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The Dawn of the Age of Ignorance and Misinformation

By William I. Newman

There emerged after the Renaissance a remarkable period (beginning around 1650–1700) often called the Age of Enlightenment, when Western Europe was freed from ignorance and misinformation. There evolved a belief that the application of intellectual approaches together with experiments could provide reproducible explanations for essentially all the mysteries of the cosmos. The scientific method had been born. Out of this rationalist milieu emerged the notion that, if we knew all the laws of nature and possessed a machine capable of computing the dynamical evolution of every atom, we would be able to calculate indefinitely into the future the state of all things. In many regards, this perspective established the raison d'être of the scientific community. With overwhelming evidence in support of these ideas, the general population came to accept the outcome of scientific investigations in all things.

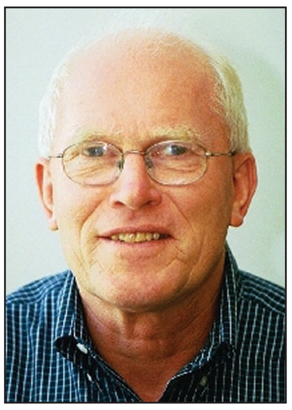
In the last half century, we have witnessed a grave decline in the public's acceptance of scientific evidence and even the scientific method. Postmodernism presented many challenges in academe and, of wider concern, the notion that science is but one of many approaches to problem solving and that "scientific results" are not necessarily better, let alone reliable. During recent weeks, we have witnessed the public's abandonment of science in connection with a number of events. Among them are the Italian trial and sentencing of six seismologists to six years in prison for failing to predict the 2009 magnitude 6.3 L'Aquila earthquake, the warnings issued for Hurricane Sandy and its destructive potential, and the magnitude 7.7 Queen Charlotte Islands earthquake and subsequent tsunami warning. Also portending grave consequences is the public's response to the emergent role of climate change and its effects on humanity.

The underlying complexity of the natural world greatly exacerbates this problem. The Earth is a remarkably complicated place. The interactions of its oceans and atmo-

See **Misinformation Age** *on page 8*

SIAM News Welcomes New Editor-in-Chief

In January, Hans Kaper will officially move into the newly created position of editor-in-chief of *SIAM News*. His very successful trial run as a guest editor of our ICIAM 2011 coverage bodes well for an increasingly lively, well-rounded, and authoritative publication.



A SIAM Fellow (class of 2009), Kaper was named Senior Mathematician Emeritus at Argonne National Laboratory on his retirement in 2008. Many readers will know him from his tenure (2001–2008) as a program director at the National Science Foundation. He is currently an adjunct professor in the Department of Mathematics and Statistics at Georgetown University, and he maintains ties in Illinois as an adjunct professor in the School of Music at the University of Illinois at Urbana–Champaign.

He identifies his current research interest as the application of dynamical systems techniques to the Earth's climate system. In related projects, he is a co-author of the forthcoming SIAM book *Mathematics and Climate*, co-director of the NSF-funded Mathematics and Climate Research Network, and a SIAM representative to Mathematics of Planet Earth 2013. He worked recently with *SIAM News* staff to assemble a new editorial board, whose names appear on page 2.

In recent weeks, an unsettling real-world development—the ruling of an Italian judge in the case of six seismologists on trial for having failed to pinpoint the time of an earthquake that devastated the town of L'Aquila—set Kaper and the new editorial board in motion. A request to William Newman of UCLA for a perspective on the implications of the Italian case rapidly produced the article at the left. This issue, says editorial board member Mac Hyman, "could affect any of our members engaged in using mathematical analysis and models, including computer simulations, to make predictions where there are economic or public health consequences."

Understanding Systemic Risk in Financial Markets

By James Case

Power grids, populations, large companies, banking systems, and other collections of numerous and highly interconnected elements are subject to what George Papanicolaou of Stanford University calls "systemic risk." As he explained in an invited talk at the 2012 SIAM Annual Meeting, each such system is susceptible to a type of "contagion" that, though triggered by seemingly unimportant events, is capable of destroying the whole if allowed to spread unchecked.

Early in the talk, Papanicolaou showed a schematic diagram of the global financial network (see Figure 1). Of course, every country has a financial market of some magnitude, and every such market trades (or can trade) with any other. Many markets and channels, however, are either too small or too faint to show up in a roughly quantitative diagram.

It is easy to imagine a similar diagram in which the spheres would represent major international banks, and the thickness of the connecting edges would represent the level of (net) indebtedness of one to another. In that case the edges would be directed, and the diagram could be used to assess the risk that the insolvency of even a few of the lesser institutions might spread throughout the global banking system. If the data were sufficiently reliable and up to date, it could even identify the banks best reinforced against the spread of insolvency.

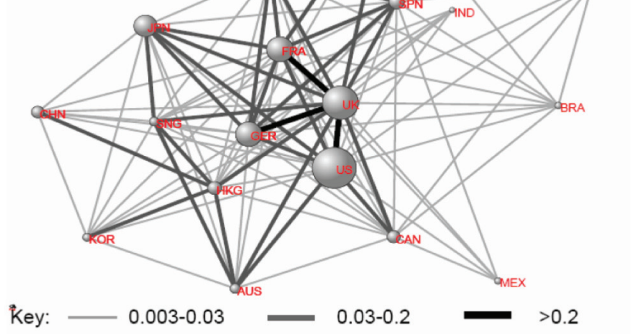


Figure 1. *The global financial market in 2005. The sizes of the spheres represent the magnitudes of the corresponding national financial markets, the thicknesses of the connecting edges the volume of traffic between them. From "Rethinking the Financial Network," a speech given by Andrew G. Haldane, executive director for financial stability, Bank of England, to the Financial Student Association, Amsterdam, April 2009.*

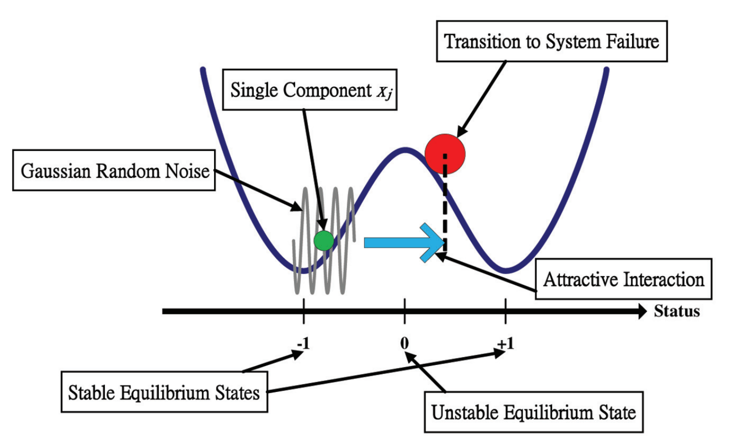


Figure 2. *System failure occurs when ξ(t) migrates from the original potential well (left) to the well on the right.*

Modeling Systemic Risk

Though the modeling of such systems is in its infancy, Papanicolaou argues that certain existing models, developed for other purposes and subsequently analyzed in depth, shed welcome light on the manner in which local and global risks relate to one another. His exhibit A is an outgrowth of the dynamic Curie–Weiss model, developed long ago for the study of phase transitions in materials and studied in detail during the 1980s. At the heart of the model is a "mean-field interaction" between a (potentially large) number of otherwise independent (scalar) state variables and their arithmetic mean. Considerable work has been done in recent years on mean-field models, in large part because they are particularly amenable to in-depth analysis.

The model Papanicolaou presented consists of N linked stochastic differential equations involving a potential function V of a single real variable having just two distinct potential wells. A typical but by no means unique choice would be $V(y) = \frac{1}{4}y^4 - \frac{1}{2}y^2$. The equations are

$$dx_j(t) = -hV'(x_j(t))\,dt + \theta(\xi(t) - x_j(t))\,dt + \sigma dw_j(t);\ j = 1, \ldots, N,$$

where $\xi = (1/N)\Sigma_{j=1}^{N} x_j$ is the arithmetic mean of the individual x_j's and the $\{w_j(t)\}_{j=1}^{N}$ are independent Brownian motions of "strength" $\sigma > 0$. If $\theta = \sigma = 0$, the equations reduce to the familiar $dx/dt = -h$ grad $V(x)$, in which h determines the relaxation time needed to restore equilibrium after a disturbance. If $\sigma = 0$, the quantities $x_j(t)$ remain indefinitely in whichever potential well they started; one of the wells represents the normal (solvent, flourishing) state, the other the failed (insolvent, extinct) state. Alternatively, if $\theta = 0$, the motions are independent. Only if $\theta > 0$ and $\sigma > 0$ are there tendencies toward both herd behavior (Papanicolaou calls it cooperation) and randomness, permitting the quantities $x_j(t)$ to both escape from and return to a particular potential well. The schematic diagram shown in Figure 2 depicts the influences on a single system component $x_j(t)$.

It is known that the empirical risk density $X_N(t) := (1/N)\ \Sigma_{j=1}^{N} \delta_{x_j(t)}(\cdot)$ converges weakly, in probability, as $N \to \infty$, to the

See **Systemic Risk** *on page 4*

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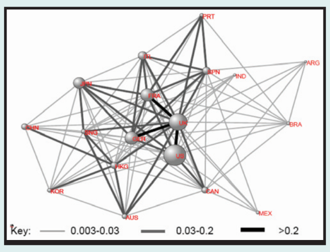

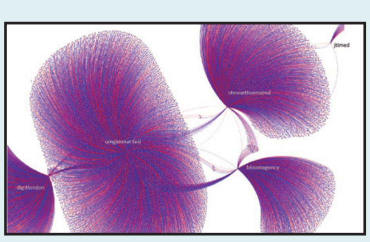

Reflections on a SIAM Presidency

FROM THE SIAM PRESIDENT

By Nick Trefethen

Quietly each autumn, with no advertising and no robocalls, no polling and no pundits, SIAM conducts an election. That is how I was chosen as president, and at the end of this month, my two-year term will come to an end.

Meanwhile, we've all just been through the tumult of another U.S. presidential race, each one seemingly more divisive than the last. It is hard to recognize SIAM's gentle ballots and the Obama–Romney tempest as examples of the same species known as Democracy. My friends may joke about my Secret Service protection and my Big Bird moment, or the King of SIAM. Mostly we just get on with business.

The biggest event of my two years has been one whose consequences are quite unclear at this stage, the "academic spring" of unrest about journal publishing. There are many strands here, some going back a long time, but the event that brought these issues to wide attention was Tim Gowers's initiation of the Elsevier boycott in January. Everybody sees that there is something odd in a world where researchers do most of the editing, refereeing, and typesetting of journal papers, and even distribution is potentially almost free thanks to the Internet, yet publishers make billions of dollars in profit by charging ever-greater fees to libraries. Something must give, and many ideas are being put forward, but this is a story that will mostly play out in the future. So far, SIAM, whose journals are fortunately among the highest ranked and most affordable, has been not much affected, but we all know changes are coming.

In Minneapolis, at his last SIAM Annual Meeting as president, Nick Trefethen catches up with former SIAM president Mac Hyman (2003–2004). The accompanying column, the final installation in Trefethen's thought-provoking two-year run, will be missed by many. Hyman, as a member of SIAM's Committee on Science Policy (and of the newly revamped SIAM News *editorial board), continues to influence SIAM directions.*

Former SIAM president Doug Arnold (2009–10) continues to monitor issues that engaged him as president, mainly in the evolving arena of publishing. In a past-president's address in Minneapolis devoted to mathematics journals, he began by asking "Why should we care?" In answers that touched on plagiarism, journal-ranking measures, the critical role played by refereeing, and the Elsevier boycott, he discussed efforts under way to address the problems. Readers who missed the talk can access it—along with many other invited addresses given at SIAM meetings—at http://www.siam.org/meetings/presents.php.

The founding of *SIAM/ASA Journal on Uncertainty Quantification* this year was a happy new development during my term. The upcoming extension of the option for journal authors to provide online supplementary materials to most SIAM journals will be another good step. Meanwhile, SIAM's undergraduate publication SIURO has become well established.

Readers know that a project of interest to me has been SIAM's attempt to reduce times for assessing manuscripts, our target being to cut the time from submission to acceptance, averaged over all journals, from 12.8 to 8 or 9 months. The new procedures to encourage this change have been coming into place, but it is too early to know how successful they will be.

The Trefethen administration saw the 100th SIAM student chapter and expansion of the student chapter program outside the U.S.—excellent! The third and fourth classes of SIAM Fellows were elected, adding to a growing list of outstanding people (google SIAM Fellows to see what I mean). SIAM began to offer its books electronically, with e-books available first in packages to institutions, then as individual titles. Attendance at conferences has grown, and next February's CS&E conference in Boston will be a record-breaker. There were worries about science funding, mixed with the knowledge that it could have been worse, and worries about mathematics education in the U.S. and abroad.

Apart from my SIAM duties, this has been a busy time for me personally as I have published two books (the *Index Cards* and *Approximation Theory and Approximation Practice*), watched the Chebfun software project begin to be known around the world, marvelled at Oxford's glamorous new mathematics building, and married Kate in a ceremony in our two colleges, Somerville and Balliol.

Here in Britain we happily remember the 1980s sitcom "Yes Minister," about the hapless minister Hacker of the Department of Administrative Affairs, whose attempts to change the world are undone by the machinations of the civil servants supposedly employed to help him, led by the ingenious Sir Humphrey Appleby. SIAM is nothing like this. Our civil service, based in Philadelphia, is an extraordinarily dedicated group of 70 people who maintain SIAM's high standards for books, journals, conferences, and public engagement. Like Sir Humphrey, SIAM's executive director Jim Crowley is a man of exceptional ability and preternatural calm who knows his organization inside out and has seen presidents come and go; but there, thank goodness, the resemblance ends. Thank you for everything, Jim.

On January 1, Nick Trefethen will hand over the SIAM presidency, "with confidence," to Irene Fonseca, shown here with another former SIAM president, Marty Golubitsky (2005–2006).

We are told that the two-party system is good for politics, but mercifully, it doesn't operate in applied mathematics societies. My predecessor, Doug Arnold, has been nothing but a help to me, and it is good for all of us that he has remained engaged in some of the SIAM issues that concern him, such as plagiarism, journal rankings, and open access. (How would Barack have liked it if George W. had offered to help?) Quietly in January, I will hand over this remarkable organization with confidence to my successor, Irene Fonseca.

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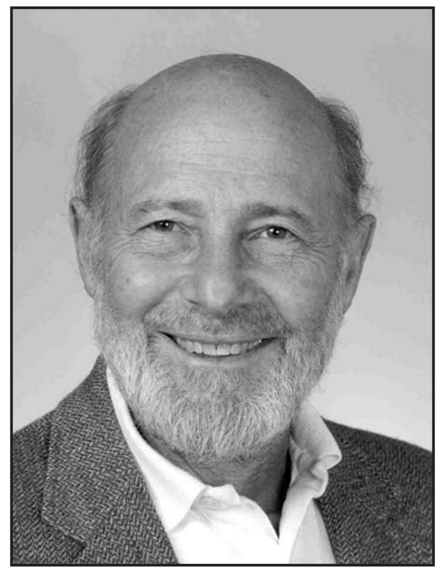
And the Ig Nobel Goes to . . . Joseph B. Keller

By L. Mahadevan

Joe Keller's contributions to the mathematical sciences have led to many honors, including the National Medal of Science and the Wolf Prize for Mathematics. Looking at his work, it is possible to pick out certain long threads that serve as unifying themes. For example, there are the foundational contributions in the domains of asymptotic analysis, perturbation methods, and hybrid numerical–analytical methods, and their deployment over a very wide range of application areas, including wave propagation and quantum, statistical, and continuum mechanics in both deterministic and stochastic settings. But no less important is his choice of problems, and indeed this rare combination of tool creation and elegant problem-solving at the highest level is perhaps the defining characteristic of his work as a mathematician–scientist.

Last month, in the riotous ceremony that accompanies the annual awarding of the Ig Nobels, he was also recognized for his contributions to the funny sciences, twice (he may well be the first double winner). The first of his Ig Nobels corrected an omission (dating from 1999) for explaining the teapot effect and the second for work published in 2010 on the swaying of ponytails (shared with a group from the UK who calculated the shape of a ponytail). And what precisely were the prize-winning contributions?

Anyone who has poured tea from a kettle knows to be wary of the dribble along the spout that can ruin everything. Most scientists, asked to explain this effect, will mumble something about surface tension . . . NOT! Inspired by experiments of the rheologist Marcus Reiner (who poured colored tea underwater, where interfacial forces are unimportant but the effect persists), Keller wrote a note [2] about how inertial effects (and Bernoulli's principle) can explain this phenomenon. Nearly 30 years later, with J.-M. Vanden-Broeck, he worked out a more complete theory [5,6], which was recognized by the 1999 Ig Nobel, though Keller's contributions were inadvertently forgotten. In an interesting recent addendum, a group of scientists showed that by coating the spout with carbon black, they could change the wettability of the teapot and thence the effect, subtly modifying the role of inertia [1]—and showing that good problems never die!



To his long list of honors, Joe Keller of Stanford University has added two Ig Nobel prizes, awarded this fall at a gala ceremony at Harvard. The annual prizes, according to the sponsor, "are intended to celebrate the unusual, honor the imaginative—and spur people's interest in science, medicine, and technology." Along with belated recognition for his work on the "teapot effect," Keller was chosen this year for his mathematical explanation of swaying ponytails.

Keller is an avid walker and runner, and the work that earned the second Ig Nobel was likely inspired by the swaying ponytails of runners in front of him during his morning runs. Why, he asked, does a ponytail swing from side to side while the head bobs up and down? The key is an instability of a flexible string forced periodically and vertically at its boundary. In a paper published in 2010 in *SIAM Journal on Applied Mathematics* [3], Keller showed that under some fairly general assumptions, it is possible to derive a Hill equation for this phenomenon, which arises generically in the theory of parametrically driven oscillators. (The same mathematics appears in many situations; it is, for example, the theoretical basis for the "ion" trap [4] for which Wolfgang Paul and Hans Dehmelt received a Nobel Prize in 1989.) This insight allowed Keller to deduce the conditions for instability and, moreover, to calculate that for a ponytail bobbing at a frequency of a few hertz, the most unstable length is about 25 cm. Test it yourself!

Joe's work reminds us, charmingly, why we do what we do. Nature's infinite variety continually beckons the observant and curious mind, making people think and then making them smile. Congratulations, Joe, and thanks for keeping us smiling.

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[5] J.-M. Vanden-Broeck and J.B. Keller, *Pouring flows*, Phys. Fluids, 29 (1986), 3958.

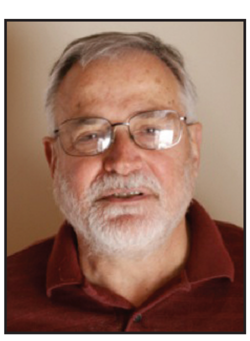
[6] J.-M. Vanden-Broeck and J.B. Keller, *Pouring flows with separation*, Phys. Fluids A, 1 (1989), 156.

L. Mahadevan is a professor of applied mathematics, physics, and organismic and evolutionary biology at Harvard University. He obtained his PhD with Joe Keller and is also an Ig Nobelist (2007).

SIAM Elects Board and Council Members

This fall's SIAM election was no exception to the quietly dignified events evoked by retiring president Nick Trefethen in this issue's column. In fact, with Trefethen about to depart and a president-elect—Irene Fonseca of Carnegie Mellon University—ready to take office in January 2013, voters focused on the SIAM Council, with four seats to be filled, and the Board of Trustees, with three.

The membership elected Lisa Fauci of Tulane University to a second term on the board, along with two members new to the group: George Papanicolaou of Stanford University (whose work on risk in financial markets is featured in this issue of *SIAM News*) and Fadil Santosa, director of the Institute for Mathematics and its Applications at the University of Minnesota. Board terms are three years, and a member can serve at most three consecutive terms.



George Papanicolaou

The council gained one new member: Andreas Griewank of Humboldt University in Germany. Voters reelected three incumbents: Tim Davis of the University of Florida; Craig Evans of the University of California, Berkeley; and Carol Woodward of Lawrence Livermore National Laboratory. Council members also serve three-year terms but are limited to two consecutive terms.

Fadil Santosa

SIAM thanks those who ran for election as well as all who voted. Special thanks are due to retiring longtime board members Marsha Berger of the Courant Institute, New York University, and Alfio Quarteroni of Ecole Polytechnique Fédérale de Lausanne.

Andreas Griewank

"Remarkable Relevance for 'Real' Applications"

LETTERS TO THE EDITOR

To the Editor:

I enjoyed reading Nick Trefethen's opinions on complex variables and taking his quiz ("From the SIAM President," October 2012). Although I can parallel park and speak French, I could have failed such a quiz in other areas of mathematics. I was able to ace this one, having taught 18.04 (Complex Variables with Applications) at MIT (some years after Nick himself). I share his love of the subject, and frankly, it was my desire to teach it that helped me decide on a career in applied mathematics, after a getting PhD in physics.

I once started a paper with the corny line, "Complex analysis is one of the most beautiful subjects in mathematics, and, despite involving imaginary numbers, it has remarkable relevance for 'real' applications." Indeed, complex analysis is fundamental not only in mathematics, but throughout science and engineering. Although Nick laments the fading familiarity with complex variables among applied mathematicians, the sickness is more advanced elsewhere. Even at a place like MIT, science and engineering curricula reflect a different sort of "mission creep" away from mathematical depth. Entire classes (like 18.04) are being replaced by a few lectures in "Math for Engineers," where Nick's quiz would not go over so well! Although complex variables may seem arcane in the computer age, the subject provides the language of quantum mechanics, signal processing, and much useful mathematics and deserves to be taught more broadly in the future.—*Martin Z. Bazant, MIT*

Riding the New Commodity Curves for Scientific Computing

By Michael Heroux

Scientific computing problems are often very challenging, requiring large numbers of operations and significant data storage. For many years, the scientific computing community has experienced performance improvements by riding "commodity curves" in the computer industry. In particular, during this time the well-known Moore's law could be interpreted as "single processor performance will double every 18 months," primarily as a result of clock rate improvements and sophisticated single-processor scheduling strategies that make sequential code execute more quickly. Memory storage capacity and bandwidth also grew dramatically, and for applications that could use multiple processors via distributed memory and MPI (message passing interface), the improvements were even better. Interconnect networks, which tie independent processors together and make these separate processors act as a single cluster, were getting faster, cheaper, and capable of supporting larger processor counts. Over a span of two years, the multiplicative effect of these commodity curves was driving increases in performance for parallel applications and in data storage capacities by a factor of more than 10.

Currently, all these trends have stalled, or even reversed. Processor clock rates have either leveled off or decreased. Memory system capacities and performance trends, which are more complicated to explain, are also far less attractive. Interconnect networks have reached a limit for the very largest computers, and clusters are more costly to operate for everyone. The overarching concern that dampens all these trends is *energy efficiency*. We have reached practical efficiency thresholds for previous commodity curves. The free lunch is over. Or is it?

There is some good news. New commodity curves are emerging to replace the old ones. The challenge is that these curves require disruptive changes in how we analyze algorithms, design computer applications, and implement them in software. Whereas concurrency—simultaneous execution of operations—has always been a path to faster computations, it is now the *only* reliable path. The time to compute any given sequential stream of instructions will not improve dramatically for the foreseeable future. On today's computers, each computing node is an integral composition of increasing numbers of computing cores, including heterogeneous types, such as GPUs. Each core itself is designed to exploit greater concurrency, although some core types are optimized more for latency (for example, the Intel X86 line found in most laptops and desktops), others more for throughput (doing many, many things at once but taking longer to produce the first result). Although the exact design of node architectures will change, it is useful to think of a node as having a collection of latency-optimized and throughput-optimized cores.

Reasoning about Concurrency

Concurrency comes in many forms, which we consider in terms of patterns. The most common pattern used for distributed-memory parallelism (with MPI on a cluster) is *single program, multiple data* (SPMD). This strategy executes the same set of instructions on processors in a cluster, with each processor assigned a portion of the data and work. The SPMD pattern remains important for scientific computing and is still the dominant form of parallelism in large-scale computing, enabling hundreds of applications to perform high-fidelity computations.

Although SPMD across multiple nodes will remain an important pattern for parallel computing, the real focus for future performance growth is parallelism on the node. Multiple cores on a node permit multiple *threads* of execution.* Thus, with increasing core counts will come the opportunity to execute more threads. Furthermore, node architectures permit each core to have an increasing number of threads "in flight": If one thread stalls because it is waiting on data, the core can switch to execution of another thread, and then switch back when the second thread stalls or completes execution.

Within each core, another growing resource for concurrency is *vectorization*, based on a *single instruction, multiple data* (SIMD) pattern. With each new generation of nodes, the number of data elements that can be processed simultaneously via vectorization grows. Moreover, additional types of computations are becoming vectorizable, including operations for which data is not contiguous in memory and must be gathered or scattered. Vectorization supports performance of the same operation on a sequence of data elements—multiplying an array of values by a scalar value, for example.

Finally, memory system performance is becoming more latency-sensitive, and bandwidth is declining relative to operation count and becoming more localized in its availability. Consequently, the most successful algorithms will be those that permit more asynchronous activity (with latency hidden by having lots of requests in flight), prefer computation to data access (reducing memory bandwidth demands), and localize data requests to a small portion of the memory system (minimizing the amount of global data traffic), if all other concerns are similar.

Exploiting the New Commodity Curves

To enjoy the increased performance on future computers that will come "for free," we need to design and implement new algorithms that permit ample multi-thread parallelism, expose vectorizable computations and data requests, and respect the performance limitations of memory systems. Additionally, software architectures must be designed to expose threading and vectorization, and data structures must map well to memory systems. Finally, programmers

See **Commodity Curves** *on page 5*

*The definitions of "core" and "thread" in this article are those commonly used in descriptions of the features of a microprocessor, e.g., from Intel or AMD. The GPU community, in particular Nvidia, uses different terminology. What we call a core is similar to a *streaming multiprocessor* (SM), which is composed of a fixed number of *CUDA threads*. SMs can have multiple thread states in flight (called the occupancy rate), and CUDA threads operate with a single instruction on multiple threads (SIMT), which is a bit more general than the SIMD model described here. The OpenCL community uses yet another taxonomy, but the concepts in all three cases are similar enough for our purposes.

Systemic Risk

continued from page 1

solution $u(t,\cdot)$ of a suitable nonlinear Fokker–Planck equation. Loosely speaking, u can be regarded as the probability density of a random variable $X_\infty(t)$ representing the centroid of an infinite population of points on a line. It can then be shown that, given h and θ, there exists a critical value σ_c such that u exhibits one stable equilibrium if $\sigma \geq \sigma_c$ and two if $\sigma < \sigma_c$. Furthermore, if h is small, u can have two stable equilibria only if the herding instinct dominates noise to the extent that $3\sigma^2 < 2\theta$.

For $V(y) = \frac{1}{4}y^4 - \frac{1}{2}y^2$, additional concrete results can be obtained by linearizing the differential equations about $x_j(0) = -1\ \forall_j$, the $N + 1$ linearized variables being δx_j and $\delta\xi$. If they all vanish at $t = 0$, then $\delta x_j(t)$ and $\delta\xi(t)$ are Gaussian processes of zero mean and readily calculable variance, provided that the ratios σ^2/N and $\sigma^2/2(\theta + 2h)$ remain small enough for the linearizations to remain valid. All this reveals that (i) a stronger herding instinct (larger θ) leads each herd member to believe that it can survive more violent shocks (larger σ), and (ii) the effects of their own actions on the overall system are invisible to other herd members.

Under additional hypotheses, it is possible to estimate (in closed form) the risk that the system will fail in the precise sense that $\xi(t)$ transitions from the healthy potential well to the unhealthy one. The resulting expression justifies the conclusions that (i) a large system is more stable than a small one; (ii) sooner or later, the dread transition will take place; (iii) any increase in the intrinsic stabilization parameter h reduces the risk of systemic transition; and (iv) a stronger herding instinct (larger θ, with σ^2/θ held fixed) increases systemic risk.

High-speed Trading

Having pretty well exhausted the potential of his modified Curie–Weiss model, Papanicolaou turned his attention to empirical studies of the real or imagined effects of "algorithmic trading" on market performance. Estimating that some 70% of all equities trading is currently algorithmic, he observed that over the last 10–15 years, the automation of exchanges, and the increasing use of high-speed, computer-driven algorithmic trading schemes—capable of assessing and electronically executing trades in mere fractions of a second—has spurred the development of new strategies that "execute trades based on complex and sophisticated trading signals." Focusing on just three macroscopic properties of financial markets—their liquidity, their volatility, and their diversity—he sumarized efforts to understand their combined effects on systemic risk.

The volatility of market indices is a familiar quantity, usually measured by the variance of day-to-day price increments. Liquidity is a more elusive quantity, inasmuch as it refers to the amount of cash or cash equivalents (aka liquid assets) available to traders for the purpose of making purchases, and is not directly observable. It is necessary, therefore, to develop "proxies" for liquidity, perhaps the most obvious being the commissions paid to brokers (who are not traders) for executing individual trades. The commissions reduce market liquidity by decreasing the amount of money available for additional trades. There is little doubt that the advent of electronic trading has decreased brokers' commissions dramatically.

The bid/ask spread on traded assets is another natural measure of liquidity: When the price would-be buyers are willing pay for a given asset differs little from the price would-be sellers are willing to accept, the volume of trade in that asset tends to increase, much as it would if traders had extra money to spend. Traders thus consider markets to be particularly liquid when the bid/ask spreads are unusually small. All told, Papanicolaou presented six measures of market liquidity, all of which tend to support the theses that volatility and liquidity are strongly and positively correlated, and that algorithmic trading has increased market liquidity in recent years.

With a particularly intriguing slide (see Figure 3), Papanicolaou compared the volatility of the S&P 500 index (as measured by the published VIX statistic) for the years from 1992 to 2008 with the number of significant eigenvalues of the empirical covariance matrix of the 500 individual stock price series. Each such eigenvector represents a group of issues that tend to move together, independently of other groups, making it possible to construct "diversified" portfolios—consisting of a single issue from each of several independent groups—that combine low risk with high reward. During the 1990s, when the VIX was consistently low, there were seldom fewer than forty such independently moving groups. But following the dot-com crisis of March 2000, and again during the financial crisis that began in 2008, the number of such groups dipped into the low single digits even as volatility soared, making low-risk/high-reward portfolios all but impossible to construct.

Papanicolaou concluded with the observation that investors are generally suspicious of reduced transaction costs and increased liquidity. Many would favor a "Tobin tax," which would impede the flow of transactions by taxing them. Europeans, he said, are generally in favor of such measures, while the "free market" ideologues in Washington and on Wall Street are unalterably opposed. With or without such a tax, difficult questions will remain concerning the command and control of systemic risk. Who, Papanicolaou wondered, will perform the basic research necessary to answer such questions? Traders aren't interested—they're too busy making money. The banks aren't interested—they get bailed out whenever they fall prey to risk of any kind. The regulators express interest but lack the necessary resources and know-how. Only academics, in his opinion, possess both the will and the skill to answer such questions.

James Case writes from Baltimore, Maryland.

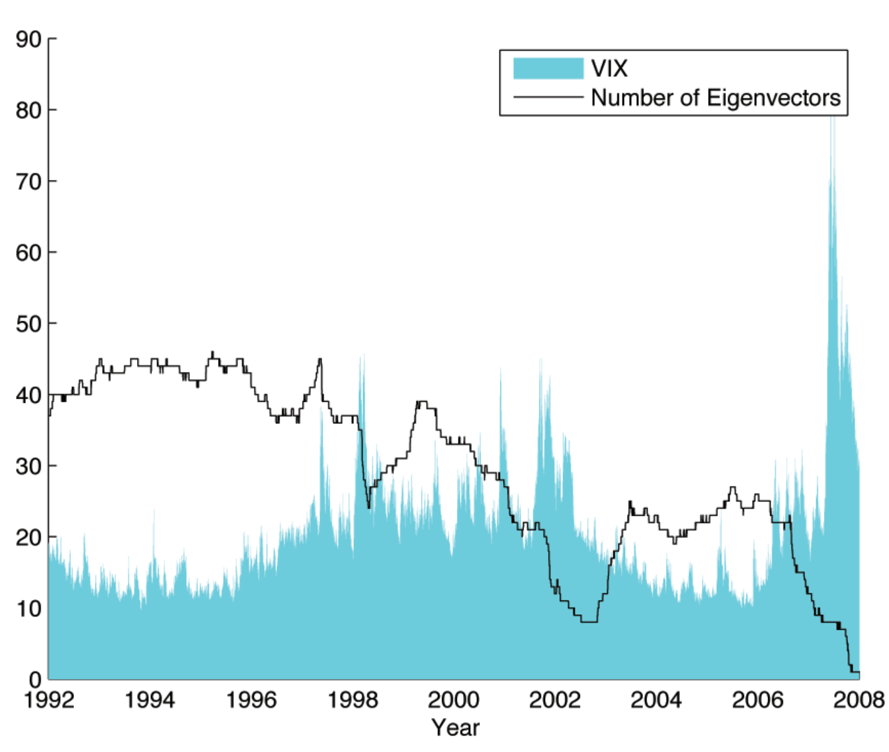


Figure 3. *The number of independently migrating asset groups (eigenvectors of the price-series correlation matrix) is inversely related to the volatility of the market, as measured by the published VIX statistic.*

Commodity Curves

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must organize their code to readily expose computations that can be executed by increasing numbers of threads. They must also write code so that the compiler identifies vectorization, which is typically obtained from the innermost loop; the loops must be sufficiently long to realize performance gains on future nodes with longer vector register lengths. At the same time, data structures must be flexible enough to adapt to emerging memory system designs.

Using Patterns to Reason About Parallelism

So far we have discussed SPMD and SIMD/SIMT as *execution patterns*, but we have not discussed how the algorithm designer and programmer might reason about parallelism using patterns. *Parallel patterns* are a useful framework for designing and describing algorithms without being specific about the execution pattern. For example, the *parallel-for* pattern specifies that a loop with n iterations can be correctly executed regardless of the order used to traverse the loop. Algorithms that match the parallel-for pattern can be mapped to SPMD, SIMD/SIMT, and several threading execution patterns. For this reason, parallel-for is a very attractive pattern to identify and exploit. *Parallel-reduce*, a related pattern, produces a single scalar result, such as computing the norm of a vector.

Fortunately, many scientific computations can be organized in a parallel-for or parallel-reduce pattern. This arises from the common activity of working on a mesh, grid, or graph, where similar computations are performed at each node[†], and many times these operations can happen in parallel across nodes with little or no interaction.

For many application developers, knowledge of the parallel-for and parallel-reduce patterns will be sufficient for most analysis, design, and implementation. Although they are conceptually simple, ensuring the properties of these patterns can be challenging in practice. Use of global variables, e.g., common blocks and direct access to attributes in a class, can introduce cross-iteration dependencies, or ambiguities a compiler cannot handle. Even in these simple cases, programmers are thus aided by the discipline that use of patterns encourages.

Additional patterns include *pipeline* and *task-graph*, which enable abstract descriptions of data flow parallelism. A pipeline is composed of *filters*. Each filter transforms input data into output data, and a filter can have the property that multiple instances can execute concurrently or not. A task-graph describes a collection of operations (tasks) such that some must be done before others can proceed. The beauty of these two patterns is that each individual filter or task can be encapsulated as sequential code fragments and, for a well-designed parallel application, new functionality can be added by simply writing a new filter or task fragment. This, in turn, creates a separation of concerns: adding functionality and achieving parallel execution.

There are other patterns, and competing taxonomies. But the primary point is to develop an abstract pattern framework for analyzing, designing, and implementing software, and doing it in a way that supports (i) reasoning about important parallel properties that are inherent in algorithms, (ii) designing a software architecture that enables separation of the concerns of extending functionality and achieving parallel execution, and (iii) implementing software so that parallelism is realized.

Preserving Value Going Forward

One fundamental property of many scientific computing applications is that sophisticated mathematical expressions are encoded in loop bodies, which are executed over a set of discrete entities. For example, a finite volume formulation of a differential equation computes an updated solution value for each cell in the physical domain. Although the exact finite volume formulation can restrict the order of execution across cells, the primary concern of the loop body expression is accurate encoding of the discrete formulation of the differential equation. More precisely: Scientific domain knowledge is encoded primarily in the loop bodies. Accordingly, our software design should respect the integrity of loop body expressions, but should otherwise be flexible, admitting different data structures and ordering of computations. Using this property as a guiding principle will allow us to preserve the tremendous investment we have in existing code.

Parallel computing is a requirement for riding the new commodity performance curves that have emerged from energy efficiency concerns. For scientists who use computing environments like Matlab and Maple, the underlying implementation layers address parallelism, and beyond a conceptual knowledge of basic parallel patterns and proper organization of work and data, no other effort is required. For scientists who write their own software, the strategies described in this article should be a good set of guiding principles for analyzing, designing, and implementing parallel programs that have sustained value.

Michael Heroux is a distinguished member of the technical staff at Sandia National Laboratories. He is a member of the organizing committee for the 2013 SIAM Conference on Computational Science and Engineering, to be held in Boston, February 25 to March 1.

[†]Notice that "node" as defined here is different from the "compute node" discussed above; both are commonly used, so we must use context to arbitrate.

Formulating Natural Hazard Policies Under Uncertainty

By Jerome L. Stein and Seth Stein

Uncertainty issues are crucial in assessing the risk posed by natural hazards and in developing strategies to mitigate their consequences for society. The challenges are illustrated by the giant earthquake that struck Japan's Tohoku coast in March 2011; much larger than predicted by sophisticated hazard models, the earthquake caused a tsunami that overtopped 5- to 10-meter seawalls and damaged the Fukushima nuclear facilities. Together, these events were responsible for more than 15,000 deaths and $210 billion in damage. Deciding whether to rebuild the defenses and, more generally, what strategies to employ against such rare events depends on estimates of the balance between the costs and benefits of mitigation. Finding that balance is a complex challenge at the intersection of geoscience, mathematics, and economics.

We have developed a general stochastic model for use in selecting an optimal mitigation strategy against future tsunamis; the model minimizes the sum of the expected present value of the damage, the costs of mitigation, and a risk premium reflecting the variance of the hazard. The probabilities, as discussed below, either are constant with time or depend on the previous history. We then considered whether new nuclear power plants should be built in Japan, using a deterministic model that does not require estimates of essentially unknown probabilities. These models can be generalized to the mitigation of other natural hazards.

Hazard Mitigation: A Stochastic Model

To illustrate our approach to inferring optimal policy for natural hazard mitigation, we begin with the question of how Tohoku's tsunami defenses should be rebuilt. For some point on the coast, we denote the cost of defense construction as $C(n)$, where n is the height of a seawall (an alternative measure, with a different method for increasing resilience, is the width of a no-construction zone). For a tsunami of height h, the present value of the future economic loss is $L(h - n)$, where $h - n$ is the height to which a tsunami will overtop a seawall, or exceed some other design parameter. $L(h - n)$ is zero for a tsunami smaller than the design value n and increases for larger tsunamis. L includes both the damage and the resulting indirect economic losses, such as those from the destruction of the Fukushima nuclear power plant, including the relocation of residents and loss of income. The probability of a tsunami overtop of height $h - n$ is $p(h - n)$; the expected present value of the loss from a number of possible tsunamis over the life of the tsunami wall is the sum of losses from tsunamis of different heights weighted by their probabilities:

$$Q(n) = E\{L(n)\} = \Sigma_h\, p(h - n)L(h - n). \quad (1)$$

Thus, $p(h - n)$ describes the hazard, the occurrence of tsunamis of a certain size, and $Q(n)$ reflects the present value of the resulting risk, which also depends on the mitigation level n.

The optimal level of mitigation n^* minimizes the total cost $K(n)$, the sum of the expected loss $Q(n)$ and mitigation cost $C(n)$:

$$K(n^*) = \min_n\, [Q(n) + C(n)]. \quad (2)$$

Because increasingly high levels of mitigation are progressively more costly, the first and second derivatives $C'(n)$ and $C''(n)$ are positive. Conversely, because increasing mitigation reduces expected loss, the derivative $Q'(n)$ is negative. $K(n)$ illustrates the tradeoff between mitigation and damage: More mitigation gives less expected damage but higher total cost, whereas less mitigation decreases construction costs but increases the expected damage and thus total cost. The solution to equation (2) is

$$C'(n^*) = -[Q'(n^*)], \quad (3)$$

where $n^* > 0$ is the optimal mitigation level.

The derivatives $[-Q'(n)]$ and $C'(n)$ intersect at the optimal point n^*, the highest level to which it pays to build the wall, as shown in Figure 1. If the intersection occurs where n^* is positive, it pays to build a wall. However, if even when the wall height is zero the incremental cost of a wall $C'(0)$ is greater than the incremental gain in mitigation $-Q'(0)$, it does not pay to build a wall.

This approach requires estimating the probability of a tsunami of a certain height and the effectiveness of the defenses, which is often less than planned. The resulting uncertainty in the expected loss is included by adding a risk term $R(n)$, the product of a risk aversion factor and the variance of the estimated loss, to the loss term $Q(n)$. This increases the optimum to n^{**}.

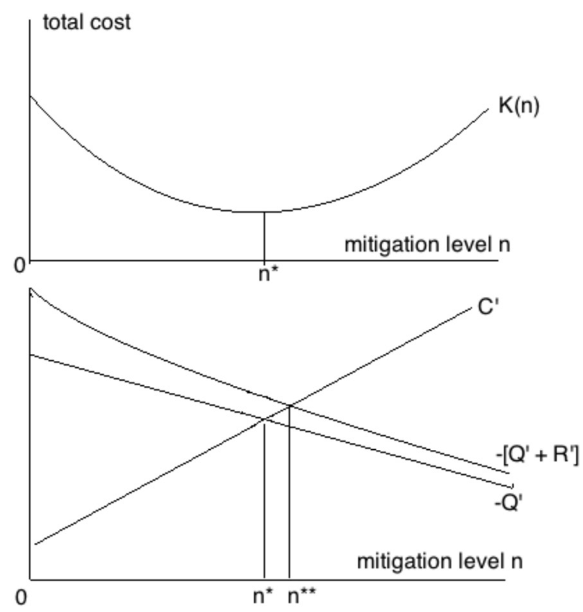

Figure 1. *The optimal level of mitigation is n* when risk aversion and uncertainty are not considered and increases to n** when these effects are included.*

Probability Estimates of Extreme Events

As the Tohoku earthquake illustrates, it is very difficult to estimate the probabilities of the extreme events that pose the greatest hazards. For any site, there are few observations of such events—e.g., earthquakes of magnitude greater than 8 or tsunamis higher than 10 meters. In many places, no geological records of such events are available, but it seems plausible that they might occur, at a rate that can be extrapolated from the rate of smaller events. Hence, it is often unclear how to describe their occurrence via a probability density function.

This uncertainty is one reason for the frequent occurrence of large earthquakes in areas predicted to have low hazard. In the Japanese government's earthquake hazard map shown in Figure 2, the probability of strong ground shaking was presumed to be much lower off the Tohoku coast than in many other areas. The map reflects assumed probabilities of earthquakes of different magnitudes in different areas; the probability of an earthquake as large as that of March 2011 off Tohoku was assumed to be zero.

Two general approaches have been taken to estimating the probabilities of such rare events. The basic choice is between a time-independent Poisson process with no "memory," so that a future earthquake is equally likely immediately after and long after the past one, and various pdfs for time-dependent models in which the probability of the next large earthquake is small shortly after the past one and increases with time. For many places, neither approach captures the complexity of the earthquake history.

Nuclear Power in Japan: A Deterministic Model

The destruction of the Fukushima nuclear power plant has prompted intense debate in Japan about whether to continue using nuclear power. The problem is to find an optimal cost/benefit balance for building nuclear plants in Japan. In comparing the costs and benefits, the challenge lies in the uncertainty in estimating the probability or likelihood of great earthquakes and megatsunamis. Because the stochastic model requires probability estimates, we consider an alternative deterministic model.

The benefit of nuclear power is its effect upon GDP (real gross national product) and its growth, described by the net return on the capital invested less its cost. Our strategy for determining the optimal investment in nuclear plants has two stages. In the first we identify the worst "expectation" or "likelihood" of the loss due to large earthquakes or tsunamis, which for simplicity we term "shocks." This is not the actual worst outcome, but the likely or expected worst outcome given a quadratic risk function. In the second stage we determine a scale of nuclear plant construction that maximizes the minimum expected real income.

To do this, we let the logarithm of the gross domestic product X equal the capital invested k multiplied by b, the productivity of capital in the absence of shocks, less the interest rate r that reflects the opportunity cost of using the capital and a term vs, where s is a measure of shocks and v represents vulnerability:

$$\log X = (b - r - vs)k. \quad (4)$$

For simplicity of exposition, we deal with constant values of the variables. The "expected" GDP is $X \times q$, an inverse measure of the likelihood of shocks of various sizes:

$$q = \exp[(1/2)s^2]. \quad (5)$$

This term is in effect an inverse measure of probability, even though we cannot precisely specify the probabilities. The logarithm of the expected GDP is then

$$Z = \log qX = (b - r - vs)k + \exp[(1/2)s^2]. \quad (6)$$

We imagine society playing a game against nature. The worst case of expected loss in real income arises for the value of the shock parameter s that produces the minimum value of Z. Given this situation, society selects a capital stock k to maximize minimum Z. This optimization,

$$\max_k \min_s\, (Z), \quad (7)$$

leads to

$$k = (b - r)/v^2. \quad (8)$$

This max-expected min gives the optimal scale of investment conditional on the expected worst outcome. It is positively related to the net return on capital invested less the interest rate, and negatively related to the square of the vulnerability of the plant to shocks. This equation bears a remarkable similarity to the optimal ratio of risky assets/net worth in models of mathematical finance.

Research Challenges

These simple models illustrate opportunities for and challenges to the applied mathematics and computational science communities. New approaches are needed to improve our ability to assess natural hazards, including those associated with climate change. A key need is better quantification of the uncertainties in estimating the occurrence and effects of such extreme events and the resulting losses, from both a societal and an economic perspective. Also

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NSF Solicits Proposals for Hazards SEES Program

The National Science Foundation has released a solicitation for its new Interdisciplinary Research in Hazards and Disasters (Hazards SEES) progam. Details can be found at http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504804.

The overarching goal of Hazards SEES is to promote well-integrated interdisciplinary research in hazards-related science and engineering. Such research should improve the understanding of natural hazards and technological hazards linked to natural phenomena, and mitigate their effects, as well as promote disaster preparedness, response, and recovery. The goal is to effectively prevent hazards from becoming disasters.

Hazards SEES will make investments in strongly interdisciplinary research that will reduce the impact of such hazards, enhance the safety of society, and contribute to sustainability. The program is a multi-directorate program that seeks to: (1) advance understanding of the fundamental processes associated with specific natural hazards and technological hazards linked to natural phenomena; (2) better understand the causes, interdependencies, impacts, and cumulative effects of hazards on individuals, the natural and built environment, and society as a whole; and (3) improve capabilities for forecasting or predicting hazards, mitigating their effects, and enhancing the capacity to respond to and recover from resultant disasters.

Hazards SEES seeks research projects that will productively cross the boundaries of the atmospheric and geospace, earth, and ocean sciences; computer and information science; cyberinfrastructure; engineering; mathematics and statistics; and social, economic, and behavioral sciences. Successful proposals will integrate across these multiple disciplines to promote research that advances new paradigms for the creation of a society resilient to hazards. A goal of the program is the transformation of hazards and disaster research through the development of an interdisciplinary approach that allows for appropriately targeted collection, integration, and management of data; modeling (including predictive models for real-time decision making); visualization and simulation; data analytics and data-driven discovery; real-time sensing; cross-cutting knowledge development; and synthesis of applicable models and theory. Proposals must demonstrate the inclusion of the appropriate expertise to address the research questions, hypotheses, and problems being posed. Hazards SEES research projects should be designed around one or more locations, identifiable hazards, and/or themes.

The deadline for full proposals is February 4, 2013.

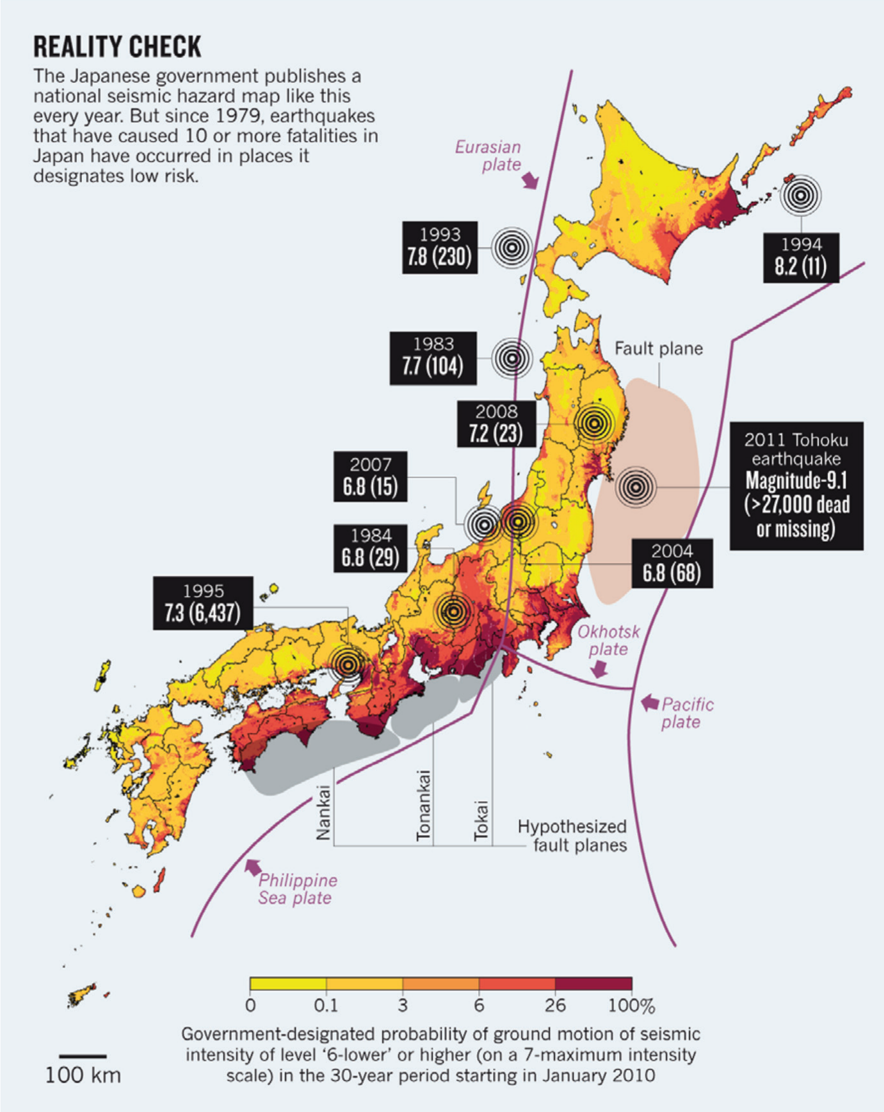

Figure 2. *Comparison of Japanese government hazard map to the locations of earthquakes since 1979 that caused 10 or more fatalities, all of which are shown as having relatively low hazard (Geller,* Nature*, Vol. 472, 2011, 407–409).*

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crucial is the development of methods for evaluating the costs and benefits of alternative adaptation and mitigation approaches, which will help society formulate strategies to address these problems. These are among the topics on which the new Consortium for Mathematics in the Geosciences (http://marina.geo.umn.edu/CMG/) seeks to promote research.

Jerome Stein is a professor of economics, the Eastman Professor of Political Economy (emeritus), and a visiting professor in the Division of Applied Mathematics at Brown University. Seth Stein is the William Deering Professor in the Department of Earth and Planetary Sciences at Northwestern University.

Mathematics/MPE 2013 Symposia Slated for AAAS Meeting in Boston

The American Association for the Advancement of Science will hold its 2013 Annual Meeting in Boston, February 14–18. The theme of the meeting is "The Beauty and Benefits of Science."

The AAAS is divided into 24 discipline-based sections, including Section A (Mathematics), which has organized four symposia for next year's meeting, two of which are sponsored by Mathematics of Planet Earth 2013 (mpe2013.org):

■ *Mathematics of Tipping Points: Framework, Applications, and Prediction*, organized by Mary Lou Zeeman (Bowdoin College); this is an MPE 2013 symposium. Scheduled speakers are Mary Silber, Sebastian Wieczorek, and Marten Scheffer.

■ *Understanding and Communicating Uncertainty in Climate Change Science*, organized by Richard L. Smith (University of North Carolina); this is an MPE 2013 symposium. Scheduled speakers are Murali Haran, Leonard Smith, and Mark Berliner.

■ *Compressive Sensing: Sensing Sparse Phenomena in Theory and Practice*, organized by Mark Davenport (Stanford University). Scheduled speakers are Mark Davenport, Justin Romberg, Dave Brady, Anna Gilbert, and Rachel Ward.

■ *Multi-scale Study of Cancer*, organized by Mark Alber (University of Notre Dame) and Jill Mesirov (Broad Institute of Harvard University and MIT). Scheduled speakers are Martin Nowak, Kathleen Wilkie, and Philip Maini.

Other symposia among the more than 150 planned for Boston that will be of interest to the mathematical community include: *Is Beauty Truth? Mathematics in Physics from Dirac to the Higgs Boson and Beyond; Predictability: From Physical to Data Sciences; The Science of Uncertainty in Genomic Medicine; Predictive Model of the Internal Combustion Engine; Computation, Computational Efficiency, and Cognitive Science; How Fundamental Computing Research Touches Everyday Lives; Smart Phones, Smart Devices, Social Networks, and Smart Health Care; Visualizing Chemistry: Seeing Another Dimension of Plants and Animals;* and *The 25th Anniversary of the First Collection in the History of Women in Science.*

Further information, including the schedule of talks, can be found at http://www.aaas.org/meetings. Section A acknowledges the American Mathematical Society for generous contributions for travel support for speakers to this meeting.

The AAAS hopes to offer symposia on topics in pure and applied mathematics at future meetings and values contributions by mathematicians and mathematics educators. Mathematical scientists are invited to volunteer as organizers and speakers for the 2014 meeting, which will be held in Chicago, February 13–17. The Steering Committee for Section A also invites members of the mathematical sciences community to attend the Section A business meeting in Boston on Friday, February 15, 2013, at 7:00 PM. On the business meeting agenda is brainstorming about future symposia, although the committee encourages the submission of topics for future symposia at any time.

Members of the Steering Committee for Section A (with terms from February 2012 to February 2013) are: Jill Mesirov, chair; Juan Meza (University of California, Merced), chair-elect; John H. Ewing (Math for America), retiring chair; Edward Aboufadel (Grand Valley State University), secretary; and members at large Tony Chan (Hong Kong University of Science and Technology), Mary Ellen Bock (Purdue University), Joceline Lega (University of Arizona), and Sheldon Katz (University of Illinois, Urbana–Champaign).—*Edward Aboufadel (aboufade@gvsu.edu).*

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spheres are governed by physical laws that are relatively well known. However, the behavior of its land masses and interior is characterized by material heterogeneity and intricately established geometries. While mathematicians take pride in the historical evolution of calculus from Newton's quintessential $F = ma$ describing the trajectory of an individual particle, the real world is infinitely more complicated.

The Navier–Stokes equations for fluid motion, which possess a beautiful mathematical underpinning, are in practice profoundly difficult to solve in all but the most pristine circumstances. Hydrodynamic problems couple complicated geometries, as might be produced by terrestrial topography, to cumbersome equations of state describing the phase change of water, and frequency-dependent radiative transfer regulating the flow of energy from the sun to the Earth and back again in the presence of clouds and aerosols. Solution of such problems is a monumental undertaking. Adding to this physical complexity is mathematical complexity: We are trying to describe a chaotic system with infinite degrees of freedom over an extended period of time. Thus, when we look at the challenges faced by meteorologists, especially those who study the origin and development of hurricanes using space-based observations coupled to mathematical and computational tools, it is truly remarkable that their predictions regarding Hurricane Sandy were so accurate.

The study of climate builds upon atmospheric and ocean science in a special way; climate is much more than an average of the weather. While weather forecasts involve all the ingredients described above (and others), the investigation of climate must fold into these considerations changes in the ambient environment that meteorologists generally regard as static—such as the variability in time of greenhouse gas abundance, of changes in the reflectivity (albedo) of the ground due to melting/freezing glacial ice masses, and of ground cover (vegetation). Humans presently inject 30 *billion* metric tons of carbon dioxide into the atmosphere each year—more than 4 tons per person worldwide (18 tons in the U.S. and other developed countries)—a significant fraction of which enters and influences our oceans; this human imprint that commenced at the beginning of the industrial revolution remains firm and growing at a rate of 2.5% per year.

The past decade was the hottest on record—and the surface temperature of the Caribbean has risen several degrees. The increased temperature of these waters increases the capacity of the atmosphere above it to carry water vapor and transport it over land. The latent heat present in this water vapor drives a phenomenally powerful engine; the heated air, upon interacting with colder air masses from the north, can have cataclysmic results. Similar considerations apply to the Indian Ocean, and typhoons (the term used to describe hurricanes in south Asia) have resulted in power outages afflicting more than half a *billion* people and displacing hundreds of millions. Attendant food shortages and the spread of disease threaten to destabilize a particularly volatile part of the globe. Climate change is no longer speculative; we are witnessing its impact, which can only be expected to grow.

The fluid processes mentioned above contribute to an even more complicated class of scientific *and* societal problems: the nature of earthquakes and tsunamis. Convection in the Earth's molten mantle drives the continental land masses (more correctly, tectonic plates) on the surface like croutons floating in a boiling pot of soup. Areas of contact between the plates, known as earthquake faults, provide frictional resistance to their relative motion, which otherwise would be of order 50 mm/yr. In reality, the distribution of faults is more complicated than this monolithic picture suggests. Earthquake faults form complicated networks, and even maintain some fractal properties. A good metaphor is to think of a piece of fine China that has broken into many fragments, with a wide range of sizes.

Observed over hundreds of millions of years, this slow motion has resulted in the displacement of the continents from one another over thousands of kilometers. In this ongoing process, the rock material on both sides of a fault undergoes steadily increasing stress until something gives—after which the stress on both sides of the fault is relieved, only to grow again.

A tree branch bent with a continually increasing applied stress provides a good analogy for earthquake prediction: It is evident that the branch will ultimately snap, but when? That is the fundamental dilemma posed by efforts to forecast earthquake events.

This so-called elastic-rebound theory, developed by Reid to explain the Great San Francisco Earthquake of 1906, is completely descriptive; efforts to model earthquakes are fundamentally phenomenological, attempting to incorporate in a quantitative way the nature of friction, the rheological properties of the rocks involved, the geometrical configuration, etc.

A tree branch bent with a continually increasing applied stress provides a good analogy for earthquake prediction: It is evident that the branch will ultimately snap, but when? That is the fundamental dilemma posed by efforts to forecast earthquake events. Although the intuitive basis is clearcut, the quantitative and physics-based ingredients are poorly understood, and first-principles equations describing such events are essentially non-existent. Earthquake phenomenology preserves some features reminiscent of fluid turbulence, such as cascades, but we have no formal equivalent for the Navier–Stokes equations to help explain, say, the formation of mountain ranges. Seismologists can make reasoned assessments of locations that are at greatest risk over some extended window of time. To make "predictions" of the sort that our colleagues in meteorology do (with all their attendant uncertainties) remains an impossible dream. Moreover, major earthquake events lack clear premonitory patterns: Only 30% of earthquakes are preceded by "foreshocks," i.e., events of lower magnitude or some other possibly relevant physical manifestations.

Given the profoundly difficult nature of earthquake forecasting, it is utterly unreasonable to expect accurate predictions of these largely stochastic events. The Italian seismologists convicted for failing to provide adequate warning of the L'Aquila earthquake are the scapegoats of a system that failed to ensure that adequate building codes and precautions were taken to address what is truly inevitable and unpredictable behavior.

Days after the egregious decision handed down by the Italian court, we experienced a magnitude 7.7 earthquake off Canada's Queen Charlotte Islands in the Cascadia fault zone. This event was closely monitored because its epicenter is loosely related to a fault—more precisely a subduction zone describing the plunging of the Pacific plate beneath the Juan de Fuca plate—centered off the British Columbia–

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Washington–Oregon coast. In 1700, the so-called Cascadia earthquake, magnitude approximately 8.7–9.2, triggered a devastating tsunami that struck the coast of Japan. We are now possibly overdue for an event of comparable magnitude. When one tectonic plate precipitously slips beneath another, as in last year's disastrous Tohoku earthquake, it is possible, depending on the geometry of the plates and their relative motion, that a massive shallow-water wave will be triggered. That tsunami caused approximately 10,000 deaths, a number that will never be completely known. In 2004, the tsunami associated with the Great Sumatra–Andaman earthquake killed more than 230,000 people to the west of its epicenter.

When an underwater earthquake occurs, it is not immediately clear whether a tsunami hazard exists. Only when the geometry of the seismic source, the orientation of the water motion, and related facts are established is the true extent of the risk clear. The prudent policy is to issue an alert and be aware that a large submarine seismic event can *always* trigger a tsunami, and belay a warning if emerging evidence shows that the risk is minimal. The Queen Charlotte Islands tsunami alert elicited many complaints from the public, underscoring the dilemma that arises with so many natural hazards: The public expects scientists to accurately predict potential disasters, yet never to warn of events that ultimately do not come to pass. This misbegotten expectation makes clear that the public has lost its appreciation for the scientific method and the capabilities of scientists. The truth is that we can project the behavior of a complex system into the near future only with significant growth of uncertainty.

The public expects scientists to accurately predict potential disasters, yet never to warn of events that ultimately do not come to pass.

We are also witnessing in some quarters the rejection of knowledge obtained through the scientific method. A case in point is Senator James Inhofe's recent book *The Greatest Hoax*, which dismisses the findings of 97–98% of climate scientists, as surveyed by the U.S. National Academy of Sciences, that climate change is occurring and is largely due to human activity, in favor of the opinion of one dissenting scientist; should that scientist's opinion not prevail, Inhofe expresses his unwavering belief that certain Biblical passages guarantee that divine intervention will safeguard our future.

We are now in an era in which global climate change is unequivocal and societal response is critical. Meanwhile, non-climate-related natural hazards, such as earthquakes, emerge in locations that are especially desirable for human habitation—including the West Coast of the U.S., southern Europe, and much of Southeast Asia—where population growth is proceeding at an exponential pace. Science is capable of providing essential insights into the prevailing problems, but it cannot predict with inerrant accuracy how natural hazards result in disasters and, potentially, catastrophes. The diminution in the eyes of the public of the significance and believability of science threatens to deny us the one tool that could spare humanity. Indeed, we must confront the evolving growth of ignorance and misinformation if we are to survive.

William I. Newman is a professor of earth and space sciences, physics and astronomy, and mathematics at UCLA.

Career Advancement for Women Is Focus of COACh Workshops

Pam Cook of the University of Delaware, currently SIAM's vice president for publications, was instrumental in arranging for COACh workshops at recent SIAM meetings. In the article that follows, Cook and Mary Silber of Northwestern University convey their impressions as participants in the workshops. If enough prospective participants express interest (to meetings@siam.org), similar workshops may be offered at future SIAM meetings.

The two most recent SIAM Annual Meetings—in Pittsburgh (2010) and Minneapolis (2012)—offered workshops for women wishing to build skills that would help them move to the next career level. Run by COACh, an organization that works to increase the numbers and success of women scientists and engineers, and supported by SIAM, a COACh partner, the workshops were free to participants. Workshop participants covered a broad spectrum of levels, from graduate students through established career women (including tenured faculty). With their widely ranging professional experience, participants contributed a variety of perspectives to the workshop.

The workshops were run by professional facilitators, Jane Tucker and Barbara Butterfield (http://coach.uoregon.edu/coach/index.php?id=85), who understand that intangible skills are required for negotiating and leadership. They have logged a great many hours helping others, in many cases women in STEM fields, meet these requirements. Their experience with the mathematics community includes workshops presented at the Institute for Mathematics and its Applications at the University of Minnesota.

The focus of the 2012 SIAM workshop was on negotiation. The facilitators began by eliciting our preconceptions about negotiation. It turned out that in many cases our notions don't serve us well; an example is the view that negotiation shouldn't be necessary—our hard work will be recognized and rewarded. Dream on!

We were also asked to reflect on how we feel about negotiating. Do we relish the opportunity? Avoid it? Are we intuitive in our approach, or do we plan and research ahead of a negotiation? Here, the facilitators did a tricky thing—using this introductory exercise, they quickly sized us up and then reflected back those first impressions. The results had us wondering how our communication style might undermine our goals when we approach our department chair or dean with a request for something that will really make a difference to our research program or to our department's mission. We also considered situations in which different styles of negotiation are appropriate. This was a great opportunity to explore errors in our thinking; the perspective that an ideal negotiation benefits both parties was a powerful revelation to many.

The workshop ended with some fun. We broke into groups to role-play, quickly drawing up case studies from our own situations and goals for advancing our own research. A twist in this exercise was that the "department chair" in the negotiation was handed confidential guidelines, and asked to take on some particularly infuriating negotiation style aimed at throwing off the poor junior faculty member! We leave that part to your imagination, but the next time you are frustrated by a negotiation and need to blow off steam, it might help to do some mental role-playing as a way to develop guidelines.

Participants were enthusiastic about the workshop. It was a reminder, one participant said, that "what we learned is to be

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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 $2.70 per word (minimum $325.00). Display advertising rates are available on request.*

Advertising copy must be received at least four weeks before publication (e.g., the deadline for the March 2013 issue is January 31, 2013).

Advertisements with application deadlines falling within the month of publication will not be accepted (e.g., an advertisement published in the March issue must show an application deadline of April 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

University of Illinois at Urbana–Champaign

College of Engineering
Department of Industrial and Enterprise Systems Engineering

The Department of Industrial and Enterprise Systems Engineering at the University of Illinois at Urbana–Champaign invites applications for two full-time tenured or tenure-track faculty positions at all levels in the areas of engineering systems design and operations research/financial engineering, to begin August 16, 2013. Applicants at all ranks will be considered. All candidates must have a doctoral degree by the appointment start date.

For a complete position announcement and application form, applicants should go to: http://jobs.illinois.edu. The review of applications began November 1, 2012, and will continue until the positions are filled. Questions should be referred to Amy Summers, (217) 244–5703; arsummer@illinois.edu.

Illinois is an affirmative action/equal opportunity employer (see http://www.inclusiveillinois.illinois.edu).

Colorado State University

Department of Mathematics

The Department of Mathematics at Colorado State University invites applications for a tenure-track assistant professor position in the area of mathematics education. A full job description, including minimum qualifications, can be viewed at http://www.natsci.colostate.edu/employment/EDU/.

Applicants should apply online at the College of Natural Sciences website: https://cns.natsci.colostate.edu/employment/MathEd/. Complete applications include the submission of an AMS cover sheet; a curriculum vitae; a statement of interest in the mathematics education position specifically, including one-paragraph summaries of dissertation topic and plans for future scholarly activities; a research statement; a teaching statement; and at least three letters of recommendation. For full consideration, applications must be completed by December 9, 2012. Complete applications of the semi-finalist candidates will be available to department faculty for review. Colorado State University conducts background checks on the final candidates.

Colorado State University is an affirmative action/equal opportunity/equal access employer.

Texas Tech University

Department of Mathematics and Statistics

The Department of Mathematics and Statistics at Texas Tech University invites applications for three tenure-track assistant professor positions, to begin in the fall of 2013. A PhD degree at the time of appointment is required. The department is seeking candidates who will be engaged in nationally visible scholarship, establish externally funded research programs, interact with existing research groups in the department, involve graduate students in their research, and show excellence in teaching at the undergraduate and graduate levels. It is anticipated that one of the positions will be in statistics, one in numerical analysis, and one in another area compatible with the department's existing research programs. Candidates with very strong records who will bring externally sponsored research to Texas Tech will be considered for associate or full professor ranks.

The department has active research groups in both pure and applied mathematics (see http://www.math.ttu.edu/FacultyStaff/research.shtml). The department fosters a spirit of interdisciplinary collaboration across areas of mathematics, as well as with engineering and the physical and biological sciences.

Applicants should apply for position numbers T96800 for statistics, T96232 for numerical analysis, and T96376 for all other areas at: http://jobs.texastech.edu. Applications should include a completed AMS standard cover sheet and a vita. Three letters of reference and any material in addition to that completed online should be sent to: Alex Wang, Hiring Committee Chair, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409–1042. The review of applications will begin immediately.

Texas Tech University is an affirmative action/equal opportunity employer. Texas Tech University is committed to diversity among its faculty. The university strongly encourages applications from women, minorities, persons with disabilities, and veterans, and will consider the needs of dual-career couples.

Dartmouth College

Department of Mathematics

The Department of Mathematics anticipates a tenure-track opening, with initial appointment at the assistant professor level in the 2013–14 academic year. The successful applicant will have a research profile with a concentration in computational or applied mathematics.

Applicants should apply online at: http://www.mathjobs.org, Position ID: APACM #3874. Applications received by December 15, 2012, will receive first consideration. For more information about this position, applicants should visit the department's website: http://www.math.dartmouth.edu/activities/recruiting/.

Dartmouth is committed to diversity and encourages applications from women and minorities.

Dartmouth College

Department of Mathematics

The Department of Mathematics anticipates a senior opening, with initial appointment in the 2013–14 academic year. The successful applicant will have a research profile with a concentration in computational or applied mathematics, will be appointed at the level of full professor, and is expected to have an overall record of achievement and leadership consonant with such an appointment.

Applicants should apply online at: http://www.mathjobs.org, Position ID: PACM #3873. Applications received by December 15, 2012, will receive first consideration. For more information about this position, applicants should visit the department's website: http://www.math.dartmouth.edu/activities/recruiting/.

Dartmouth is committed to diversity and encourages applications from women and minorities.

Dartmouth College

Department of Mathematics

The Department of Mathematics anticipates a tenure-track opening for a mathematician working in either topology or number theory, with initial appointment in the 2013–14 academic year. The appointment is for candidates at any rank.

Applicants should apply online at: http://www.mathjobs.org, Position ID: TTPTNT #3875. Applications received by December 15, 2012, will receive first consideration. For more information about this position, applicants should visit the department's website: http://www.math.dartmouth.edu/activities/recruiting/.

Dartmouth is committed to diversity and encourages applications from women and minorities.

University of Texas at San Antonio

Department of Mathematics

The University of Texas at San Antonio invites applications for one tenure-track position in mathematics at the rank of assistant professor, pending budget approval, starting in the fall of 2013. The successful candidate will be expected to have a PhD degree in mathematics by the time of appointment, a strong research record, and demonstrated evidence of excellent teaching ability. Applicants who are selected for interviews must be able to show proof that they will be eligible and qualified to work in the U.S. by the time of hire.

Information on the mathematics program, a full version of the job announcement, and details on what to include in an application can be viewed at: http://math.utsa.edu.

UTSA is an affirmative action/equal employment opportunity employer.

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Careers

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applied every day and not just a couple of times during your career" (in, say, negotiating a course schedule each semester or in negotiating with a partner who takes out the trash). The role-playing was very useful, said another, because "it doesn't matter how many times you hear people telling you what to do, it is another thing when you actually have to do it." Further impressions included: "It's a true interactive way of learning about how to negotiate in a constructive way." The workshop provided "a forum for true vertical networking of women in science where we felt safe to share our concerns and learn how to resolve them in a constructive way and negotiate in a professional way." It "helped us see the flaws in our negotiation style and learn how to improve it."

Opportunities

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University of California, Irvine

Center for Complex Biological Systems

The University of California, Irvine, is continuing its recruiting initiative in Systems Biology. One position is available in 2013, for which candidates will be considered from all areas of systems biology, including modeling, mathematical and computational biology, biological networks, regulatory dynamics and control, spatial dynamics and morphogenesis, and synthetic biology. Applications are being solicited at the assistant professor level, and appointment can be made in any of several departments, including Developmental and Cell Biology, Molecular Biology and Biochemistry, Ecology and Evolutionary Biology, Biomedical Engineering, Mathematics, Physics and Astronomy, Computer Science, and Statistics. The center highly values candidates with strong backgrounds in modeling and/or computation. Applications at the associate and full professor level will also be considered, with appointment being subject to the availability of funds. The successful applicant is expected to conduct a strong research program and to contribute to the teaching of undergraduate and graduate students.

Systems Biology research and training at UCI is fostered by several interdisciplinary research units, an NIGMS National Center for Systems Biology, and PhD training programs in bioinformatics, and mathematical and computational biology. For more information, applicants should see http://ccbs.uci.edu.

Applicants should submit a letter of application, curriculum vitae, bibliography, three letters of reference, and statements of research and teaching interests using the university's online recruitment system (instructions can be found at http://ccbs.uci.edu or https://recruit.ap.uci.edu, under "Institutes and Centers"). For full consideration, material should be received by December 3, 2012.

The University of California, Irvine, is an equal opportunity employer committed to excellence through diversity, and strongly encourages applications from all qualified applicants, including women and minorities. UCI is responsive to the needs of dual-career couples, is dedicated to work–life balance through an array of family-friendly policies, and is the recipient of an NSF ADVANCE Award for gender equity.

California Institute of Technology

Department of Computing and Mathematical Sciences

The Caltech Department of Computing and Mathematical Sciences (http://www.cms.caltech.edu) invites applications for a tenure-track faculty position. The department is looking for candidates in applied mathematics, computer science, and control and dynamical systems, who have demonstrated exceptional promise through innovative research with strong potential connections to other mathematical, natural, and engineering sciences. A commitment to high-quality teaching and mentoring is also expected. The initial appointment at the assistant-professor level is for four years and is contingent on the completion of a PhD degree in a CMS-related field.

The CMS department is a unique environment in which innovative, multidisciplinary, and foundational research is conducted in a collegial atmosphere.

Applicants can view application instructions and apply online at: http://www.eas.caltech.edu/positions/cms_broad/. Questions about the application process can be directed to: info@cms.caltech.edu. For the fullest consideration, applicants are encouraged to have all their application materials on file by January 1, 2013.

Caltech is an affirmative action/equal opportunity employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

California Institute of Technology

Department of Computing and Mathematical Sciences

Applications are invited for von Karman Instructorships, which are open to candidates who show definite promise in research. Instructorship appointments in computing and mathematical sciences are for one year and are renewable for an additional year. The teaching load is three hours a week for the academic year.

All applicants should apply online at: https://applications.caltech.edu/job/von_karman. Applicants will be asked to submit a resume, a brief statement of teaching interests, and a statement of research plans. Applicants will also be asked to provide the names and e-mail addresses of three references. Full consideration will be given to those applicants who complete their application package before December 1, 2012.

Caltech is an affirmative action/equal opportunity employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

University of California Los Angeles

Institute for Pure and Applied Mathematics

The Institute for Pure and Applied Mathematics at UCLA is seeking an associate director, to begin a two-year appointment on August 1, 2013. The associate director is expected to be an active and established research mathematician or scientist in a related field, with experience in conference organization. The primary responsibility of the AD is running individual programs in coordination with the organizing committees. The selected candidate will be encouraged to continue his or her personal research within the context of the responsibilities to the institute.

More information on IPAM's programs can be found at http://www.ipam.ucla.edu.

For a detailed job description and application instructions, applicants should go to: http://www.ipam.ucla.edu/jobopenings/assocdirector.aspx. Applications will receive fullest consideration if received by February 1, 2013; however, the institute will accept applications as long as the position remains open.

UCLA is an affirmative action/equal opportunity employer.

Princeton University

Program in Applied and Computational Mathematics
Department of Mechanical and Aerospace Engineering

The Program in Applied and Computational Mathematics and the Department of Mechanical and Aerospace Engineering at Princeton University invite applications for a tenure-track assistant professor position in the general field of applied mathematics, in areas relevant to mechanical and aerospace engineering. The program and department are especially interested in candidates who work in nonlinear mechanics; however, applicants in all areas of expertise relevant to mechanical and aerospace engineering will be considered. Applicants must hold a PhD in mathematics, engineering, physics, or a related field, and have a demonstrated record of excellence in research, with evidence of an ability to establish an independent research program.

The Program in Applied and Computational Mathematics is an interdisciplinary and interdepartmental program that provides a home for people working in many fields and directions who share a passion for mathematics and its applications. Its core faculty is presently constituted by 11 faculty members, all of whom hold a joint appointment between a home department and PACM; these core faculty members also function as an executive committee for PACM in all its important decisions. Drawing from a wide range of departments, from the physical sciences and engineering to the biological sciences, PACM counts an additional 48 members of the Princeton faculty among its associate faculty, who provide mentoring and advising to PACM students interested in their fields of expertise. More information about the program can be found at http://www.pacm.princeton.edu.

Applicants should submit a curriculum vitae, including a list of publications and presentations, a summary of research accomplishments and future plans, a teaching statement, and contact information for at least three references online to: http://jobs.princeton.edu. Personal statements that summarize teaching experience and contributions to diversity are encouraged. For full consideration, applications should have been received by December 1, 2012; however, applications will continue to be accepted until the position is filled.

Princeton University is an equal opportunity employer and complies with applicable equal employment opportunity and affirmative action regulations. The program and department seek faculty members who will create a climate that embraces excellence and diversity, with a strong commitment to teaching and mentoring that will enhance the work of both entities and attract and retain students of all races, nationalities, and genders and strongly encourage applications from members of all underrepresented groups.

Illinois Institute of Technology

Department of Applied Mathematics

The Department of Applied Mathematics at IIT in Chicago, Illinois, invites applications for tenured, tenure-track, term, and visiting faculty positions, beginning in August 2013. One of these tenured/tenure-track positions is a possible shared position with the Department of Computer Science. The successful candidates must have earned a PhD degree in (applied) mathematics or a closely related discipline. Candidates for the tenured/tenure-track positions must have demonstrated the potential for outstanding, externally fundable research and be dedicated to excellent teaching. The department is keenly interested in candidates with broad interests who will collaborate in ongoing and future strategic research in applied mathematics and related disciplines and who will provide complementary expertise in areas closely related to those currently represented in the department.

The Department of Applied Mathematics has 14 tenured/tenure-track faculty and four term faculty. The department offers BS through PhD degrees in applied mathematics, plus a Master's of Mathematical Finance that is offered in partnership with the Stuart School of Business. As the only mathematics department at IIT, the Department of Applied Mathematics faculty teaches mathematics to nearly all undergraduate students and many graduate students from other disciplines. Research in the department is funded by NSF, NSA, the Department of Energy, and commercial firms. More about the department and the available positions can be found at http://www.iit.edu/csl/am.

With a very diverse student body of over 7000, IIT is a private, PhD-granting university with programs in engineering, science, human sciences, architecture, business, design, and law. IIT is located in a city-park-like campus designed by the influential 20th-century architect Mies van der Rohe in the heart of the vibrant city of Chicago.

Applicants should submit an application through: http://www.MathJobs.org. Questions regarding this position can be addressed to Fred J. Hickernell, Chair, Department of Applied Mathematics, (312) 567–8983; amsearch@math.iit.edu. The review of applications started in early December 2012 and will continue until the positions are filled.

IIT is an affirmative action/equal opportunity employer and especially encourages applications from women and underrepresented groups.

University of Colorado Denver

Department of Mathematical and Statistical Sciences

The Department of Mathematical and Statistical Sciences at the University of Colorado Denver invites applications for a tenure-track assistant professor position in numerical methods and scientific computing, starting in August 2013. The successful candidate will be expected to develop a strong, independent research program with external funding and to teach a variety of courses at both the graduate and undergraduate levels. A doctoral degree in mathematical sciences or a related area by the start of the appointment is required. The successful candidate should have an excellent record in research commensurate with this career stage, a strong commitment to quality teaching, and research interests compatible with those of present faculty, including numerical solutions of partial differential equations, numerical linear algebra, parallel computing, mathematical modeling, data assimilation, and quantification of uncertainty.

The University of Colorado Denver in downtown Denver and the Anschutz Medical Campus is one of the nation's top public urban research universities. The university owns a major supercomputing facility and large reserved allocations are available. Applicants can see http://math.ucdenver.edu for information about the department.

For further details and application procedures, applicants should see: http://www.jobsatcu.com (job posting 819515). The review of applications will begin January 7, 2013, and will continue until the position is filled. Questions can be sent to julien.langou@ucdenver.edu.

The University of Colorado is committed to diversity and equality in education and employment. The university encourages applications from women, ethnic minorities, persons with disabilities, and all veterans.

University of Colorado Denver

Department of Mathematical and Statistical Sciences

The Department of Mathematical and Statistical Sciences at the University of Colorado Denver invites applications for a tenure-track assistant professor position in statistics, beginning in August 2013. The department seeks candidates with excellent research potential and strong commitment to quality teaching.

For more information, applicants should see the full posting at: http://www.jobsatcu.com (job posting 819855) or contact Stephanie.Santorico@ucdenver.edu. The review of applications will begin January 7, 2013.

The University of Colorado Denver is committed to diversity and equality in education and employment.

Faculty Positions in Applied Operations Research

Cornell is a community of scholars, known for intellectual rigor and engaged in deep and broad research, teaching tomorrow's thought leaders to think otherwise, care for others, and create and disseminate knowledge with a public purpose.

Cornell University's School of Operations Research and Information Engineering (ORIE) seeks to fill one or more tenured/tenure-track faculty positions in Applied Operations Research on the Ithaca campus. Applicants with research interests in supply chain/logistics, information engineering/technology, energy/sustainability, OR and healthcare, or statistics are of primary interest.

Requisite is a strong interest in the broad mission of the School, an ability and willingness to teach at all levels of the program, strong potential for leadership in research and education, and a PhD in Operations Research, Mathematics, Statistics, or a related field by the start of the appointment. Salary will be appropriate to qualifications and engineering school norms.

Cornell ORIE is a diverse group of high-quality researchers and educators interested in probability, optimization, statistics, simulation, and a wide array of applications such as manufacturing, supply chains, scheduling, transportation systems, health care, financial engineering, service systems and network science. We value mathematical and technical depth and innovation, and experience with applications and practice. Ideal candidates will have correspondingly broad training and interests.

Please apply online at **https://academicjobsonline.org/ajo/jobs/2053** with a cover letter, CV, statements of teaching and research interests, sample publications, list of references and, for junior applicants, a doctoral transcript. Applications will be reviewed beginning December 1, 2012 and will be accepted until these positions are filled.

ORIE and the College of Engineering at Cornell embrace diversity and seek candidates who can contribute to a welcoming climate for students of all races and genders. Cornell University seeks to meet the needs of dual career couples, has a Dual Career program, and is a member of the Upstate New York Higher Education Recruitment Consortium to assist with dual career searches. Visit **http://www.unyherc.org/home/** to see positions available in higher education in the upstate New York area. Cornell University is an equal opportunity, affirmative action educator and employer. We strongly encourage qualified women and minority candidates to apply.

Find us online at http://hr.cornell.edu/jobs or
Facebook.com/CornellCareers

Diversity and inclusion have been and continue to be a part of our heritage.
Cornell University is a recognized EEO/AA employer and educator.

香港城市大學
City University
of Hong Kong

Worldwide Search for Talent

City University of Hong Kong is a dynamic, fast-growing university that is pursuing excellence in research and professional education. As a publicly-funded institution, the University is committed to nurturing and developing students' talent and creating applicable knowledge to support social and economic advancement. Currently, the University has six Colleges/Schools. Within the next two years, the University aims to recruit **100 more scholars** from all over the world in various disciplines, including **science**, **engineering**, **business**, **social sciences**, **humanities**, **law**, **creative media**, **energy**, **environment**, and other strategic growth areas.

Applications and nominations are invited for:

Chair Professor/Professor/Associate Professor/Assistant Professor
Department of Mathematics *[Ref. A/094/49]*

Duties : Conduct research in areas of Applied Mathematics including Analysis and Applications, Mathematical Modelling (including biological/physical/financial problems), Scientific Computation and Numerical Analysis, and Probability and Statistics; teach undergraduate and postgraduate courses; supervise research students; and perform any other duties as assigned.

Requirements : A PhD in Mathematics/Applied Mathematics/Statistics with an excellent research record.

Salary and Conditions of Service
Remuneration package will be driven by market competitiveness and individual performance. Excellent fringe benefits include gratuity, leave, medical and dental schemes, and relocation assistance (where applicable). Initial appointment will be made on a fixed-term contract.

Information and Application
Further information on the posts and the University is available at http://www.cityu.edu.hk, or from the Human Resources Office, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong [Fax : (852) 2788 1154 or (852) 3442 0311/email : hrojob@cityu.edu.hk].

Please send the nomination or application with a current curriculum vitae to Human Resources Office. **Applications and nominations will receive full consideration until the positions are filled.** Please quote the reference of the post in the application and on the envelope. Shortlisted candidates for the post of Assistant Professor will be requested to arrange for at least 3 reference reports sent directly by their referees to the Department, specifying the position applied for. The University reserves the right not to fill the positions. Personal data provided by applicants will be used strictly in accordance with the University's personal data policy, a copy of which will be provided upon request.

The University also offers a number of visiting positions through its "CityU International Transition Team" for current graduate students and for early-stage and established scholars, as described at http://www.cityu.edu.hk/provost/cityu_international_transition.htm.

City University of Hong Kong is an equal opportunity employer and we are committed to the principle of diversity. We encourage applications from all qualified candidates, especially those who will enhance the diversity of our staff.

Collaboration Blooms from *SIAM News* Article

By Peter Grindrod, Desmond J. Higham, and Peter Laflin

Last year, two of us (PG and DJH) contributed to a two-part article in *SIAM News* about the growth of social network analysis in business and government [5]. Joined in the present article by Peter Laflin, head of Data Insight at the UK-based digital marketing agency Bloom [1], we describe some developments that followed directly from the *SIAM News* article.

Bloom clients typically wish to monitor and improve their online social media presence. The *SIAM News* article alerted Bloom's Insight team to a discussion of time-dependent networks in [4]. The matrix-based algorithms described there proved to be useful for identifying key players in the large-scale online conversations taking place on topics of interest to Bloom clients. Following this initial success, Bloom made a good old-fashioned telephone call, which has led to the mutually beneficial collaboration briefly reported here. On the academic side, researchers at the Universities of Reading and Strathclyde have advised on cutting-edge developments; Bloom's role has been to provide examples of large data sets, along with some current and future challenges [6].

As an example of knowledge exchange driving new research, our collaboration on a Twitter data set [8,9] flagged the need to identify and categorize spam accounts that generate automated Tweets. That case study also provided the university researchers with a rare benchmarking opportunity—Twitter accounts deemed influential by the computational algorithms could be compared with those picked out from the same data set by a team of social-media experts with day-to-day experience in hand-curating this type of information. Our study found the best computational measures to be essentially indistinguishable from the selections made by human experts.

This fall, Bloom presented an overview of its work at Londata, a regular "big data" event in London. Before the talk, the team ran a preprocessing step in which it assessed the influence of the people who had registered for the event, based on their Twitter footprints. The ten most influential attendees, ranked in terms of their "dynamic broadcast" score from [4], are shown in Table 1. Where available, the table also shows some other measures of influence: number of followers for each account, Klout score [7], and Peer Index score [10].

This initial analysis wasn't conversation-specific: It simply took the 150 people registered for Londata and considered how readily messages could flow between them. The @LondataEvent account is of interest here; its third-place ranking, in our opinion, shows the account to be highly influential. It has a small following, but those people typically amplify messages received from @LondataEvent. This indicates that the dynamic broadcast measure of influence goes far deeper than a simple counting of followers. The measure can also be applied in real time, so the Insight team—at the risk of disappearing into an infinitely recursive puff of smoke—used its analytical tools to calculate influence and visualise the interactions by listening to Twitter activity during the course of Bloom's own presentation on the topic. The team thus recorded and analysed the 290 Tweets made by participants (the audience was made up of digitally savvy types!), updating the influence scores every 5 minutes. Figure 1 shows a snapshot of part of the interaction network during its evolution. This visualisation reveals distinct communities involved in the LonData conversation and highlights the influential Twitter accounts.

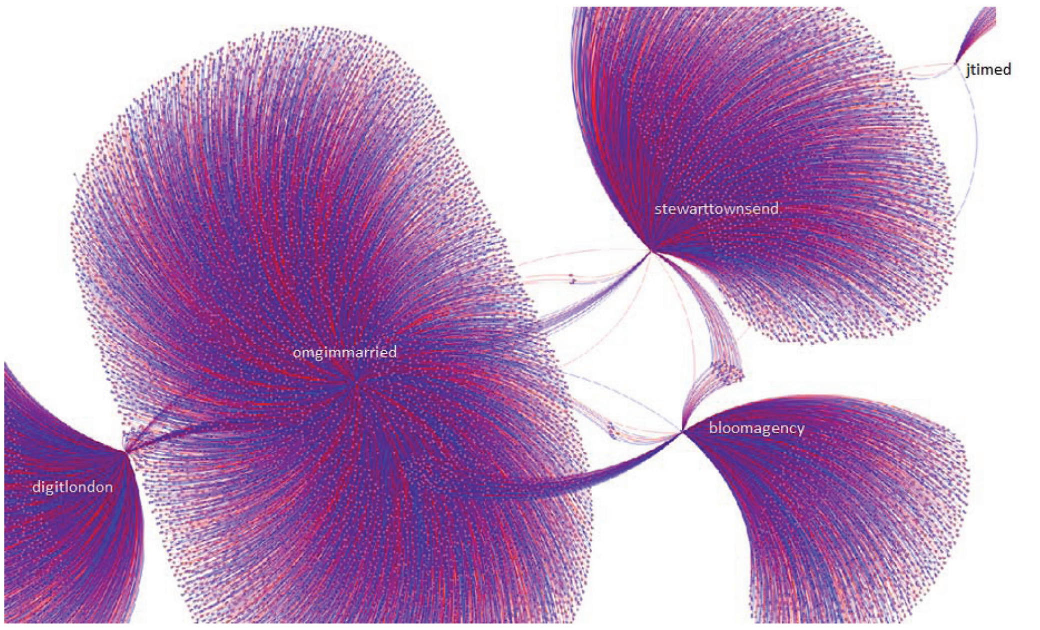

Figure 1. *A snapshot of part of the interaction network during the recording and analysis of 290 Tweets made during a presentation at Londata. The visualisation reveals distinct communities involved in the Londata conversation and highlights influential Twitter accounts.*

Tweets can be rated negatively or positively for "sentiment," and Bloom used its tools to construct a weighted sentiment score that summarizes current feeling on a topic. Alex Craven, the Bloom CEO, began the Londata presentation at 18:20 hours. As shown in Figure 2, his introduction was welcomed with a burst of positive sentiment. The subsequent drop was caused by Peter Laflin's discussion of the three V's of big data (volume, velocity, and variety); people in the audience perhaps wondered whether the talk would have any new and interesting content. The biggest spike of sentiment, at around 20:00, coincided with Bloom's explanation of how the agency's tools successfully predicted that Sweden would win the 2012 Eurovision Song Contest [2], based on Twitter activity during the semifinal shows. The two further peaks in the graph correspond to discussion about the identification of spam accounts.

The influence ranking of the top ten Twitter accounts at the end of the talk is shown in Table 2, in order of dynamic broadcast score. (Number of followers, Klout score, and Peer Index score, which are not topic-specific and do not change over this timescale, are the same as given in Table 1.)

Although the matrix algorithms underlying Bloom's tools arose in academia, and hence are in the public domain [3,4], making them work in the online social media setting involves extra levels of know-how; in particular, creating suitable networks from what can be huge amounts of time-stamped interactions is a key step. The first generation of social media monitoring tools, such as Klout and PeerIndex, judge who is "likely" to influence, whereas Bloom's "big data" approach is to listen to topic-based conversations in real time and measure who is actually influencing. Just as large-scale matrix computations brought order to the web in the guise of Google's PageRank algorithm, they now offer the potential to tame the Twittersphere.

Dynamic Broadcast Rank	Username	Number of Followers	Klout Score	Peer Index Score
1	Omgimmarried	9243	56	
2	Stewarttownsend	3685	53	66
3	LondataEvent	69	24	
4	AlexGraul	570	50	
5	Richard_Edwards	961	53	37
6	Tilapia	539		41
7	duncan3ross	224		
8	Manumarchal	745		37
9	Souterconsults	812		52
10	Cumulyst	633	41	51

Table 1. *The ten most influential attendees who registered for Londata as ranked by their dynamic broadcast score [4], and some other measures of their influence.*

Dynamic Broadcast Rank	
1	Omgimmarried
2	Bloomagency
3	Souterconsults
4	Stewarttownsend
5	FinancialHubris
6	Digitlondon
7	Richard_Edwards
8	PaulMalyon
9	ScroffTheBad
10	Clairehs

Table 2. *The influence rankings of the top ten at the end of a Londata talk this fall.*

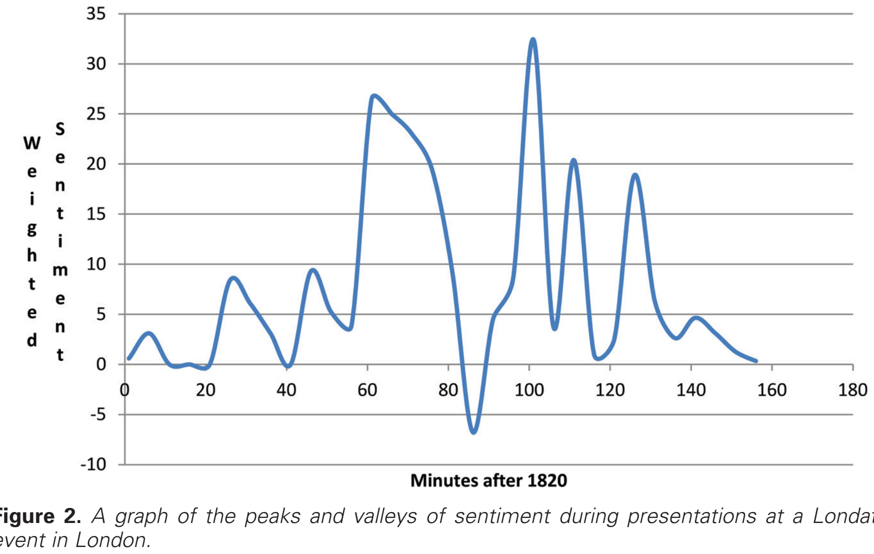

Figure 2. *A graph of the peaks and valleys of sentiment during presentations at a Londata event in London.*

References

[1] Bloom Agency, www.bloomagency.co.uk/.

[2] Eurovision Song Contest 2012, http://www.eurovision.tv/page/baku-2012/about/shows/final.

[3] P. Grindrod and D.J. Higham, *A matrix iteration for dynamic network summaries*, SIAM Rev. (Research Spotlights), to appear.

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