields and Long Range Dependence (Code: SS 2A), **Mark M. Meerschaert** and **Yimin Xiao**, Michigan State University.

Recent Advances in the Geometry of Submanifolds, Dedicated to the Memory of Franki Dillen (1963-2013) (Code: SS 12A), **Alfonso Carriazo Rubio**, University of Sevilla, **Yun Myung Oh**, Andrews University, **Bogdan D. Suceavă**, California State University, Fullerton, and **Joeri Van der Veken**, KU Leuven.

Stochastic Partial Differential Equations and Applications (Code: SS 4A), **Leszek Gawarecki**, Kettering University, and **Vidyadhar Mandrekar**, Michigan State University.

Survey of Biomathematics (Code: SS 13A), **Hannah Callender**, University of Portland, **Peter Hinow**, University of Wisconsin, Milwaukee, and **Deena Schmidt**, Case Western Reserve University.

Huntsville, Alabama

University of Alabama in Huntsville

March 27–29, 2015

Friday – Sunday

Meeting #1109

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: January 2015
Program first available on AMS website: February 11, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: August 20, 2014
For abstracts: February 4, 2015

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

Invited Addresses

Eva Bayer-Fluckiger, EPFL, *Title to be announced.*

M. Gregory Forest, University of North Carolina at Chapel Hill, *Title to be announced.*

Dan Margalit, Georgia Institute of Technology, *Title to be announced.*

Paul Pollack, University of Georgia, *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 http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Fractal Geometry and Ergodic Theory (Code: SS 1A), **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

New Developments in Population Dynamics and Epidemiology (Code: SS 4A), **Jia Li**, University of Alabama in Huntsville, **Maia Martcheva**, University of Florida, and **Necibe Tuncer**, Florida Atlantic University.

Recent Trends in Mathematical Biology (Code: SS 3A), **Wandi Ding** and **Zachariah Sinkala**, Middle Tennessee State University.

Stochastic Processes and Related Topics (Code: SS 2A), **Paul Jung**, University of Alabama at Birmingham, **Erkan Nane**, Auburn University, and **Dongsheng Wu**, University of Alabama in Huntsville.

Las Vegas, Nevada

University of Nevada, Las Vegas

April 18–19, 2015

Saturday – Sunday

Meeting #1110

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2015
Program first available on AMS website: March 5, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: September 18, 2014
For abstracts: February 24, 2015

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

Invited Addresses

Joel Hass, University of California, Davis, *Title to be announced.*

Ko Honda, University of California, Los Angeles, *Title to be announced.*

Brendon Rhoades, University of California, San Diego, *Title to be announced.*

Bianca Viray, 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 http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Algebraic Structures in Knot Theory (Code: SS 7A), **Sam Nelson**, Claremont McKenna College, and **Radmila Sazdanović**, North Carolina State University.

Data Analysis and Physical Processes (Code: SS 4A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Eric Machorro**, National Security Technologies.

Inverse Problems and Related Mathematical Methods in Physics (Code: SS 1A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico, Albuquerque.

Nonlinear Conservation Laws and Applications (Code: SS 6A), **Matthias Youngs**, Indiana University-Purdue University Columbus, **Cheng Yu**, University of Texas at Austin, and **Kun Zhao**, Tulane University.

Stochastic Analysis and Rough Paths (Code: SS 2A), **Fabrice Baudoin**, Purdue University, **David Nualart**, University of Kansas, and **Cheng Ouyang**, University of Illinois at Chicago.

Topics in Graph Theory: Structural and Extremal Problems (Code: SS 3A), **Jie Ma**, Carnegie Mellon University, **Hehui Wu**, Simon Fraser Univerisy, and **Gexin Yu**, College of William & Mary.

Porto, Portugal

University of Porto

June 10–13, 2015

Wednesday – Saturday

Meeting #1111

First Joint International Meeting involving the American Mathematical Society (AMS), the European Mathematical Society (EMS), and the Sociedade de Portuguesa Matematica (SPM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Not applicable

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/internmtgs.html.

Invited Addresses

Marcus du Sautoy, *The secret mathematicians* (Public Lecture, Wednesday evening, 8:30 p.m.)

Rui Loja Fernandes, University of Illinois at Urbana-Champaign, *Title to be announced*.

Irene Fonseca, Carnegie Mellon University, *Title to be announced*.

Annette Huber, Albert-Ludwigs-Universität, *Title to be announced*.

Mikhail Khovanov, Columbia University, *Title to be announced*.

André Neves, Imperial College London, *Title to be announced*.

Sylvia Serfaty, Université Pierre et Marie Curie Paris 6, *Title to be announced*.

Gigliola Staffilani, Massachusetts Institute of Technology, *Title to be announced*.

Marcelo Viana, Instituto de Matemática Pura e Aplicada, Brasil, *Title to be announced*.

Chicago, Illinois

Loyola University Chicago

October 3–4, 2015

Saturday – Sunday

Meeting #1112

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2015
Program first available on AMS website: August 20, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: March 10, 2015
For abstracts: August 11, 2015

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

Invited Addresses

Julia Chuzhoy, Toyota Technological Institute at Chicago, *Title to be announced*.

Andrew Neitzke, The University of Texas at Austin, *Title to be announced*.

Sebastien Roch, University of Wisconsin-Madison, *Title to be announced*.

Peter Sarnak, Princeton University, *Title to be announced* (Erdős Memorial Lecture).

Memphis, Tennessee

University of Memphis

October 17–18, 2015

Saturday – Sunday

Meeting #1113

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: August 2015
Program first available on AMS website: September 3, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 3

Deadlines

For organizers: March 17, 2015
For abstracts: August 25, 2015

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

Invited Addresses

Mark van Hoeij, Florida State University, *Title to be announced*.

Vaughan Jones, Vanderbilt University, *Title to be announced*.

Mette Olufsen, 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 http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Computational Analysis (Code: SS 1A), **George Anastassiou**, University of Memphis.

Fractal Geometry and Dynamical Systems (Code: SS 2A), **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Fullerton, California

California State University, Fullerton

October 24–25, 2015

Saturday – Sunday

Meeting #1114

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2015
Program first available on AMS website: September 10, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: March 27, 2015
For abstracts: September 1, 2015

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

Invited Addresses

Mina Aganagic, University of California, Berkeley, *Title to be announced.*
John Lott, University of California, Berkeley, *Title to be announced.*
Eyal Lubetzky, Microsoft Research, Redmond, *Title to be announced.*
Zhiwei Yun, Stanford 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 http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Geometric Analysis (Code: SS 1A), **John Lott**, University of California, Berkeley, and **Aaron Naber**, Northwestern University.

New Brunswick, New Jersey

Rutgers University

November 14–15, 2015

Saturday – Sunday

Meeting #1115

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: September 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: November 2015
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: April 14, 2015
For abstracts: September 22, 2015

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

Invited Addresses

Lee Mosher, Rutgers University, *Title to be announced.*
Jill Pipher, Rutgers University, *Title to be announced.*
David Vogan, Massachusetts Institute of Technology, *Title to be announced.*
Wei Zhang, Columbia 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 http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Applications of CAT(0) Cube Complexes (Code: SS 1A), **Sean Cleary**, City College of New York and the City University of New York Graduate Center, and **Megan Owen**, Lehman College of the City University of New York.

Seattle, Washington

Washington State Convention Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday
Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th Annual Meeting of the Mathematical Association of America (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*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For abstracts: To be announced

Salt Lake City, Utah

University of Utah

April 9–10, 2016

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Fargo, North Dakota

North Dakota State University

April 16–17, 2016

Saturday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday
Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For abstracts: To be announced

Charleston, South Carolina

College of Charleston

March 10–12, 2017

Friday – Sunday
Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: November 10, 2016
For abstracts: To be announced

Bloomington, Indiana

Indiana University

April 1–2, 2017

Saturday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Pullman, Washington

Washington State University

April 22–23, 2017

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday – Saturday
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
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2017
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
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Central Section: **Georgia Benkart**, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

Eastern Section: **Steven H. Weintraub**, Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: steve.weintraub@lehigh.edu; telephone: 610-758-3717.

Southeastern Section: **Brian D. Boe,** Department of Mathematics, University of Georgia, 220 D W Brooks Drive, Athens, GA 30602-7403, e-mail: brian@math.uga.edu; telephone: 706-542-2547.

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.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 99 in the January 2014 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

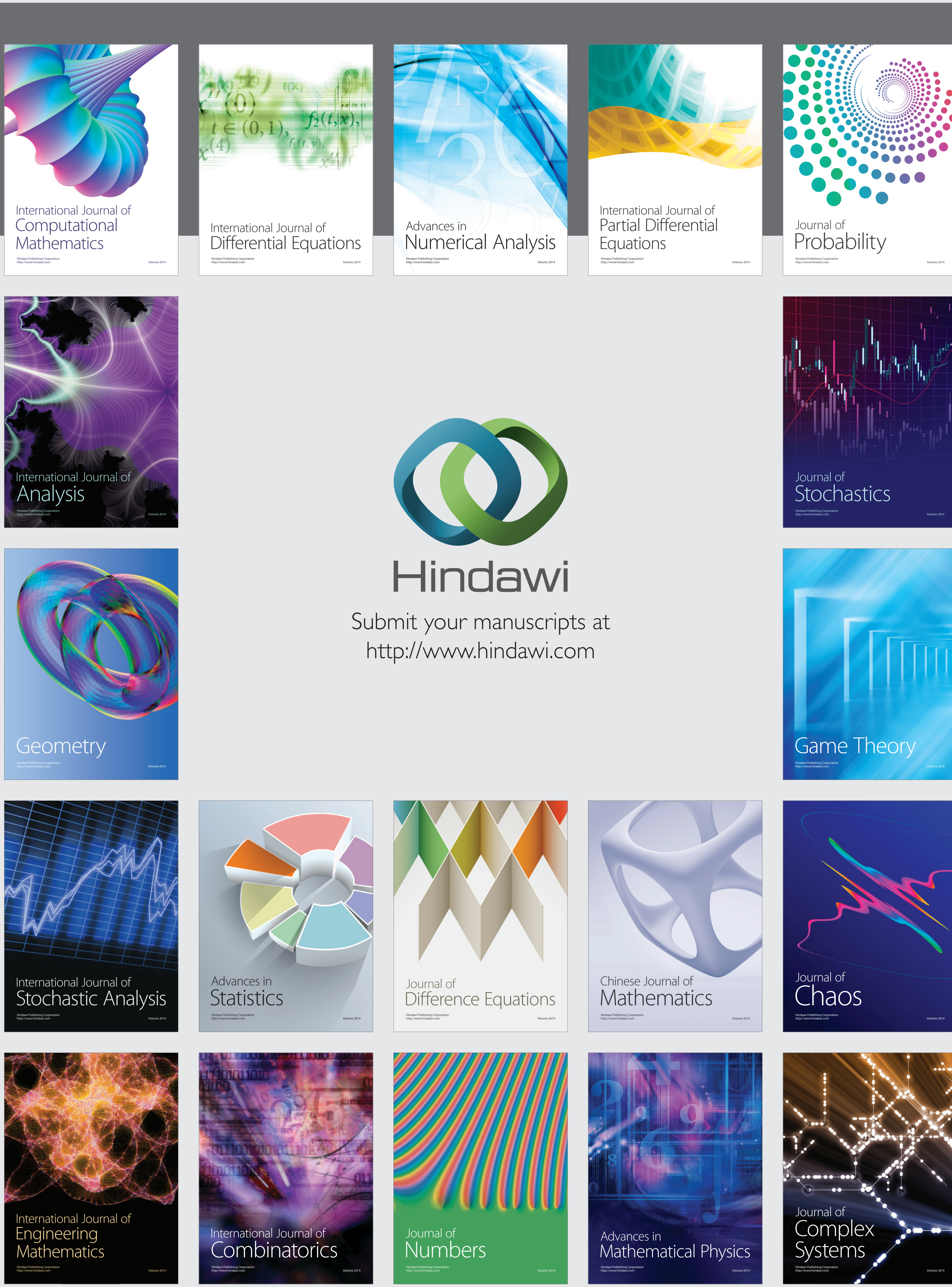
Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences in Cooperation with the AMS: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

November 7–9, 2014: 7th International Conference on Science and Mathematics Education in Developing Countries, Mandalay University, Myanmar.

December 8–12, 2014: ICPAM-Goroka 2014: International Conference on Pure and Applied Mathematics, University of Goroka, Papua, New Guinea.

April 2–5, 2015: The Second International Conference on Mathematics and Statistics (AUS-ICMS '15). American University of Sharjah, United Arab Emirates.


International Journal of Computational Mathematics
International Journal of Differential Equations
Advances in Numerical Analysis
International Journal of Partial Differential Equations
Journal of Probability
International Journal of Analysis
Hindawi
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Journal of Stochastics
Geometry
Game Theory
International Journal of Stochastic Analysis
Advances in Statistics
Journal of Difference Equations
Chinese Journal of Mathematics
Journal of Chaos
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International Journal of Combinatorics
Journal of Numbers
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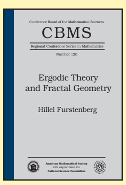
Recent Releases from the AMS



Ergodic Theory and Fractal Geometry

Hillel Furstenberg, *The Hebrew University of Jerusalem, Israel*

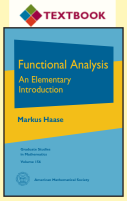
The primary goal in this monograph is to demonstrate how the minute structure of fractals is unfolded when seen in the light of related dynamics.

A co-publication of the AMS and CBMS.

CBMS Regional Conference Series in Mathematics, Number 120; 2014; 69 pages; Softcover; ISBN: 978-1-4704-1034-6; List US$32; AMS members US$25.60; Order code CBMS/120

Applied Mathematics

TEXTBOOK



Functional Analysis

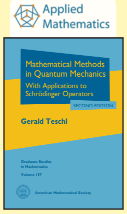
An Elementary Introduction

Markus Haase, *Delft University of Technology, The Netherlands*

This book introduces functional analysis at an elementary level without assuming any background in real analysis.

Graduate Studies in Mathematics, Volume 156; 2014; 372 pages; Hardcover; ISBN: 978-0-8218-9171-1; List US$79; AMS members US$63.20; Order code GSM/156

Applied Mathematics



Mathematical Methods in Quantum Mechanics

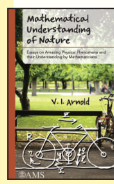
With Applications to Schrödinger Operators, Second Edition

Gerald Teschl, *University of Vienna, Austria*

This book is a brief, but self-contained, introduction to the mathematical methods of quantum mechanics, with a view toward applications to Schrödinger operators. This new edition has additions and improvements to make the presentation more student-friendly.

Graduate Studies in Mathematics, Volume 157; 2014; 356 pages; Hardcover; ISBN: 978-1-4704-1704-8; List US$67; AMS members US$53.60; Order code GSM/157

Applied Mathematics



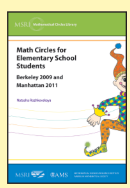
Mathematical Understanding of Nature

Essays on Amazing Physical Phenomena and Their Understanding by Mathematicians

V. I. Arnold

This collection of 39 short stories gives the reader a unique opportunity to take a look at the scientific philosophy of Vladimir Arnold, one of the most original contemporary researchers.

2014; 167 pages; Softcover; ISBN: 978-1-4704-1701-7; List US$29; AMS members US$23.20; Order code MBK/85



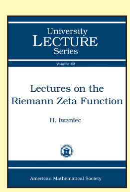
Math Circles for Elementary School Students

Natasha Rozhkovskaya, *Kansas State University, Manhattan, KS*

The book introduces the basics of many important areas of modern mathematics, including logic, symmetry, probability theory, knot theory, cryptography, fractals, and number theory.

Titles in this series are co-published with the Mathematical Sciences Research Institute (MSRI).

MSRI Mathematical Circles Library, Volume 13; 2014; approximately 163 pages; Softcover; ISBN: 978-1-4704-1695-9; List US$25; All individuals US$20; Order code MCL/13



Lectures on the Riemann Zeta Function

H. Iwaniec, *Rutgers University, Piscataway, NJ*

This book provides most basic results about the zeros of the Riemann zeta function; in particular, it contains a proof that a positive density of zeros are on the critical line.

University Lecture Series, Volume 62; 2014; 119 pages; Softcover; ISBN: 978-1-4704-1851-9; List US$40; AMS members US$32; Order code ULECT/62

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