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Commemorating Pólya as Communicator

Exposition: "the act of explaining something: clear explanation . . . Discourse or an example of it designed to convey information or explain what is difficult to understand."—Merriam-Webster Dictionary

In recognition of the importance of good exposition to the SIAM community, SIAM has reconfigured the longstanding George Pólya Prize. Long awarded every other year to recognize outstanding work in, alternately, combinatorics and other mathematical interests of George Pólya, the Pólya Prize is now an annual prize. Every odd-numbered year, beginning in 2015, the Pólya Prize will recognize outstanding exposition. In even-numbered years, the prize will continue to alternate between combinatorial and other mathematical research. The amount that will be awarded in any year is $10,000.

"For his outstanding editorial contributions to applied mathematics," including the founding of Acta Numerica*, Arieh Iserles received the 2014 SIAM Prize for Distinguished Service to the Profession.*

In the 2014 John von Neumann Lecture ("Fast, Accurate Tools for Physical Modeling in Complex Geometry"), Leslie Greengard delivered "a fair and unbiased pitch for doing everything possible in integral equations." Greengard, shown here with SIAM president Irene Fonseca, was recognized for his "transformative contributions to computational science."

In a recent blog post about the new prize (http://blogs.siam.org/putting-a-value-on-expository-writing), SIAM executive director Jim Crowley points out that *SIAM Review* and *SIAM News*, natural homes for good expository writing, always welcome new submissions. The George Pólya Prize for Mathematical Exposition, as described at www.siam.org,

> "may be given for a specific work or for the cumulative impact of multiple expository works that communicate mathematics effectively. The nature of the work may range from popular accounts of mathematics and mathematical discovery to pedagogy to systematic organization of mathematical knowledge."

David Keyes, whose responsibilities as SIAM vice president at large (2006–2009) included oversight of the SIAM prizes, was instrumental in the "partitioning and refocusing" of the Pólya Prize, motivated in part by his admiration for what is probably George Pólya's best-known example of expository excellence. As Keyes wrote to *SIAM News*:

> "My fondness for Pólya's writings originates from his book *How to Solve It*, which was one of the first that I ordered for the KAUST library. How many math books have sold more than a million copies or been translated into so many languages? One of SIAM's most practical contributions to the profession could be to inspire us to produce more manuscripts like Pólya's that endear math to the masses. This prize could help solve a daunting problem in STEM education. As Pólya himself said: 'If you can't solve a problem, then there is an easier problem you can solve: find it!' Congratulations, SIAM. You found one."

At *SIAM News*, we can't think of a better setting than the "post-Annual Meeting" issue to draw readers' attention to the new prize. As shown in photos throughout this issue, the 2014 SIAM Annual Meeting, held in Chicago, July 7–11, offered abundant examples of outstanding communication in many forms—from the I.E. Block Community Lecture to the 2014 John von Neumann Lecture, and from the "poster blitz" to talks given by recipients of best-paper prizes.

The 2014 Student Paper Prizes were awarded in Chicago to, from left, Sean Cornelius (Northwestern University), Carlos Fernandez-Granda (Stanford University), and Iain Smears (University of Oxford).

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2014 Annual Meeting

Devising Optimization Algorithms for Machine Learning

By Jorge Nocedal

Optimization is one of the pillars of statistical learning. It plays a crucial role in the design of "intelligent" systems, such as search engines, recommender systems, and speech and image recognition software. These systems, which embody the latest advances in machine learning, have made our lives easier. Their success has created a demand for new optimization algorithms that, in addition to being scalable and parallelizable, are good *learning algorithms*. Future advances, such as effective image recognition, will continue to rely heavily on methods from statistics and optimization.

It was not supposed to be that way. I remember being dazzled by the promise of artificial intelligence depicted so brilliantly in the 1968 movie *2001: A Space Odyssey*. HAL, the personal assistant, had human-like intelligence and even personality. Forty-five years later, that promise has not been realized. Very few people would consider Siri a real personal assistant. Instead of using classical artificial intelligence techniques, the intelligent systems mentioned above rely heavily on statistical learning algorithms. Combined with powerful computing platforms, very large datasets, and expert feature selection, the algorithms form the bases for innovative learning systems that are accessible to the public through "the cloud." Improvements continue at a rapid rate.

To give an example, in the last few years, deep neural networks have revolutionized speech recognition. Table 1 shows the word error rate for three standard speech recognition tasks, as reported by three leading research centers. The results obtained with deep neural nets are compared with those from earlier systems based on Gaussian mixture models. Although the reduction in error rate with DNN may not seem surprising to an outsider, it is greater than the advances made in the preceding 10 years.

Task	GMM WER (%)	DNN WER (%)	Research Group
Switchboard	27.4	18.5	Microsoft
YouTube	52.3	47.6	Google
Broadcast News	17.2	14.9	IBM

Table 1. *Word error rate (WER) for three speech recognition tasks. GMM, Gaussian mixture models. DNN, deep neural nets. Data provided by Brian Kingsbury from IBM.*

Deep neural networks are highly nonlinear, and optimizing their parameters represents a formidable problem. A typical neural network for speech recognition has between five and seven hidden layers, with about 1000 units per layer, and tens of millions of parameters to be optimized. (See Figure 1.) Training requires up to 1000 hours of speech data, representing on the order of 100 million training examples. Optimizing (i.e., training) a neural network of this size takes two weeks on a supercomputer.

The new challenge that arises for optimization methods in the machine learning setting, as mentioned earlier, is that they must be good learning algorithms. By this I mean that the hypothesis functions they define must make good predictions on unseen data; it is not enough that the optimization methods perform efficiently on a particular training set. The new

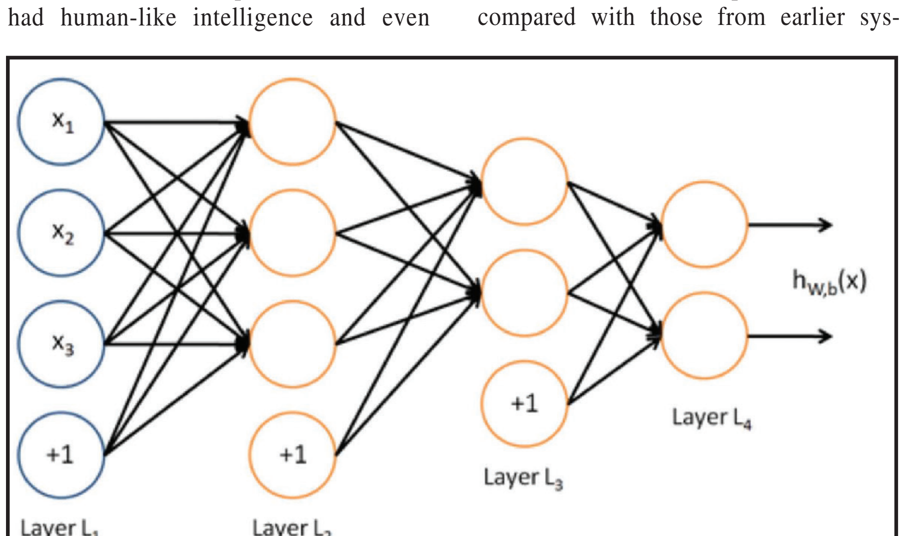

Figure 1. *A neural network for speech recognition.*

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Machine Learning

continued from page 1

demands imposed on optimization algorithms in the context of machine learning—large scale, stochasticity, nonlinearity, parallelism, good generalization—have led to a burst of research activity.

Supervised Learning

This research is best described in the context of supervised learning. We are given a training set of size N; each training point (x_i, z_i) consists of feature information x_i (think of an acoustic frame 70 milliseconds long) and a correct label z_i (the word or phoneme) associated with it. We define a prediction function h that depends on a parameter w, e.g.,

$$h(w;x) = w^T x \qquad (1)$$

that makes good predictions on unseen data, $\hat{x}$, i.e.,

$$\hat{z} = w^T\hat{x} \quad \text{and} \quad \hat{z} \approx z, \quad \text{with } z \text{ being the correct label.} \qquad (2)$$

(The prediction function h could be more complex, as is the case with neural networks.) We also require a loss function ℓ that measures the deviation between a prediction and the data; it could be defined as the square loss, a hinge loss, or a logistic function.

The objective function in supervised learning is typically the sum of error terms, each corresponding to a training point (x_i, z_i):

$$F(w) = \frac{1}{N}\sum_{i=1}^{N} \ell(h(w;x_i), z_i). \qquad (3)$$

The goal of the optimization method is to minimize this function, with respect to the model parameters w.

Stochastic vs. Batch Methods In Machine Learning

Optimization methods for machine learning fall into two broad categories: stochastic and batch. A prototypical batch method first chooses a sufficiently large sample of training examples to define (3), and minimizes F using a standard gradient-based method. The iteration has the familiar form $w_{k+1} = w_k - \alpha_k \nabla(w_k)$, where α_k is a step-length parameter. Although this method is convenient in that it can make use of many established optimization methods, the majority opinion is that it is not the best learning algorithm.

The method of choice in most large-scale machine learning applications is the stochastic gradient method proposed by Robbins and Monro in 1951. A typical implementation chooses *a single* training point (x_j, z_j) at random, and updates the parameters of the model through the iteration

$$w_{k+1} = w_k - \alpha_k \nabla \ell\,(h(w_k\,; x_j), z_j). \qquad (4)$$

In other words, the method acts as if only one training point is revealed at a time. This is not a descent method (the update can easily yield an increase in the objective F); rather, it is a Markov chain method, and w_k is a random variable. Because the gradient estimate is poor (it is correct only in expectation), the step length α_k must satisfy $\alpha_k \to 0$. Under normal conditions, one can show convergence in expectation,

$$|\mathbb{E}[F(w_k)] - F(w^*)| \leq C/k, \quad \text{for some constant } C > 0, \qquad (5)$$

where $F(w^*)$ is the optimal value of (3).

This sublinear rate of convergence can be shown to be optimal for iterations that employ only first-order information in this manner. Now, this optimal rate $O(1/k)$ is achieved also for testing cost (i.e., for generalization error) as long as each data point is seen only once. Other optimization algorithms do not enjoy this property: A given rate of convergence for training cost does not translate into the same rate for testing cost.

In addition, Bottou and Bousquet [1] argue persuasively that when estimation and optimization error are taken into account, the stochastic gradient method has better work complexity bounds than the batch gradient method. By work complexity we mean the total amount of computational effort to reach a given level of accuracy. These arguments, together with ample computational experience, seem to settle the question in favor of the stochastic gradient method, and might suggest that there is little room for improving the optimization process.

"Semi-stochastic" Methods

The question is far from settled, however. The arguments given above assume a sequential computational setting, but everything changes in a parallel setting. The stochastic gradient method is particularly difficult to parallelize [7], whereas batch methods are not. Moreover, the complexity analysis does not consider newly developed methods that, neither purely stochastic nor purely batch, are sometimes called *semi-stochastic*.

One method of this type gradually increases the size of the sample S_k used to define the gradient estimate in iteration (4), which is now given by

$$w_{k+1} = w_k - \alpha_k \frac{1}{|S_k|}\sum_{i\in S_k} \nabla \ell\,(h(w_k\,; x_i), z_i). \qquad (6)$$

These methods emulate the stochastic gradient method at the start, but evolve toward the batch regime. It has been shown that this approach enjoys work complexity at least as good as that of the stochastic gradient method [3,6] provided that $|S_k|$ increases geometrically with k.

A semi-stochastic method of a different type achieves variance reduction by computing the full batch gradient periodically, and then updating it gradually [4]. At the beginning of a cycle where the current estimate of the solution is $\tilde{w}$, the algorithm computes $\nabla F(\tilde{w})$. Then, for the next m iterations an integer $j \in \{1, \ldots N\}$ is chosen at random and this vector is updated as

$$v_k = \nabla \ell(h(w_k; x_j), z_j) - \nabla \ell(h(\tilde{w}; x_j), z_j) + \nabla F(\tilde{w});$$

v_k is used in lieu of the gradient in the iteration (4).

The last line of research I would like to highlight (and there are several more!) focuses on the design of stochastic and batch methods that emulate Newton's method. Contrary to the conventional wisdom in the machine learning community that only first-order optimization methods are practical in large-scale learning, methods that incorporate Hessian information in a judicious manner can be quite effective. A batch approach that has proved successful for both logistic regression and neural nets is a matrix-free Newton-CG [2,5], where the Hessian is *sub-sampled*, i.e., formed using only a small percentage (say, 0.01%) of the sample points appearing in (3). And very recently, a fully stochastic quasi-Newton method has been developed, motivated by the fact that the constant C in (5) depends on the square of the condition number of the Hessian. The quasi-Newton approach is designed to diminish this harmful effect of the condition number on the convergence rate.

It is too early to tell which of these new optimization methods will become established techniques in machine learning. The interested reader can follow this research in, for example, *SIAM Journal on Optimization* and the proceedings of both the Neural Information Processing Systems conferences and the International Conference on Machine Learning.

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Developmental Learning of Sensorimotor Models for Control in Robotics

By Pierre-Yves Oudeyer

Robotics is evolving today toward applications in which robots enter into everyday life and thus need to be able to interact with non-engineers; robots that assist people with disabilities in their homes are an example [5]. For such applications, robots must be able to manipulate and use objects in the human environment that cannot be known and modelled beforehand by engineers. For reasons of safety and energy efficiency, the use of soft materials and soft actuators is flourishing in these applications [12]; difficult control problems arise, however, because the dynamics of these soft materials are difficult to model analytically. For these reasons, a crucial goal has become the development of learning methods that allow robots to acquire models of the dynamics of their own bodies and their interactions with new objects.

Researchers working on these learning methods face several challenges: (1) the sensorimotor spaces to be modelled are high-dimensional and strongly nonlinear; (2) learning should occur incrementally through physical interaction, as it is impossible to anticipate all situations "in factory"; (3) data has to be acquired autonomously through sensorimotor experiments that are costly in time and energy. It is not possible to rely on pre-built databases containing learning examples, fed in a batch manner to statistical inference algorithms. A major challenge is to find ways to acquire data efficiently: Learning by randomly chosen experiments is bound to fail; recently, developmental learning methods, partially inspired by infant development, have been studied to guide the process of data acquisition [10].

Several strands can be distinguished among learning methods. Methods of active learning that allow the choice of experiments that maximize model improvement combine advanced empirical evaluation of information gain [3] with stochastic action-selection algorithms [8]. These methods have made possible, for example, the acquisition of omnidirectional locomotion skills in a compliant robot on slippery surfaces [3]. Other methods have exploited the ability of (non-engineer) humans to learn by imitation. Demonstration of a skill by a human is used as input to a stochastic optimization method in an effort to adapt to the physical particularities of the robot; the idea is to infer either which aspects of the demonstrated skills are relevant [2,4] or the hidden objective through inverse reinforcement learning [1]. The combination of active autonomous learning and learning by imitation was recently approached through methods allowing the active choice of learning strategies [9]. Developers of methods making up other strands have explored how processes of maturation, progressively freeing degrees of freedom in the motor and perceptual spaces, could accelerate learning in large spaces [7].

Finally, a topic of central importance is the co-design of body morphologies, controllers, and learning methods: The integrated design of body geometry, distribution of mass, and material properties can indeed considerably facilitate the acquisition of control skills [11]. This explains recently released robotic platforms that allow the combination of rapid prototyping of body morphologies (based on 3D printing) and control methods [6].

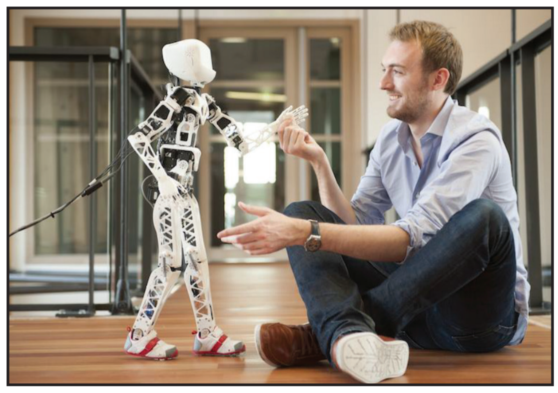

Figure 1. *The design of humanoid robots for rich, safe interactions with everyday environments and humans requires techniques for online learning of sensorimotor and social control skills. The open-source 3D-printed humanoid robot Poppy shown here allows systematic experimentation in the integration of such learning methods with adequately designed morphologies (http://www.poppy-project.org; photo Inria/H. Raguet).*

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Everyday Problems "Shot Through with Mathematics"

How Not To Be Wrong: The Power of Mathematical Thinking. *By Jordan Ellenberg, Penguin Press, New York, New York, 2014, 468 pages, $27.95.*

BOOK REVIEW

By Ernest Davis

In *How Not To Be Wrong*, Jordan Ellenberg takes on the daunting task of explaining to a lay audience why they should care about mathematics. In many ways, he succeeds brilliantly. The book is entertaining, informative, wise, and extremely well written. Ellenberg's specific objective is to explore the interaction of mathematical reasoning and common sense, and to show how mathematics is a powerful extension of common sense. "Math is like an atomic-powered prosthesis that you attach to your common sense, vastly multiplying its reach and strength," he writes. "The problems that we think about every day—problems of politics, of medicine, of commerce, of theology—are shot through with mathematics."

The most visible interactions of mathematics and common sense in recent years, and the most common applications of mathematics to problems of politics, commerce, and medicine, have been in probability and statistics; accordingly, about two-thirds of Ellenberg's book deals with the basic issues in those areas. He also considers the dangers of mindless linear extrapolation, the pitfalls in reporting a percentage of a sum formed of both positive and negative terms, the difficulties of finding a good voting scheme, and formalism in mathematical philosophy. A wide range of mathematical topics, including projective geometry, finite geometry, Lobachevskian geometry, error-correcting codes, the distribution of primes, the theory of the reals, and the non-standard theory of the reals, make cameo appearances.

Ellenberg's arguments require no mathematical background beyond arithmetic and very basic geometry. The many diagrams are almost all crudely hand-drawn, a very wise decision. The book includes only one non-trivial proof, but that one—Barbier's solution of Buffon's needle problem—is a beaut. At his best, Ellenberg is about as good a science writer as any I've come across. He achieves his best in the first chapter, with a story about Abraham Wald.

Advising the Army Air Force during World War II, Wald had the task of recommending sites on fighter planes where additional armor should be placed. The key data was the relative frequency of bullet holes in different parts of the planes after they returned from their missions. On average, the numbers of bullet holes per square foot were 1.11 in the engine, 1.73 in the fuselage, 1.55 in the fuel system, and 1.85 in the rest of the plane. What the data showed, Wald realized, was not that the engine was hit less often, but rather that planes hit in the engine were less likely to come back; the engine was thus the most important place to add armor.

In terms of pure writing technique, Ellenberg's pacing here is particularly admirable; he pulls off the trick of moving the story along, while making it seem as if he had all the time in the world. The writing is equally impressive—both crystal clear and captivating—in many other sections as well.

In describing the book as "wise," what I mean is that it has many of the intellectual virtues that I most value. Ellenberg is strikingly fair-minded on contentious topics; for instance, his account of the debate between frequentist and Bayesian statistics is as balanced as I have seen. (I think he could say more about the difficulties, in the Bayesian approach, of choosing a hypothesis space and assigning priors, but that's just a hobbyhorse of my own.) He has a strong sense of history, and a deep knowledge of it. He deals fairly with historical figures, making a serious effort to understand why they took the approaches and reached the conclusions they did, in a manner that brings to mind Stephen Jay Gould's essays. Ellenberg is very aware of the limitations of mathematical approaches, the meaninglessness of overly precise numbers, the futility of assigning a number when all that exists is a partial ordering. He decries the cult of the genius in mathematical mythology. His taste in deciding when to put himself into the story is very good.

The book does have flaws. The most conspicuous arises from Ellenberg's tendency to go on too long, sometimes much too long. He would have benefited from a more hard-hearted editor. An interminable story about MIT students and other groups who regularly made money from a Massachusetts lottery goes on for forty pages, and another about finding predictions from letter patterns in the Hebrew Bible gets twenty pages; two pages each would have been more than enough. The reader cannot safely skip these two chapters, though: The former contains, as a digression, the beautiful proof of Buffon's needle problem, the latter an important discussion of the Baltimore stockbroker scam.

In a similar way, the book sometimes goes beyond its mandate, in ways that I find unhelpful. I do not think that there is anything to be learned from comparing Antonin Scalia's formalist view of law with Hilbert's formalist view of mathematics;* learning from the comparison, at the least, would require analysis much deeper than possible in a book like this one. In fact, I would have cut the entire chapter on mathematical foundations, which covers well-worn ground and does not contribute to the question of how not to be wrong.

A deeper problem is that the book does not exactly do what it sets out to do. As pointed out earlier, the ostensible aim is to show how math extends common sense. Most of the examples in the book, however, center on cases in which multiple mathematical arguments can be made; often, adjudication is via common sense rather than more mathematics.

To a large extent, therefore, the subject is as much "How invalid use of mathematics can confuse you" as "How correct use of mathematics can empower you." (In some respects, the book is an update of Darrell Huff's sixty-year-old classic *How to Lie with Statistics*.) Of course, this itself is an enormously important subject; but the discrepancy between the stated aim and the actual contents leaves the reader a little confused as to what has been accomplished.

Many of the debates necessarily end up unresolved. The book's last chapter is a defense of the wisdom of being in doubt. Ellenberg contrasts quotes from two public figures. First, Theodore Roosevelt:

> "It is not the critic who counts; not the man who points out how the strong man stumbles, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena . . . who errs, who comes short again and again because there is no effort without error and shortcoming."

The second quote is from John Ashbery: "For this is action, this not being sure." Ellenberg sides with Ashbery.

I have mixed feelings. Skepticism and intellectual caution are valuable qualities, particularly in these days of ubiquitous hype, but it is important to recognize their limitations. It is, after all, very easy not to be wrong by opting for the expedient of being too wise to commit to any answer. If one relies on this too much, one can end up like Gattling in Stephen Potter's *Lifemanship*:

> "[Gattling] was one of the most ignorant and ill-educated men I have ever met, and it was therefore always a particular pleasure to hear him say, to a perfectly ordinary question, 'I don't know' slowly, kindly, and distinctly. He was able to indicate, by the tone of his voice, that although he knew practically everything about practically everything, and almost everything about this really, yet the mere fact that he knew such a tremendous lot about it made him realise, as we couldn't possibly, that the question was so inextricably two-sided that only a smart-Alec would ever dream of trying to pass judgement either way."

These complaints aside, the book is a splendid accomplishment, and very well worth reading, whatever your level of expertise. I learned a lot, and got a clearer perspective on all kinds of things—writing and teaching technique, history and biographical anecdotes, fallacies, social science, even a little math—and had a very enjoyable time in the process.

*As Leo Corry points out in *David Hilbert and the Axiomatization of Physics (1894–1905)*, Hilbert was by no means as one-sidedly formalist as he is sometimes portrayed. He was very much engaged with the axiomatization of physics—it is Hilbert's 6th problem—and that can hardly be a purely formalist undertaking.

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The Mathematical Legacy of Martin Gardner

By Elwyn Berlekamp

As a high school student in the late 1950s, I became an ardent follower of Martin Gardner's monthly "Mathematical Games" column in *Scientific American*. I continued to read it for many years. It wasn't until the 1970s when I was a professor that I came to realize how many other mathematicians had also been influenced by him.

Gardner's thought-provoking columns required almost no prerequisites. He often posed a problem, a puzzle, a trick, or an effect that seemed paradoxical. Yet sufficient thought usually led the reader to a joyous "Aha!" moment when the resolution became clear. There was a bit of an addictive quality to these intellectual "Eureka!" exclamations. Success bred the quest for more success, which then led to a productive and joyous cycle of continual progress.

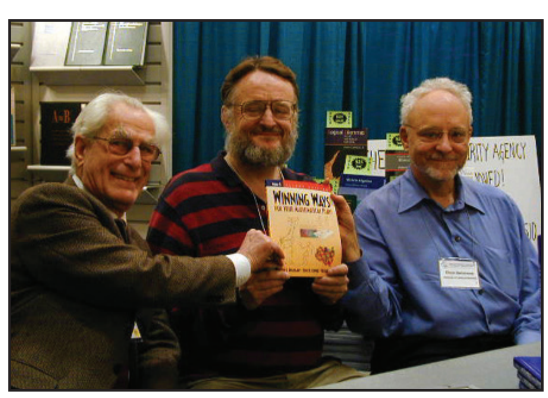
Gardner answered postal correspondence from his many readers. In 1960, I learned that a fellow MIT student named William L. Black had invented a Gardner-like game, which we called the Game of Black. I solved it and sent a note about it to Martin Gardner. To my delight and surprise, he published it. It was the first time I had seen my name in print in such a prestigious setting.[1]

It was in Gardner's columns that I first learned of the popular early-20th-century writings of Henry Dudeney[2] and Sam Loyd[3], which publicized the impartial game of Kayles[4] and the solution to it written by Richard Guy and Cedric A.B. Smith.[5]

Partly because of what I had read about them in Martin Gardner's columns, I was appropriately awestruck in the 1960s when I first met Sol Golomb and then Richard Guy, each of whom had a large influence on my subsequent work. Richard invited me to Calgary to give a colloquium on the game of Dots-and-Boxes and its relationship to Kayles. The talk got an enthusiastic reception, after which I pursued research on other mathematical games with increased vigor.

In 1969 Richard introduced me to John Horton Conway, and the three of us immediately began collaborating on a book that eventually became *Winning Ways for Your Mathematical Plays* (WW). In the 1970s, I joined Conway in some of his many visits to Gardner's home on Euclid Avenue, in Hastings-on-Hudson, New York. Gardner soon became an enthusiastic advocate of our book project, and he previewed various snippets of it in his *Scientific American* columns. Some of his readers became students in courses taught by each of us, and/or thesis students under the supervision of one of us.

Both the breadth and the depth of combinatorial game theory grew, and we began to branch out in somewhat different directions. In his book *On Numbers and Games,* Conway introduced "surreal numbers," combining and superseding classical works of Dedekind and Cantor. Time marched on, and by 1982, when the first edition of our WW was published, Gardner was retiring from his *Scientific American* column. Readers viewed his retirement as a big setback. In 1993, in an effort to rekindle their enthusiasm, Tom Rodgers organized the first "Gathering for Gardner." At this event, many of Martin's fans—mathematicians, magicians, puzzlers, skeptics, and others—gathered in his honor for several days in Atlanta. A second such gathering was held three years later, after which it became a biennial event. The eleventh G4G was held March 19–23, 2014.



Martin Gardner's influence on (from left) Richard Guy, John Conway, and Elwyn Berlekamp extended to an enthusiastic recommendation for their book Winning Ways for Your Mathematical Plays *("the greatest contribution of the 20th century to the burgeoning field of recreational mathematics"). Courtesy of Alice Peters.*

Research on mathematical games thrived after the publication of WW. Led by Aviezri Fraenkel, studies of various mathematical games resulted in refinements of the algorithmic complexity classes used in theoretical computer science. Conferences on combinatorial game theory led to the publication of several volumes of mathematical results. The first of these, *Games of No Chance*, included Fraenkel's survey of the subject and an early version of his selected bibliography, which already contained 666 entries. Many of these new results were included in the second edition of *Winning Ways*, published by A.K. Peters in four volumes conveniently dated 2001, 2002, 2003, and 2004. *Games of No Chance* was followed by *More Games of No Chance* and *Games of No Chance III*. In 2007, Michael Albert, Richard

See **Gardner** *on page 7*

[1] *Scientific American*, October 1963.

[2] *Scientific American*, June 1958.

[3] *Scientific American*, August 1957.

[4] *Scientific American*, February 1967.

[5] R.K. Guy and C.A.B. Smith, in Proceedings of the Cambridge Philosophical Society, 52: 1956, 516–526.

The SIAM Board and Council at Work

TALK OF THE SOCIETY
By James Crowley

The July 2014 meetings of the SIAM Council and Board were unusually busy, with full agendas and lengthy debates. As many readers will know, the Council deals with scientific issues and future directions for SIAM. An important example is oversight of the journals and conference programs, with regard to the scope, mission, and place of the journal or conference within its field. The Council delegates much of the groundwork in these areas to committees that report back to it. Irene Fonseca, as SIAM president, chaired the Council meeting.

The Board of Trustees is responsible for strategic directions and the finances of the society. The Board chooses a chair each year from its elected members; Tim Kelley, the current Board chair, ran the meeting in Chicago.

Each body considered a full slate of issues. Some overlapping issues were taken up by both, each from its own perspective. On the agendas were proposals for new activity groups, for a new regional section, and for a new journal. Also proposed were changes in prize rules and to the Fellows program. The new items that were adopted are briefly described below.

Members of the 2014 class of SIAM Fellows were recognized at the SIAM Annual Meeting in Chicago. In attendance were (from left): Valeria Simoncini, Mikhail Shashkov, Leah Edelstein-Keshet, Bengt Fornberg, Suncica Canic, Inderjit S. Dhillon, Omar Ghattas, Dorit S. Hochbaum, Yuriko Yamamuro Renardy, and Peter J. Olver.

New SIAG, SIAM Section

Both the Board and the Council approved creation of the SIAM Activity Group on Education. The petition, which will be posted on the SIAM website, was approved after extensive discussion. SIAG/Education will begin operation as soon as practical, with Peter Turner, whose term as vice president for Education ends this year, as the first chair.

SIAGs—both proposed and existing—were the focus of several other discussions as well. A theme that emerged was a reminder that SIAGs are to serve the mission of SIAM: to promote mathematics (and/or computational science) *and its application*. As Irene Fonseca is fond of saying: We should not forget either the "I" or the "A" in SIAM's name.

Regional sections being the responsibility of the Board alone, the petition to create a mid-American section of SIAM was taken up and approved by the Board. SIAM tends to take a "bottom-up" approach to regional sections and moves to create new ones only on the request of members in a given region. To dispel any uncertainty about the location of "mid-America," the new section that won Board approval covers the states of Arkansas, Colorado, Iowa, Kansas, Mississippi, Missouri, Nebraska, and Oklahoma. The petition specified the initial slate of officers: Xiaoming He, Missouri University of Science and Technology; Stephen Pankavich, Colorado School of Mines; Erik Van Vleck, University of Kansas; and Xiu Ye, University of Arkansas at Little Rock.

The Board also approved an expanded charge for the Committee on Section Activities, enlarging its responsibility for oversight and reporting on section activities, as well as sunsetting sections and reviewing proposals for creating new ones. Details about the new committee charge will be posted on the SIAM website.

Rachel Levy, editor-in-chief of the undergraduate research journal SIURO, becomes SIAM vice president for education in January 2015, succeeding Peter Turner. Having served two terms as vice president for education, Turner is founding chair of the newly created SIAG on Education.

Richard James, one of two recipients of the 2014 Theodore von Kármán Prize, accepted the prize certificate from SIAM president Irene Fonseca. Honored for his contributions to materials science and mathematics, James was cited more specifically for "his seminal work with John Ball on shape memory alloys, his more recent work with Gero Friesecke and Stefan Müller on a nonlinear Korn inequality that played an essential role in the successful rigorous derivation of nonlinear plate theories, and his very recent discovery and analysis of low-hysteresis shape memory alloys." Not present in Chicago was Weinan E, the second honoree, who was cited for "his deep mathematical contributions to fundamental questions in physics."

SIAM Awards Finetuned

The Major Awards Committee, chaired by Daniel Szyld, SIAM vice president at large, proposed several changes to the Fellows program. Both the Council and the Board approved revised submission requirements—in the future, nomination packages will require a single letter of nomination from all three nominators and exactly two letters of recommendation from people other than the nominators. The aim is greater homogeneity among nomination packages, which should make the decision process more straightforward for the Fellows Selection Committee. The Council and Board also agreed that the FSC should meet in person at least once in the course of the decision process. Expanded guidelines for nominators and letter writers will be posted on the SIAM website when available.

Pam Cook, SIAM president-elect, has taken on the task of collecting the wisdom of past Fellows Selection Committees and is writing guidelines for future chairs of the committee. The Council looked into possible changes to eligibility rules for the Fellows program (years of membership required, time in the profession) but will await further deliberation by the Major Awards Committee before making any decisions.

As recommended by the Major Awards Committee, the Council and Board approved an increase in the minimum award size for any of the SIAM Major Awards to $2000 (the change does not affect SIAG prizes or prizes joint with other societies). Also approved were changes to the specifications of several SIAM prizes. As amended, the George Pólya Prize is given for "a significant contribution in mathematics as evidenced by a refereed publication." (See article on page 1 about the new category established in 2013 for the Pólya Prize.) The Theodore von Kármán Prize specification includes a revised statement: "The award is given to a single individual for a significant achievement or for a collection of such achievements."

Outside the Formal Agendas

Of course, many of the valuable contributions of the Council and Board stem not

See **Board and Council** *on page 8*

Professional Opportunities

Send copy for classified advertisements to: Advertising Coordinator, SIAM News*, 3600 Market Street, 6th Floor, Philadelphia, PA 19104–2688; (215) 382–9800; fax: (215) 386–7999; marketing@siam.org. The rate is $2.85 per word (minimum $350.00). Display advertising rates are available on request.*

Advertising copy must be received at least four weeks before publication (e.g., the deadline for the November 2014 issue is September 30, 2014).

Advertisements with application deadlines falling within the month of publication will not be accepted (e.g., an advertisement published in the November issue must show an application deadline of December 1 or later).

Students (and others) in search of information about careers in the mathematical sciences can click on "Careers and Jobs" at the SIAM website (www.siam.org) or proceed directly to

www.siam.org/careers

Institute for Advanced Study

School of Mathematics

The School of Mathematics at the Institute for Advanced Study, in Princeton, New Jersey, will have a limited number of memberships with financial support for research during the 2015–16 academic year. School term dates for 2015–16 are: Term I, Monday, September 21 to Friday, December 18, 2015; Term II, Monday, January 11 to Friday, April 8, 2016. Applicants should note that the school's Term II begins and ends one week later than the rest of the institute's. The school frequently sponsors special programs; however, these programs comprise no more than one-third of the membership so that a wide range of mathematics can be supported each year.

During the 2015–16 academic year, the school will have a special program on geometric structures on 3-manifolds. Ian Agol, of the University of California, Berkeley, will be the Distinguished Visiting Professor. Thurston proposed classification of geometric structures on n-manifolds. While the spectacular geometrization theorem classified the geometric structures on 3-manifolds with compact isotropy group, i.e., locally homogeneous Riemannian metrics, there is a cornucopia of other fascinating structures, such as contact structures, foliations, conformally flat metrics, and locally homogeneous (pseudo-) Riemannian metrics. The goal of this program is to investigate these other geometric structures on 3-manifolds and to discover connections between them. Additionally, it is important to forge connections between geometric structures on 3-manifolds and other geometric constructs, such as gauge theory, PD (3) groups, minimal surfaces, cube complexes, geometric structures on bundles over 3-manifolds, and strengthened structures, such as taut foliations, tight contact structures pA flows, convex projective structures, and quasi-geodesic foliations. Many of these do not even have a conjectural classification (in terms of topological restrictions and moduli), and specific examples are still being constructed.

Applicants must have given evidence of ability in research comparable with at least that expected for a PhD degree but can otherwise be at any career stage. Successful candidates will be free to devote themselves full time to research. About half of the school's members will be postdoctoral researchers within five years of receipt of a PhD. The school also expects to offer some two-year postdoctoral positions.

Applications are invited for up to eight von Neumann Fellowships that are available each academic year; to be eligible for a von Neumann Fellowship, applicants should be at least five, but no more than 15, years after receipt of a PhD. Applicants can also apply for Veblen Research Instructorships, which are three-year positions that were in established in partnership with the Department of Mathematics at Princeton University. These instructorships are offered each year to candidates in pure and applied mathematics who have received a PhD within the last three years. Usually, Veblen research instructors spend their first and third years at Princeton University; these years will carry regular teaching responsibilities. The second year is spent at the institute and dedicated to independent research of the instructor's choice. Applicants interested in a Veblen instructorship position can apply directly at the IAS website, https://applications.ias.edu or through MathJobs, https://www.mathjobs.org/jobs. Applicants applying through MathJobs must also complete an application form at https://applications.ias.edu; however, they do not need to submit a second set of reference letters. Applicants who have questions about the application procedure can e-mail applications@math.ias.edu.

Applications are also invited for two-year postdoctoral positions in computer science and discrete mathematics to be offered jointly with one of the following: Department of Computer Science at Princeton University, http://www.cs.princeton.edu; DIMACS at Rutgers, The State University of New Jersey, http://www.dimacs.rutgers.edu; or the Intractability Center, http://intractability.princeton.edu. For a joint appointment applicants must apply to the IAS, as well as to one of the listed departments or centers, indicating their interest in a joint appointment. The deadline for all applications is December 1, 2014.

The Institute for Advanced Study is committed to diversity and strongly encourages applications from women and minorities.

San José State University

Department of Mathematics and Statistics

The San Jose State University Department of Mathematics and Statistics has four tenure-track assistant professor openings in pure and applied mathematics starting August 2015. Successful candidates must teach undergraduate and graduate courses, maintain an active research program, and supervise graduate students. PhD required by July 2015.

For full consideration, submit all application materials at http://www.mathjobs.org/jobs (job opening ID 22990) by December 1, 2014. See the complete position description at http://www.sjsu.edu/math/employment/tenure-position.

SJSU is an Affirmative Action/Equal Opportunity committed to the core values of inclusion, civility, and respect for each individual.

Read Professional Opportunities online:

jobs.siam.org/

INSTITUTE FOR COMPUTATIONAL ENGINEERING & SCIENCES

The *Institute for Computational Engineering and Sciences (ICES)* at *The University of Texas at Austin* is searching for exceptional candidates with expertise in computational science and engineering to fill several Moncrief endowed faculty positions at the Associate Professor level and higher. These endowed positions will provide the resources and environment needed to tackle frontier problems in science and engineering via advanced modeling and simulation. This initiative builds on the world-leading programs at ICES in Computational Science, Engineering, and Mathematics (CSEM), which feature 16 research centers and groups as well as a graduate degree program in CSEM. Candidates are expected to have an exceptional record in interdisciplinary research and evidence of work involving applied mathematics and computational techniques targeting meaningful problems in engineering and science. For more information and application instructions, please visit: www.ices.utexas.edu/moncrief-endowed-positions-app/. This is a security sensitive position. The University of Texas at Austin is an Equal Employment Opportunity/Affirmative Action Employer.

THE UNIVERSITY OF TEXAS AT AUSTIN

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty Position(s)
Department of Mathematics

The Department of Mathematics invites applications for tenure-track faculty positions at the rank of Assistant Professor in all areas of mathematics. Applications at the rank of Associate Professor or above may also be considered. Other things being equal, preference will be given to areas consistent with the Department's strategic planning.

Applicants should have a PhD degree and strong experience in research and teaching. Applicants with exceptionally strong qualifications and substantial experience in research and teaching may be considered for positions above the Assistant Professor rank.

Starting rank and salary will depend on qualifications and experience. Fringe benefits include medical/dental benefits and annual leave. Housing will also be provided where applicable. Initial appointment will be on a three-year contract, renewal subject to mutual agreement. A gratuity will be payable upon successful completion of the contract.

Application Procedure
Applications received on or before 31 December 2014 will be given full consideration for appointment in 2015. Applications received afterwards will be considered subject to the availability of positions. Applicants for Assistant Professor position should send their curriculum vitae together with at least three research references and one teaching reference to the Human Resources Office, HKUST, Clear Water Bay, Kowloon, Hong Kong. Applicants for Associate Professor position and above should send a curriculum vitae and the names of at least three research referees to the Human Resources Office.

More information about the University is available on the University's homepage at http://www.ust.hk.

(Information provided by applicants will be used for recruitment and other employment-related purposes.)

Senior Health Services Investigator Opportunity

Geisinger Health System is seeking a Senior Health Services Investigator in Geisinger's Institute for Advanced Application (IAA).

We are seeking an accomplished health services scientist at the associate or full professor level with a record of external funding, peer-review publication and program building with expertise in identifying the problems facing healthcare and developing and testing solutions. The candidate will lead a software development team with a focus on creating healthcare software applications from the concept stage to a viable product.

Geisinger's IAA consists of 3 centers, 9 labs, a computational core facility, and an IT trials office. Work is under the direction of Gregory J. Moore, MD, PhD, Chief, Emerging Technology and Informatics, & Director, Institute for Advanced Application.

For more information, please visit geisinger.org/careers or contact: Gregory J. Moore, MD, PhD, c/o Jocelyn Heid, Manager, Professional Staffing, at 800.845.7112 or jheid1@geisinger.edu.

THE CENTENNIAL CELEBRATION GEISINGER 100

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Gardner

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Nowakowski, and David Wolfe published *Lessons in Play*, a wonderful undergraduate textbook in which they introduced and analyzed scores of new games. In 2013, Aaron Siegel's book *Combinatorial Game Theory* introduced several additional major new results, and also provided a clear and concise mathematical summary of nearly all that was then known.

On the more "applied" side, combinatorial game theory found applications to several classical board games, including the ancient Hawaiian game of Konane. In our 1994 book *Mathematical Go*, David Wolfe and I applied combinatorial game theory to late-stage endgames in what for several millennia has been the foremost intellectual board game in East Asia (and arguably in the world). More recently, a dozen of the world's best professional Go players in Korea and China have competed in tournaments of "Coupon Go," a mathematically based version of the game that sheds more light both on real Go endgames and on the related mathematics.

The first three volumes of *Winning Ways* dealt with traditional two-player games of no chance, but the fourth considered one-person games, such as sliding block puzzles. Martin Gardner's "Mathematical Games" columns covered an even wider range of topics, including magic. These helped some students to become professional magicians, others to become professional mathematicians, and some (e.g., Persi Diaconis) to become both.

Some of us view our own mathematical work as both recreational mathematics and "serious" mathematics, but many others try to distinguish between the two. I think that whatever distinctions exist are to be found not in the subject matter, but in the researchers' motivations. Many mathematicians, as well as scientists and historians, agree that much of the best research is primarily driven by curiosity. The distinguishing feature of Martin Gardner's writings is that they encouraged curiosity-driven investigations by people of many ages and at many educational levels. To continue this tradition, following Gardner's death in 2010 the G4G foundation began to sponsor annual "Celebration of Mind" events all over the world on or near October 21, Martin's birthday. In 2013, these events occurred at more than 150 locations on all seven continents. Events like these not only encourage intellectual pursuits, they also increase popular appreciation of mathematics.

Elwyn Berlekamp is professor emeritus at the University of California, Berkeley.

Board and Council

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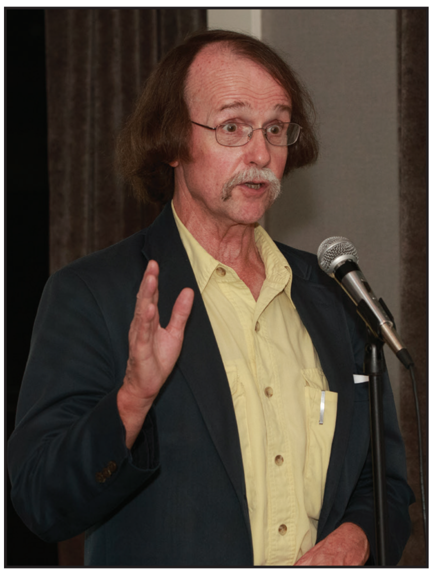

Jim Crowley (right), surprised guest of honor at a dinner held in Chicago to celebrate his 20th anniversary as executive director of SIAM, accepted the congratulations of Tim Kelley, chair of the SIAM Board of Trustees.

just from the formal consideration of proposals but also from the lively discussions ignited during the meetings. Discussions of the SIAM budget or reports from officers on the programs in their areas of responsibility might sound dry to some readers but give rise to many interesting ideas.

Daniel Spielman (left) and Adam Marcus accepted the George Pólya Prize from SIAM president Irene Fonseca at the Annual Meeting in Chicago. They (and Nikhil Srivastava, the third member of their group, who was not in Chicago) were cited "for the introduction and development of the method of interlacing polynomials, and for its use in the solution of the Kadison–Singer problem." (See "Kadison–Singer Problem Solved," SIAM News, *January/February 2014, page 1.)*

How many in the community are aware that SIAM arranges for audio recording/slide capture of invited talks and selected minisymposia at its larger conferences? SIAM Presents, which is hosted on the BlueSky platform, contains hundreds of presentations from SIAM conferences. Board and Council members expressed interest in increasing the visibility of this activity. Recorded talks can now be accessed from the lists of invited speakers on conference programs (and in some cases from the speakers' websites); SIAM is working to make access easier, ultimately via web search.

SIAM provides information to the community through numerous vehicles, including Unwrapped (an email digest); SIAM Connect (short news items accessible from the SIAM home page); a blog (http://blogs.siam.org/); and the print and online versions of *SIAM News*. Many of these feed media outlets like Twitter and Facebook.

In this year's I.E. Block Community Lecture ("Search and Discovery in Human Networks"), Sep Kamvar (center), who has a PhD in scientific computing from Stanford, appealed to the entire audience—both the non-mathematical "community" and the many meeting participants who turned out for the event. He is shown here at the reception following his talk with Margot Gerritsen and Esmond Ng, co-chairs of the organizing committee for the 2014 SIAM Annual Meeting.

A further note on *SIAM News*: We recently updated and redesigned the online version of *SIAM News*. Accessible at http://sinews.siam.org/, it currently contains all the articles that appear in the written version, with some new capabilities (such as embedded video), in a format that is compatible with mobile devices. Please take a look!

In ongoing discussions, the SIAM leadership is looking for ways in which SIAM could better serve industry (and national labs). Ideas in the development stage include an expanded job fair that focuses on non-academic employment, an expanded job board with increased listings, and promotion of internships in industry. More information on these efforts will be released as available; meanwhile, your ideas are welcome.

Readers are encouraged to send comments and suggestions about any of the activities, projects, and plans discussed in this article to Jim Crowley (jcrowley@siam.org).

2014 Annual Meeting

Spotlight on DMS/NSF at Federal Agency Session

Representing the National Science Foundation's Division of Mathematical Sciences at the federal funding panel at the SIAM Annual Meeting in Chicago, Henry Warchall described two new programs and alluded to several ongoing programs of particular interest to the SIAM community. He began with MSII (Mathematical Sciences Innovation Incubator), new in 2014 and presented in a Dear Colleague letter from DMS director Michael Vogelius on April 22.

Henry Warchall, deputy director of the Division of Mathematical Sciences at NSF.

An aim of MSII is to facilitate the co-review and co-funding of multidisciplinary research collaborations involving the mathematical sciences and programs outside DMS. MSII was established to provide "leverage for investments of non-DMS programs in projects that include mathematical scientists" and "a uniform mechanism through which collaborative research teams involving mathematical scientists can request DMS co-review."

The emphasis is on programs of national priority that would benefit from innovative developments in mathematics and statistics, Warchall said, naming as featured MSII programs for 2014 DMREF (Designing Materials to Revolutionize and Engineer our Future) and EaSM (Decadal and Regional Climate Prediction Using Earth System Models). He also advised those in the audience to "keep an eye on optics and photonics," which indeed turned out to be the subject of a July 17 Dear Colleague letter (see below).

From the Dear Colleague letter on MSII:

> "The increasingly important challenges of deriving knowledge from huge amounts of data, whether numerical or experimental, of simulating complex phenomena accurately, and of dealing with uncertainty effectively are some of the areas where the mathematical sciences will play a central role. Other promising areas where mathematical scientists could play larger roles include research on the power grid, the brain . . ."

MSII proposals must be submitted to NSF programs outside DMS.

The second of the new programs Warchall discussed in Chicago is EDT (Enriched Doctoral Training). Designed for academic departments wishing to better prepare their students for non-academic jobs, the program is open to proposals from PhD-granting mathematical sciences departments and from professional organizations. Under the program, departments are encouraged to collaborate with other departments in their institutions or with business, industry, or government organizations.

The other panelist at the Chicago session was Sandy Landsberg of ASCR (Advanced Scientific Computing Research) in the Department of Energy's Office of Science. Look for an article on highlights from her information-rich presentation in a future issue of SIAM News. *Meanwhile, visit http://science.energy.gov/ascr for ASCR news, including current funding opportunities.*

Optics and Photonics at NSF: A Closer Look

As predicted by Henry Warchall at the SIAM Annual Meeting, three assistant directors of NSF (Fleming Crim, Mathematical and Physical Sciences; Pramod Khargonekar, Engineering; and Farnam Jahanian, Computer & Information Science & Engineering) have released a Dear Colleague letter naming research and education in optics and photonics as a key area of interest across the NSF directorates, and encouraging the community to submit innovative proposals relevant to one or more divisions in MPS, Engineering, or CISE.

Topics in two categories are of particular interest for FY 2015:

(1) light–matter interactions at the nanoscale that encompass materials, devices, and systems, such as but not limited to low-loss metamaterials, plasmonics, and quantum phenomena that could impact computation, communication, and sub-wavelength resolution detection/imaging; and (2) novel terabit/second and above communication systems, especially those integrating devices and systems that advance the state of the art in networking, high-performance computing, and computer architecture.

Proposals that would benefit from a joint review can be submitted to a primary program, with secondary programs in other divisions identified in a cover letter.