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Energy-efficient Building Design: "A SIAM Kind of Problem"

By Barry A. Cipra

John Burns has a reading list for mathematicians. On it are papers from the journals *Energy and Buildings* and *Building and Environment*. He also recommends the *Journal of Building Performance Simulation* (whose parent organization, IBPSA (the International Building Performance Simulation Association), runs a biennial meeting).

In July, in a joint invited address at the 2013 SIAM Annual Meeting and Conference on Control and its Applications, Burns, a control theorist at Virginia Tech, urged the audience to take advantage of the virtually unlimited opportunities to apply mathematical principles to the problem of designing truly energy-efficient buildings. For inspiration, he showed a series of slides listing dozens of mathematics-intensive papers published in journals most mathematicians have never heard of—those mentioned above are just a few of the possibilities—all in the first half of 2013.

Take, for example, a paper from *Building and Environment*: "Study for Flow and Mass Transfer in Toilet Bowl by Using Toilet Seat Adopting Odor/Bacteria Suction Feature," by Korean engineers Youngjin Seo and Il Seouk Park. "Guess what," Burns says. "Most of that is CFD analysis. Computational fluid dynamics."

The titles, Burns says, make clear that buildings are understood to be complex, multiscale, nonlinear, infinite-dimensional systems with hundreds of components that call for modeling, control, optimization, and other cornerstones of applied mathematics. In short, he says, "It's a SIAM kind of problem."

To be sure, it's a problem that anyone who's ever had a drafty window—or anyone who's ever shivered through a talk in a frigid hotel ballroom—can appreciate. Buildings consume enormous amounts of energy. They account for roughly 39% of total U.S. energy consumption, including 71% of electric power and 54% of natural gas. Each year, Americans pour more than 600 kilowatt-hours per square meter (roughly the rate of consumption of a 60-watt light bulb left on in a clothes closet) into heating, cooling, lighting, and otherwise utilizing their homes, office buildings, shopping centers, warehouses, and manufacturing plants. The Department of Defense alone spends billions of dollars on the energy needs of its more than 300,000 buildings' 2.2 billion square feet. (In comparison, Walmart owns approximately 4400 stores spanning roughly 690 million square feet.) DoD is also concerned that many of its buildings receive their power from the nation's commercial grid, with all the vulnerabilities that that implies.

In 2009, then-secretary of energy Steven Chu cited the need to develop design tools that would reduce the energy consumption of residential and commercial buildings by upward of 80%, with a 10-year return-on-investment target. A 70% reduction, Burns points out, would be equivalent to bringing the entire U.S. transportation system to a halt.

One solution, of course, is obvious, Burns notes. "If you want an energy-efficient building, it's real simple: You turn out the lights, lock the doors, turn off the heat." The challenge, of course, is to create something people can live and work in.

One challenge for mathematicians will be overcoming barriers in the current technological "infrastructure"—models, templates, procedures—of the building design process. Another challenge will be dispelling some misconceptions on the part of building designers about mathematics and mathematical modeling.

The first mathematical challenge is to come up with useful models. The computer tools that designers currently use were not created with optimization and control in mind. Most existing computational tools focus on energy simulations, and although these tools are very good for that purpose, it is nearly impossible to use them for control or optimization. Therein lies one of the misconceptions, Burns says: Many people think that if you can simulate a system, then you can control and optimize it. But mathematicians know better. They need to create new models and new modeling tools that incorporate the powerful techniques of optimization and control; most important, the new tools will need to solve problems of actual significance. "It's not enough to produce a model," Burns says. "You don't want to produce one that's irrelevant."

That isn't a call for super-high-fidelity models. In fact, Burns says, another misconception is that control and optimization are impossible in the absence of high-fidelity simulations. "People in control know that's not true," he says. "We design controllers with some really bad, low-order models,

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The Persistent Challenge of Modeling Traffic Flow

In a blog post about the 2013 Gene Golub SIAM Summer School, Nick Higham (lecturer on matrix functions) commented on some extracurricular aspects of the event, which was held in Shanghai. Particularly taken with "Chinese (motor) cyclists, who carry a wondrous variety of goods on their bikes and ride without any attention to the traffic signals but miraculously seem to avoid accidents," he illustrated the observation with several photographs, including the one shown here. An article on the summer school by three of the students appears on page 8.

Dana Mackenzie also takes traffic as a subject in this issue: "Heterogeneous traffic," he writes, "is a headache not only for traffic but also for traffic modelers"; see page 4.

Multiscale Modeling of Foams

Foams are everywhere—in the head on a beer, in the soapsuds in a kitchen sink . . . . Liquid foams like these are also key ingredients in industrial manufacturing, where they are used in fire retardants, in froth floatation for separating substances, even in baking bread. Solidification of liquid foams can result in solid foams, which have remarkably strong compressible strength because of their pore-like internal structure; a common use of solid foams is in lightweight bicycle helmets.

Devising mathematical and numerical models for evolving foams is daunting. In a foam, thin fluid-containing membranes, called "lamellae," separate pockets of air. As the foam evolves, fluid from the membranes drains into connecting rivers known as "Plateau borders," until one of the membranes ruptures, disturbing the balance of forces between surface tension in the membranes and the trapped air pockets. In the ensuing rearrangement of the bubbles, macroscopic effects of gas dynamics compete with microscopic effects driven by fluid flow and surface tension, until a new equilibrium configuration is reached. All this is accompanied by continuing drainage, until another membrane ruptures and the cycle repeats itself.

What makes the modeling of foams so challenging is the vast range of space and time scales involved [6]. Consider an open, half-empty bottle of beer: It may seem that nothing is happening in the collection of interconnected bubbles near the top, but close examination of the currents in the lamellae separating the air pockets shows slow but steady drainage. With respect to time scales alone, it can take tens to hundreds of seconds for the fluid in a thin lamella to drain. Rupture of a membrane triggers an explosion at hundreds of centimeters a second, after which the imbalanced configuration rights itself to a new stable structure in less than a second. On the spatial side, the membranes are barely micrometers thick, while the large gas pockets can span many centimeters. All told, the biggest and smallest scales differ by roughly six orders of magnitude in both space and time.

Finding a static equilibrium configuration of bubbles, even without considering the fluid mechanics, has been a rich source of mathematical problems for centuries, drawing on aspects of minimal surfaces theory, optimization, partial differential equations, and differential geometry. One of the most powerful tools for computing energy-minimizing configurations in the absence of fluid flow has been Ken Brakke's "Surface Evolver" [1], which constantly readjusts a discretized triangulation of the interface to lower the energy and converge to an optimal structure.

A recent article in *Science* magazine [3] described a mathematical approach developed by Berkeley mathematicians Robert Saye and James Sethian to tackle the combined multiscale effects of large-scale fluid and gas flow, drainage of lamellae, and membrane rupture, all within one computational model. The article caught the attention* of the popular press. According to the accompanying *Science* commentary [5], "This new class of numerical modelers has laid foundations for a fresh start."

Saye and Sethian use a scale-separated approach to split the problem into three distinct phases that cycle continuously. During the rearrangement phase, a cluster of bubbles readjusts itself as surface tension in the membranes pushes on air in the pockets, according to equations of multiphase incompressible flow, until a new macroscopic equilibrium is attained. Once this large-scale equilibrium is reached, the model invokes a drainage stage, in

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*And the fancy—articles that appeared shortly afterward bore such titles as "Heady Mathematics," "The Life Cycle of a Bubble," "The Secret Lives of Bubbles," "Pop the Champagne: Bubble Mystery Solved," and even "Physics Gets Frothy as Mathematicians Dissect Mister Bubble."

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The Remarkable Career of a Pioneering Computational Scientist

By Gail Pieper and Lois Curfman McInnes

Margaret Butler, the first woman named a fellow of the American Nuclear Society, of which she was also an Honorary Lifetime Member, passed away in Illinois on March 8, 2013, at the age of 89. Deeply involved in the mathematics and numerical computations for the design of the Navy's first nuclear submarine reactor, Margaret subsequently became part of the logical design team for several early computers at Argonne National Laboratory. She later headed the first operating system used at Argonne for the IBM 704, was leader of the Applications Programming Section in Argonne's Applied Mathematics Division, and served as director of the National Energy Software Center. Margaret was widely recognized for her contributions to computer architecture and programming, benchmarking and performance measurement, and software standards. She remains an inspiration to anyone interested in working in the computational sciences.

Like many students, Margaret was at first unsure of her career goals. As an undergraduate at Indiana University, she enrolled in the typical basic courses, such as philosophy and social science. But she found them frustrating. One could, she claimed, simply argue different sides to a question. She preferred subjects where one could get the "right" answer. It was when she enrolled in mathematics and statistics courses that she found her lifelong love—she majored in mathematics and graduated with a bachelor's degree in 1944.

Her first job was with the Bureau of Labor Statistics as a statistician in Washington, DC. This was soon followed by a three-year position as a statistician in the U.S. Air Force in Europe. Margaret often spoke of these early experiences, urging young people to take advantage of opportunities to travel and gain a better understanding of their abilities and interests.

On returning to America, Margaret began her long career at Argonne National Laboratory—initially as a "computer." At the time, a computer was a far cry from the giant architectures of today. In fact, a computer was a person, one who carried out numerical calculations—on a slide rule—needed to solve complex engineering problems. Margaret's work involved solving eigenvalue problems, applying relaxation methods to PDEs, and finding Bessel functions for nuclear reactor design studies. She found the work fascinating, though sometimes tedious, she admitted, because the same calculations had to be repeated to verify the results. Such insistence on rigorous testing, as well as perseverance in a task, became an important part of her work ethic, and one she often stressed to those new to computational science.

In 1949, Margaret was invited to join a special project at the Bureau of Labor Statistics. Feeling that her gender and lack of a PhD would make further advancement at Argonne difficult, she decided to accept the invitation. Rather than being discouraged by the obstacles at Argonne, Margaret jumped at the new adventure. We all have a lot of choices, she said, and that is what makes our lives interesting.

Margaret Butler and Rudolph Klein, an engineer at Oak Ridge National Lab, worked on the assembly of the ORACLE computer. Designed at Argonne and constructed at ORNL, ORACLE was in 1953 the world's fastest computer, multiplying 12-digit numbers in .0005 seconds.

Upon completion of the project at BLS, Margaret returned to Argonne to work in the Reactor Engineering Division—the Applied Mathematics Division would be created only much later. Her choice this time was both personal—she married Jim Butler, an Argonne mathematician (with whom she later had a son, Jay)—and professional: Her new title was assistant mathematician.

The next two decades were an exciting time for Margaret. One of her earliest assignments in her new position was to write the floating-point arithmetic system for the AVIDAC computer. Floating-point hardware had not yet been built into computers. Nor were any courses available on computer architecture: She had to learn along with her colleagues—and then teach the material to newcomers! Some would have found it difficult. Margaret called it "the best of times!" After AVIDAC, Margaret moved on to Argonne's next two computers, GEORGE and ORACLE, for which she wrote mathematical subroutines, systems software, reactor applications, and utilities.

Margaret's skills in interacting with scientists and engineers, coupled with her technical expertise, earned her promotions, to group leader for the Reactor Computing Group in 1957 and head of the newly formed Applications Programming Section in 1958. She worked with scientists not only in reactor physics but also in other scientific disciplines and management applications. Creating effective team environments was a critical key to her success.

Margaret also found time to conduct original research. A particularly challenging project was the development of an automatic system for analyzing metaphase chromosome images using Chloe, a new film-scanning and image-processing system developed at Argonne. Another project involved measuring fragmentation residues on films from chemical engineering studies of physical and chemical interactions between reactor structure and fuel materials.

But Margaret may be most remembered for her contributions as director of the National Energy Software Center (NESC), from 1972 to 1991. Under her leadership, the center expanded from its small beginnings as the Argonne Code Center to became the software exchange and information center for the U.S. Department of Energy and the Nuclear Regulatory Commission. For almost two decades, Margaret led an ever-expanding staff responsible for collecting, packaging, and distributing software. Her role was not without controversy. Her insistence on rigorous testing was viewed by some as just a way to slow the use of their products. Today, this very insistence on testing has become paramount!

After "retiring" in 1991, Margaret remained deeply interested in the role of women in science; acknowledging that women still did not constitute a critical mass in computer science, she exhorted them to work hard, take lots of math courses, and participate in activities of professional societies. A mentor and role model herself, she continued to work at Argonne from 1993 to 2006 as a special-term appointee. With colleagues, she formed the Chicago-area chapter of the Association for Women in Science, which sponsored career conferences for middle-school and high-school students, and helped pave the way for Argonne's annual Science Careers in Search of Women event.

Margaret may be most remembered for her contributions as director of the National Energy Software Center (1972–1991).

Margaret will be remembered as a pioneer, from her work as a "computer" to her achievements as a computer scientist. Her motto: Onward and Upward! Her analytical talents, vision, and drive led to a lifetime of scientific contributions—and helped build a foundation for the emergence of computational science as a peer in the process of scientific discovery with experimental and theoretical research.*

In memory of Margaret Butler, the Argonne Leadership Computing Facility

See **Margaret Butler** *on page 3*

*For further details, see *Margaret Butler: One Woman's Life in Science*, by Margaret Butler and Holly Stump, SemiWiki Forum, 2013, http://www.semiwiki.com/forum/content/2128-margaret-butler-one-woman%92s-life-science.html.

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Building Design

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and they work well in practice because the controllers are designed to be robust."

The algorithms do need to be able to deal with everything from a single room in a small house to an entire complex of skyscrapers. "The methods have to be scalable, and you want them to interface with other control tools," Burns notes. They will also need to cope with unpredictability. Buildings are monuments to uncertainty, both in the physical conditions they face (most notably the weather) and in the ways they are utilized, with people coming and going and using or ignoring the amenities provided: An auditorium that's comfortable with a hundred people in it can be a furnace with a thousand, or an icebox with a dozen.

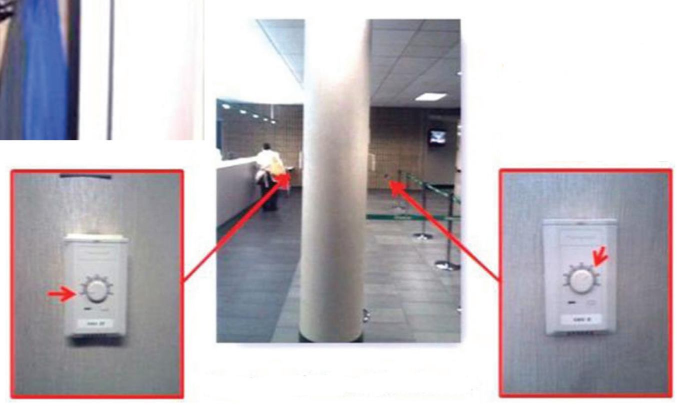

Figure 1. *Optimal thermostat placement? The thermostat in the hotel room shown at left had been placed in a closet. A pillar in an airport concourse (below, courtesy of Bryan Eisenhower) had thermostats on opposing sides, set at different temperatures.*

Often overlooked in this area is the power that mathematical analyses can bring to bear on integrating the various aspects of energy efficiency. One of the most telling misconceptions, Burns says, is summed up in the words of one building designer: "I don't need a mathematical model or a supercomputer to tell me where to put a thermostat."

In the San Diego talk, Burns followed this up with a couple of photographs (Figure 1): One, which he had taken in a hotel room, showed the thermostat conveniently located inside a closet. The other, supplied by a colleague, showed a pillar in the middle of an airport concourse with thermostats on opposing sides; a pair of close-ups for the latter revealed that the two thermostats were set at different temperatures.

Burns continued with a small case study he and colleagues had done for the optimal placement of a thermostat in a two-bed hospital room. A simple floor plan showed the locations of doors and airvents in the room and adjacent bathroom. After glancing at the plan, a building designer concluded that the thermostat should be positioned beside the door between the room and bathroom. Burns's group let math decide on the placement. They set up and solved a system of convection–diffusion equations based on airflow patterns in the room. Then, taking a brute-force approach, they "marched" the thermostat around the room, looking for the position that gave the most accurate indication of the actual ambient temperature in the room. The designer's choice of a position beside the door, they found, wasn't bad, but a far better choice turned out to be on the wall directly opposite that door. Just a modicum of optimization can, in principle, improve comfort while simultaneously cutting the costs of heating and cooling. Even better would be to model the whole enchilada, optimizing placement not just of the thermostat, but also of the airvents.

What the designer accomplished in a glance, however, chewed up 22 hours of a desktop computer's time. But that was because the mathematicians intentionally used a slow, brute-force algorithm. To make their methods practical, so that they can apply not just to a single room but to entire buildings, mathematical modelers will need to take "smart" approaches, Burns notes. Even in an age of petaflop machines, algorithms still rule. Burns's group adopted just such an approach: Using a PDE trust-region algorithm and a multigrid-like optimization model, they were able to reduce the computation by an order of magnitude on the same workstation.

How much of a dent can math make in the world of energy-efficient building design? "There are possibilities for short-term successes," Burns says. "You're not going to be able to do all buildings this way. But big-box stores and cookie-cutter stores are where I think we could make big impact." If one run of an algorithm can cut the costs of operating a hundred identical buildings, the computer cycles will be well worth it.

Barry A. Cipra is a mathematician and writer based in Northfield, Minnesota.

Obituaries

Yuri Vasilyevich Prokhorov

Yuri Vasilyevich Prokhorov was born in December of 1929 and died in July 2013 at the age of 83. He received his doctorate at Moscow State University, under the guidance of Andrey Kolmogorov. That was in 1956, a time when activity in probability theory was at its peak in the former Soviet Union.

Prokhorov's thesis, which dealt with weak convergence of probability measures on complete separable metric (Polish) spaces, continues to play an important role in the theory of stochastic processes. Prokhorov's compactness criterion for families of probability measures on a Polish space is a standard tool in proving limit theorems for stochastic processes. He made important contributions to probability as well as to statistics.

A member of the Russian Academy of Sciences, Prokhorov spent most of his professional life at the Steklov Institute of Mathematics, where he succeeded Kolmogorov as head of the probability section. He was the recipient of many honors, including the Lenin Prize.

For more than 40 years, Prokhorov was editor-in-chief of *Teoriya Veroyatnostei i ee Primeneniya*, the Soviet–Russian journal in applied probability that SIAM has long published in translation as *Theory of Probability and Its Applications*.—*S.R.S. Varadhan, Courant Institute of Mathematical Sciences, New York University*.

Margaret Butler

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(ALCF) has created a new postdoctoral fellowship that offers computational scientists an opportunity to work at the forefront of high-performance computing.

ALCF invites outstanding postdoctoral candidates, both male and female, to apply for the Margaret Butler Fellowship in Computational Science, a one-year appointment that can be renewed for a second year. As one of two leadership-computing facilities supported by the U.S. Department of Energy, ALCF provides the computational science community with a world-class computing capability dedicated to accelerating breakthrough science and engineering discoveries for humanity. Additional information can be found at http://www.alcf.anl.gov/margaret-butler-fellowship-computational-science.

Gail Pieper is a coordinating writer/editor and Lois Curfman McInnes is a senior computational scientist in the Mathematics and Computer Science Division at Argonne National Laboratory.

Smells Like a Traffic Jam

By Dana Mackenzie

Next time you're at a picnic and you discover a procession of ants marching over your meal, wait just a second before you throw your hamburger into the nearest trash can. Take a moment to admire the rapid, purposeful flow of traffic on the ant highway. Pause to appreciate what you *don't* see: stopped ants.

Now compare this ant highway to an interstate highway through any large American city at rush hour. Whether it's Route 5 in Seattle or Route 95 outside Washington, DC, the story will be the same—long lines of stopped vehicles.

What gives? What do ants know that we don't know? And more importantly, is there anything we can do to make our highways a little bit more like ant highways?

Those are some of the questions studied by Katsuhiro Nishinari, a self-described "jam-ologist" at the University of Tokyo, who spoke about traffic at this year's SIAM Annual Meeting in San Diego. "Jam-ology is a very interdisciplinary study," says Nishinari. "It extends not only to vehicles and ants but also pedestrians, schools of fish in the water, or inventory in a warehouse."

Even the brain has some similarities to a traffic network, as another traffic expert points out. "They are both consensus-like systems with nearly identical equations," says Sean Brennan of Pennsylvania State University. "I don't think it's a coincidence that the 1-dimensional shock-wave behavior of vehicle traffic jams is remarkably similar to the 2-dimensional neural behavior that manifests itself as seizures."

Traffic engineers, physicists, biologists, and mathematicians have been modeling different kinds of traffic for more than 75 years, and they have come up with a wide variety of mathematical models. And yet, we still don't have an answer even to some simple questions, such as: Can one person unblock a traffic jam?

Let's get back to those ants. One of the main things that makes them different from humans is a specialized sense of smell. According to Nishinari, their ability to detect pheromones excreted by other ants gives them a way to estimate the density of ants in their immediate vicinity. Unlike humans at rush hour, ants won't let the density exceed a critical level beyond which the flux of ants would start to decrease. Another thing they won't do is pass one another. And they always maintain a safe following distance. As a result, they tend to form large platoons that move in a synchronized fashion to their goals. If humans adopted these three simple behaviors, we would be a long way toward curing our traffic woes.

Technological Fixes for Selfish Humans

Perhaps it's hopeless to expect humans to behave this way—we're just too selfish. Moreover, we have no incentive to change. If just one driver chose to obey these rules, it wouldn't make any difference as long as other drivers continued in their normal selfish ways.

But technology can encourage us to behave more altruistically. Metering lights on highway entrance ramps are intended to keep the density of traffic below a critical level. High-occupancy vehicle lanes have the same purpose, along with another, less obvious benefit: They reduce the amount of lane-changing. According to Michael Cassidy, a civil and environmental engineer at the University of California at Berkeley, people often overlook this point. "Even if the special lane is underused, even if it's only 60% filled, the net benefit to *all* traffic can be positive. There is less lane changing between the adjacent lanes, and that means less lane changing near the bottlenecks."

Another technological innovation just starting to show up on the world's roads is automatic cruise control. Nishinari consulted on the development of a system called CyberNavi (sold by Pioneer Electronics in Japan, but not in the U.S.), that warns drivers when they get within 40 meters of the car ahead. More ambitious systems, already under development in Europe, will enable cars to "talk" to each other and to the infrastructure of the highway. Using wireless communication and GPS devices, cars will tell the highway where they are and what the conditions are around them. In turn, the highway will warn them of traffic jams up ahead, enabling them to slow down in advance. If *everybody's* car has the technology, it will keep all the cars spaced far enough apart to give the jam a chance to dissipate. It's the next best thing to ant pheromones.

You don't have to wait, however, if a retired engineer and amateur scientist named Bill Beaty is right. In 1998, Beaty wrote the following Internet post about an impromptu experiment he had conducted on State Route 520 near Seattle:

"Rather than repeatedly rushing ahead with everyone else, only to come to a halt, I decided to try to move at the average speed of the traffic. I let a huge gap open up ahead of me, and timed things so I was arriving at the next 'stop-wave' just as the last red brakelights were turning off ahead of me.

"Finally I happened to glance at my rear-

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What's in a Model?

The earliest traffic models described traffic as a fluid with no individual cars. Such models are called *macroscopic*, because they depend only on large-scale variables, such as the average density and velocity of traffic. One valuable insight provided by these models is the *fundamental diagram*, which conveys the important information that on any road the flux of traffic (i.e., the velocity times the density) increases only up to a certain density, and then it starts to decrease. This is, in a nutshell, why jams occur.

Unfortunately, fluid models have certain undesirable features. They predict that traffic jams should travel in either direction from a bottleneck; in practice, though, jams travel in only one direction: upstream. Fluid models also tend to have a rather unrealistic fundamental diagram. Empirical data show that at high densities, traffic enters a synchronized state in which all the cars travel at almost the same velocity. As soon as a disturbance happens (for example, one driver hits the brakes), the synchrony is broken and the flux drops, creating a "phantom traffic jam," i.e., one with no visible cause, such as an accident or bottleneck. The very existence of *two* equilibrium states—one stable and the other metastable—violates a central tenet of the basic fluid models.

In recent years, traffic modelers have turned more toward microscopic models, which simulate every single car. *Cellular automaton* models are discrete in both time and space, representing the road as a row of cells that cars move into and out of at each time step. The most realistic class of models attempts to describe drivers' actual behavior—representing the rate at which they accelerate as a function of the headway (distance between cars) or any other variables the modeler deems relevant. These models lead to huge systems of differential equations, either deterministic or stochastic, with as many variables as vehicles on the road. Another drawback of microscopic models is that the difficulty of acquiring experimental data on individual drivers makes all such models somewhat speculative.—*DM*

Traffic Jams

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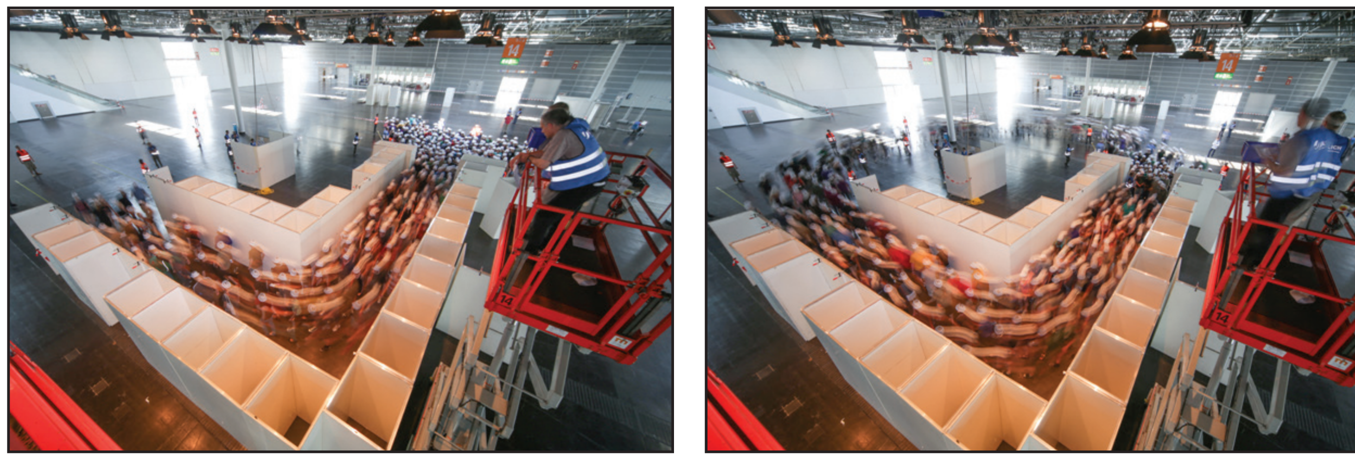
view mirror. There was an interesting sight. . . . In the neighboring lanes I could see maybe five of the traffic stop-waves. But in the lane behind ME, for miles, TOTALLY UNIFORM DISTRIBUTION. . . . By driving at the average speed of traffic, my car had been 'eating' the traffic waves." [Emphasis present in original.]



In this experiment conducted in 2013 in Dusseldorf, pedestrians in encoded hats round a corner. The experiments were intended to provide data on how traffic jams form in pedestrian traffic. The first few pedestrians travel unimpeded around a corner (left). Later, a wave of congested traffic forms in advance of the corner and the velocity of the pedestrians through the corner decreases. Photos courtesy of Forschungszentrum Jülich/Ralf Eisenbach; readers can find additional illustrations of the pedestrian experiment online in the November issue of SIAM News.

Because his article was not published in a scientific journal, Beaty's home-brewed experiment did not attract a lot of attention. Last year, though, Nishinari and three co-authors put "jam-absorption driving" to the test. In a simple computer model of a single-lane road, they confirmed that Beaty's strategy works. "Slow-in, fast-out" driving, even by one driver, could give an already-formed jam time to dissolve and also prevent the creation of new jams behind the jam-absorbing driver. Beyond that, Nishinari and his colleagues showed (in work not yet published) that the total fuel consumption of *all* the vehicles on the highway would be decreased by as much as 35%. Thus, one person can make the driving experience more pleasant for everyone *and* benefit the environment.

Jam-absorbing Drivers

Before you go out and try to drive like Beaty, it's important to be aware of certain caveats. First, the model Nishinari's group used was extremely simplistic. The "fast-out" part of the model (which was not part of Beaty's experiment) was actually instantaneous, which is both physically impossible and extremely unwise. Even if you could accelerate instantaneously, you would run into the car ahead of you unless it was doing the same thing. Also, the model did not take into account the likelihood that the big gap in front of a jam-absorbing driver would encourage drivers from other lanes to cut in front of him.

Other jam-ologists have differing opinions. "The 'slow into a jam' strategy is in complete accord with our prior work," says Brennan. He and his student Kshitij Jerath have work in progress that leads to a similar conclusion, but with a catch. There appear to be "event horizons" such that a car outside the event horizon can eat the jam, although a car inside the event horizon cannot have any effect. Brennan also thinks, based on intuition rather than study, that a gap of more than 5 MPH between your speed and your neighbors' speeds would lead to more accidents—which certainly would not solve the jam problem.

Cassidy, by contrast, is very skeptical of one car's ability to affect a traffic jam. "The name of the game should be one thing and one thing only, maximizing discharge rate from your bottleneck," he says. Because the "slow-in" phase doesn't affect anything downstream of the bottleneck, he thinks that it cannot address the root of the problem.

Adaptive cruise control (ACC) should, in principle, be even better than manual "jam-absorption," and it's based on a similar principle—slowing down long in advance of the "event horizon." But Brennan and Jerath have shown that a little bit of a good thing can actually turn out badly. They studied a traffic model with two populations of cars. The cars in one group, with a "sensitivity" of 0.3 to the actions of the car in front of them, would correspond to cars not equipped with automatic cruise control. The other group, with a sensitivity of 0.7, would be cars with ACC systems that could detect when the car in front was slowing down, and react accordingly.

When almost all the vehicles on the road had ACC, Brennan and Jerath showed that the highway could accommodate twice as much traffic before starting to jam. But the increased capacity came with a cost: The flow of traffic became highly vulnerable to the introduction of just a few non-ACC vehicles. If the number of ACC-equipped vehicles decreased from 95% to 90%, for instance, the road's capacity would decrease significantly. If the density was already close to capacity when the non-ACC vehicles joined the flow, traffic would almost certainly jam. The result suggests that ACC-equipped vehicles should get a separate lane, if and when these systems become popular. But the lane restriction would need to be enforced very strictly.

Heterogeneous traffic (made up, say, of vehicles with and without ACC) is a headache not only for traffic but also for traffic modelers. A team led by Saskia Ossen of the Delft University of Technology recently showed that none of the seven leading traffic models predicted the behavior of heterogeneous traffic accurately, when compared to real data extracted from high-speed videos taken from a helicopter. The models include lots of parameters that describe the average behavior of drivers. But a highway where half the vehicles have sensitivity 1 and half have sensitivity 0 will behave very differently from a highway where all the vehicles have sensitivity 0.5. Now imagine a highway with buses, trucks, ACC-equipped vehicles, non-ACC-equipped vehicles . . . Or even worse, go to India, where pedicabs, motorcycles, and elephants are added to the mix.

Investing in Pedestrian Traffic

The elephants bring up a final interesting point. Though we usually think of traffic as a problem involving vehicles, some of the least-understood traffic problems involve pedestrians (of the two-legged variety). According to Tobias Kretz, a project manager for Viswalk, a pedestrian simulation developed by PTV in Karlsruhe, Germany, it's partly a matter of cost. When you build a road, you'll do a traffic simulation because the relative cost is small. That's not true when you build a sidewalk. However, pedestrian flow becomes very important during major events like the Olympic Games. PTV has consulted with the organizers of the Vancouver, London, and Rio de Janeiro Olympics to get fans to their desired events faster.

Because the behavior of pedestrians has been studied much less than that of vehicles, Kretz had to develop his own simulations from the ground up. This year, though, a group of researchers led by Frank Fiedrich of Wuppertal University conducted experiments with 1000 pedestrians to see how they behaved when forced to go around corners or when funneled through a narrow entrance. Kretz looks forward to comparing his models to the group's field data.

It may not be obvious, but research on pedestrian traffic is important for automobile traffic, too. According to the Downs–Thompson paradox, travel times in a big city tend to an equilibrium at which all methods of transportation will get you to your destination in the same time. Therefore, the transportation system is only as strong as its weakest link. If societies invest more in road traffic but neglect public transportation or pedestrian traffic, the result may be increased travel times. "We will just blow up the area extent of our cities, implying longer trip length, implying more people choosing the car instead of cycling or walking," Kretz says. "If we invest in pedestrian traffic, cycle paths, and comfortable walking routes, the spiral will go the other direction." For this reason, Kretz is skeptical of technological improvements like adaptive cruise control, special lanes, or adaptive speed limits. "I doubt that road jams can be prevented with measures for road traffic only. What we need is innovation in walking, cycling, and public transport."

Dana Mackenzie writes from Santa Cruz, California.

Professional Opportunities

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

Advertising copy must be received at least four weeks before publication (e.g., the deadline for the January/February 2014 issue is December 13, 2013).

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

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

www.siam.org/careers

Institute for Advanced Study

School of Mathematics

The School of Mathematics at the Institute for Advanced Study, in Princeton, New Jersey, will have a limited number of one- and two-year memberships with financial support for research in mathematics and computer science at the institute for the 2014–15 academic year. The school frequently sponsors special programs; however, these programs comprise no more than one-third of the membership so that a wide range of mathematics can be supported each year. "The Topology of Algebraic Varieties" will be the topic of the special program in 2014–15. Claire Voisin, of the Institut de Mathématiques de Jussieu, will be the school's Distinguished Visiting Professor and lead the program. More information about the special program can be found on the school's homepage (http://www.math.ias.edu/).

Several years ago the school established the von Neumann Fellowships. Up to eight of these fellowships will be available for each academic year. To be eligible for a von Neumann fellowship, applicants should be at least five, but no more than 15, years after receipt of a PhD. Veblen Research Instructorships are three-year positions that were established in partnership with the Department of Mathematics at Princeton University in 1998. Three-year instructorships will be offered each year to candidates in pure and applied mathematics who have received a PhD within the last three years. Usually, Veblen research instructors spend their first and third years at Princeton University; these years will carry regular teaching responsibilities. The second year is spent at the institute and dedicated to independent research of the instructor's choice.

Candidates must have given evidence of ability in research comparable with at least that expected for a PhD degree. Postdoctoral applicants in computer science and discrete mathematics may be interested in applying for a joint (two-year) position with one of the following: Department of Computer Science at Princeton University, http://www.cs.princeton.edu; DIMACS at Rutgers, The State University of New Jersey, http://www.dimacs.rutgers.edu; or the Intractability Center, http://intractability.princeton.edu. For a joint appointment, applicants should apply to the School of Mathematics, as well as to one of the listed departments or centers, noting their interest in a joint appointment.

Applicants can request application materials from: Applications, School of Mathematics, Institute for Advanced Study, Einstein Drive, Princeton, NJ 08540; applications@math.ias.edu. Applications can also be found online at: https://applications.ias.edu. The deadline for all applications is December 1, 2013.

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

College of Engineering: Open Rank Faculty

Department of Aerospace Engineering
College of Engineering
University of Illinois at Urbana-Champaign

The Department of Aerospace Engineering at the University of Illinois at Urbana-Champaign is seeking highly qualified candidates for multiple faculty positions in all areas of aerospace engineering, with emphasis on aerodynamics, autonomous aerospace systems, space systems, aeroelasticity, and aerospace materials and structures. Particular emphasis will be placed on qualified candidates who work in emerging areas of aerospace engineering and translate their scholarly activities into high impact applications.

Please visit **http://jobs.illinois.edu** to view the complete position announcement and application instructions. Full consideration will be given to applications received by **November 1, 2013**. Applications received after that date will be considered until positions are filled.

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National University of Singapore

Department of Mathematics

The Department of Mathematics at the National University of Singapore invites applications for tenured, tenure-track, and visiting positions at all levels, beginning in August 2014. The department seeks promising scholars and established mathematicians with outstanding track records in any field of pure and applied mathematics. The department, housed in a newly renovated building equipped with state-of-the-art facilities, offers internationally competitive salaries with start-up research grants, as well as an environment conducive to active research, with ample opportunities for career development. The teaching load for junior faculty is kept especially light. The department is particularly interested in, but not restricted to, considering applicants specializing in any of the following areas: Ergodic theory and dynamical systems; partial differential equations and applied analysis; computational science, imaging, and data science; operations research and financial mathematics; and probability and stochastic processes.

NUS is a research-intensive university that provides quality undergraduate and graduate education. The Department of Mathematics has about 65 faculty members and teaching staff, whose expertise cover major areas of contemporary mathematical research. For further information about the department, applicants should visit http://www.math.nus.edu.sg.

Application materials should be sent via e-mail (as PDF files) to the Search Committee at: search@math.nus.edu.sg. Applicants should include the following supporting documentation in an application: (1) an American Mathematical Society Standard Cover Sheet; (2) a detailed CV, including a list of publications; (3) a statement (maximum of three pages) of research accomplishments and plans; and (4) a statement (maximum of two pages) of teaching philosophy and methodology. Applicants should attach evaluations of teaching from faculty members or students at their current institutions, where applicable, and arrange for at least three letters of recommendation, including one that indicates effectiveness in and commitment to teaching. Applicants should ask their referees to send their letters directly to: search@math.nus.edu.sg; inquiries can also be sent to this e-mail address. The review process will begin on October 15, 2013, and will continue until the positions are filled.

Southern Methodist University

Dedman College
Department of Mathematics

Applications are invited for the Clements Chair of Mathematics (Position No. 00050961), to begin in the fall semester of 2014. The department is searching for senior scholars with outstanding records of research in computational and applied mathematics as well as a strong commitment to teaching, including an established history of advising doctoral students. The department is seeking candidates whose interests align with those of the department and who would contribute in a substantial way to the university's initiatives in high performance computing and interdisciplinary research. A PhD in applied mathematics or a related field is required.

SMU, a private university with active graduate and undergraduate programs in the sciences and engineering, is situated in a quiet residential section of Dallas. The Dallas–Fort Worth Metroplex is America's fourth largest metropolitan area, and residents enjoy access to world-class cultural and entertainment activities.

The Department of Mathematics offers graduate degrees in computational and applied mathematics and includes 16 tenured or tenure-track faculty researchers, all of whom work in application areas. Applicants should visit http://www.smu.edu/math/ for more information about the department.

Applicants should send a letter of application, a curriculum vitae, a list of publications, research and teaching statements, and the names of three references to: Faculty Search Committee, Department of Mathematics, Southern Methodist University, P.O. Box 750156, Dallas, TX 75275–0156. The Search Committee can also be contacted at: (214) 768–2452; fax: (214) 768–2355; mathsearch@mail.smu.edu. Applications received by November 1, 2013, will receive full consideration; however, applications will continue to be accepted until the position is filled. Applicants will be notified when the search is concluded.

SMU will not discriminate on the basis of race, color, religion, national origin, sex, age, disability, genetic information, or veteran status. SMU's commitment to equal opportunity includes nondiscrimination on the basis of sexual orientation and gender identity and expression. Hiring is contingent on the satisfactory completion of a background check.

Dartmouth College

Department of Mathematics

Applications are invited for John Wesley Young Research Instructorships. These positions are for new or recent PhD recipients whose research overlaps a department member's and are available for two to three years. Instructors teach three ten-week courses spread over three terms; appointment is for 26 months, with possible renewal for 12 months. Monthly salary is $5100, including a two-month research stipend for instructors in residence during two of three summer months; for those not in residence for 11 months, salary is adjusted accordingly.

Applicants should apply online at: http://www.mathjobs.org, Position ID: JWY #4928. Applicants can also access an application through a link at http://www.math.dartmouth.edu/activities/recruiting/. General inquiries can be directed to Tracy Moloney, administrator, Department of Mathematics, tfmoloney@math.dartmouth.edu. Applications completed by January 5, 2014, will be considered first.

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

Georgia Institute of Technology

School of Mathematics

The School of Mathematics at Georgia Tech is accepting applications for faculty positions at all ranks and in all areas of pure and applied mathematics and statistics. Applications by highly qualified candidates, and especially those from groups underrepresented in the mathematical sciences, are particularly encouraged.

Applicants should see http://www.math.gatech.edu/resources/employment for more details and application instructions.

See **Opportunities** *on page 7*

Faculty Positions

School of Operations Research & Information Engineering (ORIE)

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 up to two tenured/tenure-track faculty positions for its Ithaca campus. Applicants with research interests in all areas of operations research and information engineering will be considered, but applicants in areas aligned with the School's current strategic plan will receive primary consideration: the plan seeks to strengthen the School's leading role in advancing the analytical, methodological, and modeling tools of operations research together with the potential of "Big Data" and the information revolution.

Requisite is a strong interest in the broad mission of the School, exceptional potential for leadership in research and education, an ability and willingness to teach at all levels of the program, 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, e-commerce, 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/3039** with a cover letter, CV, statements of teaching and research interests, sample publications, list of reference letter writers and, for junior applicants, a doctoral transcript. Applications will be reviewed starting on October 1, 2013 (prior to the annual INFORMS conference); although all applications completed by November 15, 2013, will receive full consideration, candidates are urged to submit all required material as soon as possible. Applications will be accepted until the 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

Cornell University is an innovative Ivy League university and a great place to work. Our inclusive community of scholars, students and staff impart an uncommon sense of larger purpose and contribute creative ideas to further the university's mission of teaching, discovery and engagement. Located in Ithaca, NY, Cornell's far-flung global presence includes the medical college's campuses on the Upper East Side of Manhattan and in Doha, Qatar, as well as the new CornellNYC Tech campus to be built on Roosevelt Island in the heart of New York City.

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

Department of Electrical and Systems Engineering

Penn Engineering

Tenured/Tenure-Track Faculty Position

The Department of Electrical and Systems Engineering of the School of Engineering and Applied Science at the **University of Pennsylvania** invites applications for tenured and tenure-track faculty positions at all levels. Candidates must hold a Ph.D. in Electrical Engineering, Systems Engineering, or related area. The department seeks individuals with exceptional promise for, or proven record of, research achievement, who will take a position of international leadership in defining their field of study, and excel in undergraduate and graduate education. Leadership in cross-disciplinary and multi-disciplinary collaborations is of particular interest. We are interested in candidates in all areas that enhance our research strengths in

1. Nanodevices and nanosystems (nanophotonics, nanoelectronics, integrated devices and systems at nanoscale),
2. Circuits and computer engineering (analog and digital circuits, emerging circuit design, computer engineering, embedded systems), and
3. Information and decision systems (communications, control, signal processing, network science, markets and social systems).

Prospective candidates in all areas are strongly encouraged to address large scale societal problems in energy, transportation, health, economic and financial networks, critical infrastructure, and national security. Diversity candidates are strongly encouraged to apply. Interested persons should submit an online application at **http://facultysearches.provost.upenn.edu/postings/40** including curriculum vitae, statements of research and teaching interests, and the names of at least four references. Review of applications will begin on December 1, 2013.

The University of Pennsylvania is an Equal Opportunity Employer.
Minorities/Women/Individuals with Disabilities/Veterans are encouraged to apply.

Opportunities

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University of Toronto

Department of Mathematical and Computational Sciences, UT Mississauga
Department of Mathematics, UT St. George Campus

The Department of Mathematical and Computational Sciences, University of Toronto Mississauga, and the Department of Mathematics, University of Toronto, St. George campus, invite applications for two tenure-stream appointments at the rank of assistant professor in the area of applied mathematics. The expected start date of the appointments is July 1, 2014.

All qualified applicants are invited to apply at the following link: https://www.mathjobs.org/jobs/jobs/4921. For full consideration, applications should be received by November 15, 2013.

The University of Toronto is strongly committed to diversity within its community and especially welcomes applications from visible minority-group members, women, Aboriginal persons, persons with disabilities, members of sexual minority groups, and others who can contribute to the further diversification of ideas. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

North Carolina State University

Department of Mathematics

The Department of Mathematics at North Carolina State University invites applications for the LeRoy Martin Professorship in Mathematics. The department is seeking exceptionally well-qualified, world-renowned individuals with research interests compatible with those in the department. All areas of pure and applied mathematics will be considered. Candidates must have a PhD in the mathematical sciences. Applicants must have an internationally recognized research program, demonstrated ability to attract external funding, a strong record of mentoring PhD students and postdocs, and a commitment to effective teaching at all levels.

Many members of the department participate in interdisciplinary programs and research groups on campus and in the broader Research Triangle community. More information about the department can be found at http://www.math.ncsu.edu.

Application materials should be submitted to: http://www.mathjobs.org/jobs/ncsu. Applications must include a vita, at least four letters of recommendation, and a description of current and planned research. Applicants will then be given instructions to go to http://jobs.ncsu.edu/postings/4072 and complete a Faculty Profile for the position.

NC State is an affirmative action/equal opportunity employer. NC State welcomes all persons without regard to sexual orientation. The College of Sciences welcomes the opportunity to work with candidates to identify suitable employment opportunities for spouses or partners.

Boston University

Department of Mathematics and Statistics

The Department of Mathematics and Statistics at Boston University invites applications for a three-year postdoctoral position in dynamical systems, pending final budgetary approval, starting in July 2014. Strong commitment to research and teaching is essential.

Applicants should submit an AMS cover sheet, CV, research statement, teaching statement, and at least four letters of recommendation, one of which addresses teaching, to: http://mathjobs.org. Alternatively, applicants can send all material to: Dynamical Systems Postdoctoral Search Committee, Department of Mathematics and Statistics, Boston University, 111 Cummington Mall, Boston, MA 02215. The application deadline is December 15, 2013.

Boston University is an affirmative action/equal opportunity employer.

University of Michigan

Department of Mathematics

The Department of Mathematics at the University of Michigan is initiating a multi-year search for anticipated appointments, pending approval, at the level of tenure-track assistant, associate, or full professor. These will be university-year appointments, to begin September 1, 2014 or 2015. Applicants at all ranks are encouraged to apply. Applicants should hold a PhD in mathematics or a related field (e.g., statistics); have extraordinary credentials in any area of pure, applied, computational, or interdisciplinary mathematics; and show outstanding promise and/or accomplishments in both research and teaching. Salaries are competitive and are based on credentials. Junior candidates should furnish a placement dossier consisting of a letter of application, curriculum vitae, and three letters of recommendation; senior candidates should send a letter of application, curriculum vitae, and the names of three suggested references. In all cases, applicants should provide a statement of teaching philosophy and experience, evidence of teaching excellence, and a statement of current and future research plans.

More detailed information regarding the department can be found on the department's website: http://www.math.lsa.umich.edu.

Application materials should preferably be submitted electronically through the AMS website: http://mathjobs.org. Alternatively, applications can be sent to: Personnel Committee, University of Michigan, Department of Mathematics, 2074 East Hall, 530 Church Street, Ann Arbor, MI 48109–1043. Applications are considered on a continuing basis; however, candidates were urged to apply by November 1, 2013. Inquiries can be made via e-mail to: math-fac-search@umich.edu.

The University of Michigan is an affirmative action/equal opportunity employer and is supportive of the needs of dual-career couples. Women and minority candidates are encouraged to apply.

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/118/49]*

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 Tong, Hong Kong [Email : hrojob@cityu.edu.hk/Fax : (852) 2788 1154 or (852) 3442 0311].

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** and only shortlisted applicants will be contacted. Please quote the reference number in the application. 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's privacy policy is available on the homepage.

The University also offers a number of visiting positions through its "CityU International Transition Team" scheme for current graduate students, postdoctoral scholars, 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.

INSTITUTE FOR COMPUTATIONAL ENGINEERING & SCIENCES

POSTDOCTORAL RESEARCH FELLOWSHIPS

Research areas include, but are not limited to, inverse analysis, differential equations, kinetic theory, remediation of groundwater contaminants, tidal surges in coastal environments, drug design, damage and failure of composite materials, patient-specific surgical procedures, dynamics of polar ice, and the human ear.

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Faculty Positions

INSTITUTE FOR ADVANCED COMPUTATIONAL SCIENCE

Stony Brook University is one of America's most dynamic public universities, a center of academic excellence and a leader in health education, patient care and research. Listed among the top 1 percent of all universities in the world by the *Times Higher Education World University Rankings*, Stony Brook is home to more than 24,100 undergraduate, graduate and doctoral students and more than 14,000 faculty and staff, including those employed at Stony Brook Medicine, Long Island's premier academic medical center and teaching hospital. With 603 beds, Stony Brook University Hospital is the region's only tertiary care center and Regional Trauma Center. The University is a member of the prestigious Association of American Universities and co-manager of nearby Brookhaven National Laboratory.

Applications are invited for four tenure-track faculty positions in applied mathematics and computer science in the Institute for Advanced Computational Science (IACS) at Stony Brook University – two at the assistant professor level and two at the full professor level with named chairs and significant individual endowments within the institute. Candidates wishing to apply should have a doctoral degree in Computer Science or Applied Mathematics, though a degree in related fields may be considered. Ten years of faculty or professional experience is required for the two senior positions along with a demonstrated record of publications and research funding. A demonstrated record of publications and a demonstrated potential for research funding is required for the junior faculty position. The selected candidate is expected to participate in interdisciplinary program development within the Institute and to establish a research program with a solid funding base through both internal and external collaborations. Of specific interest is research in, for example, programming models, algorithms or numerical representations that advance scientific productivity or broaden the benefit and impact of high-performance computing. The selected candidates will have access to world-class facilities including those at nearby Brookhaven National Laboratory.

The Institute for Advanced Computational Science (*iacs.stonybrook.edu*) was established in 2012 with anendowment of $20 Million, including $10 Million from the Simons Foundation. The current eight faculty members will double in number over the next few years to span all aspects of computation with the intent of creating a vibrant multi-disciplinary program. IACS seeks to make sustained advances in the fundamental techniques of computation and in high-impact applications including engineering and the physical, life and social sciences. Our integrated, multidisciplinary team of faculty, students and staff overcome the limitations at the very core of how we compute, collectively take on challenges of otherwise overwhelming complexity and scale, and individually and jointly define new frontiers and opportunities for discovery through computation. In coordination with the Center for Scientific Computing at Brookhaven National Laboratory, our dynamic and diverse institute serves as an ideal training and proving ground for new generations of students and researchers, and provides computational leadership and resources across the SBU campus and state of New York.

The search will remain open until suitable candidates are found. Optimal start date is Fall 2014. All candidates must submit the required documentation online through the link provided below. Please input a cover letter, copy of your curriculum vitae, research plan (max. two pages), publication list, funding history, one-page statement of your teaching philosophy and three reference letters to *https://academicjobsonline.org/ajo/jobs/3072*.

Alternatively, applicants may submit a cover letter, résumé/CV, research plan (max. two pages), publication list, funding history, one-page statement of teaching philosophy and three reference letters to: Search Chair
Institute for Advanced Computational Science
Heavy Engineering, Suite 230
Stony Brook University, Stony Brook, NY 11794-5250

Stony Brook University

Stony Brook University/SUNY is an affirmative action, equal opportunity educator and employer.

INSTITUTE FOR COMPUTATIONAL ENGINEERING & SCIENCES

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

THE UNIVERSITY OF TEXAS AT AUSTIN

Foams

continued from page 1

which liquid in the lamellae drains into the Plateau borders, obeying thin film equations. Once a membrane becomes too thin, the model removes it, kicking the cluster far from equilibrium and leading back to the rearrangement stage. As the model slides through these phases, the resulting foam cluster pops, readjusts, and drains in a continual bubble cascade.

At the heart of this computational model is a collection of new algorithmic techniques for solving the underlying equations of motion; Sethian presented this work in an invited talk ("Tracking Multiphase Physics: Geometry, Foams, and Thin Films") at SIAM's 2013 conference on materials science. For the rearrangement phase of their model, Saye and Sethian use their Voronoi implicit interface method (VIIM) [2,4] to capture multiphase flow. For the drainage step, the researchers have constructed an elaborate model that couples thin film equations for each individual lamella to similar equations for each of the connecting Plateau borders; the coupled system is then solved in a finite element scheme on a triangulated mesh of the set of curved interconnected surfaces and junctions. When a lamella is thin enough, the model removes it, causing the gas pockets on each side to merge. This moves the system out of macroscopic balance, and the rearrangement module is then re-invoked.

As an added bonus, by using the membrane thickness as input to well-known methods for solving the thin film interference equations, Saye and Sethian determined how light is reflected from the evolving structures. The resulting images (Figure 1), which appeared in their *Science* article, show the dynamics of a foam cluster as it evolves through the multiscale sequence of rearrangement, drainage, and rupture, visualized through computation of the thin film patterns generated by a beach scene reflected from the evolving cluster.

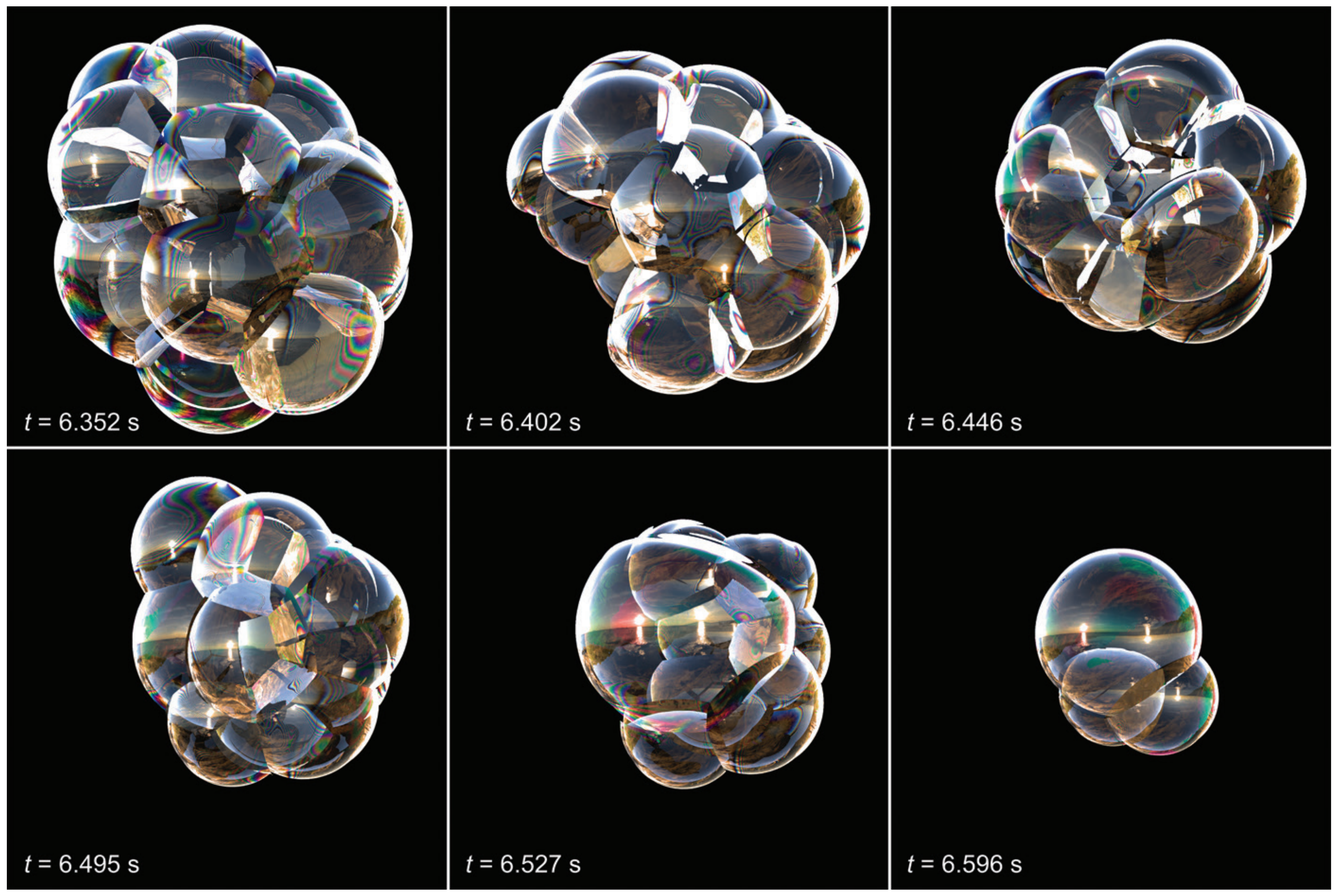

Figure 1. *Reflections on an evolving bubble cluster, combining macroscopic rearrangement, drainage of lamellae, and rupture [3].*

The model, while powerful, is missing some important effects. "To get a more complete picture," Sethian says, "we need to include additional physical effects, such as diffusive coarsening and different types of surface rheologies, including liquid–gas interfaces with more elaborate surface viscosities, evaporation dynamics, and heating."

Looking ahead, he and Saye plan to use this approach to study industrial applications and problems related to multiphase multiphysics. Their current interests include biological cell cluster modeling and industrial foams.

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On the invitation of SIAM News*, Robert Saye and James Sethian provided content for this article.*

A Scorching Summer School in Shanghai

By Jing Leng, Charles Puelz, and Leo Taslaman

The 2013 Gene Golub SIAM Summer School, in conjunction with the third International Summer School on Numerical Linear Algebra and the 10th Shanghai Summer School on Analysis and Numerics in Modern Sciences, took place July 22 to August 2 in a hot Shanghai, with record-breaking temperatures, close to 40°C/104°F. We were well prepared; the organizers equipped each of us with a flask for water and an umbrella for the sun—both very much appreciated! Our schedule was more or less the same every day: four hours of lectures in the morning, starting at eight, followed by lunch and a bit of rest before the afternoon tutorials. Several students used an impressive cafe on the 15th floor of the mathematics building as a venue for digging into our assigned problems. Coffee and a view of downtown Shanghai accompanied our discussions of matrix functions, model reduction, eigenvalues, and high-performance computing.

Nick Higham and Marlis Hochbruck gave the lectures during the first week. Higham focused on functions of matrices, beginning with the history of the subject and ending with recently developed algorithms for computing matrix exponentials. Hochbruck discussed exponential integrators and explained how matrix functions (exponential and phi-functions in particular) can be used to solve differential equations. During the tutorials we cut our teeth on plenty of problems, some of them open, so no one was left unchallenged.

The second week of the summer school saw lectures by Peter Benner, Ren-Cang Li, and Sherry Li. Benner followed a thorough presentation of the basic notions and common algorithms used in model reduction with some state-of-the-art results. Ren-Cang Li lectured on Rayleigh quotient-based methods for eigenvalue computations, providing detailed explanations of various algorithms. Offering a refreshingly computational/HPC component to the summer school, Sherry Li explained how combinatorial arguments are useful in quantifying fill-in for particular factorizations of matrices. She complemented the theory with several lectures on parallel computing. The tutorials for this part of the school consisted of both theoretical exercises and computational problems in OpenMP and MPI.

In addition to the presentations of cutting-edge material, we took advantage of the phenomenal opportunity to converse with new acquaintances from all over the world. The organizers seem to have put a lot of thought into this aspect of the summer school: The students' home institutions represented 15 countries. In addition, the lecturers allocated part of the tutorial time to ten-minute presentations by students of their current work—an opportunity that a majority took. Interactions among students occurred not only on a mathematical level: Randomly assigned seats for every lunch and dinner facilitated further dialogue, allowing us to chat about everything from hobbies to favorite foods, with fellow students as well as with lecturers and local organizers. We feel confident that these contacts will lead to connections and future collaborations. Given our new networks of friends, conferences will surely be more fun in the future!

On the weekends some ambitious students studied, but most chose to enjoy the vivid night life of Shanghai. We spent the first week sightseeing, visiting museums, and exploring several local bars, but in the end we all converged on an obscure club known as "Perry's." The local organizers also made sure that we experienced a fair amount of Chinese culture. In particular, the array of local dishes offered at each lunch and dinner left no one bored; to mention only a few, we tried jellyfish, frog, duck feet, and pig intestine and stomach. The organizers also arranged an excursion to a beautiful old village outside Shanghai. There, we walked around in ancient gardens, smelled stinky tofu, enjoyed boat taxis, and haggled in the local market.

The Gene Golub SIAM Summer School provided us with many things: exposure to important material in numerical linear algebra, networking with other students and professors, and incredible cultural experiences. In addition to what we learned in the daily lectures and exercises on leading-edge research topics, we now know scholars—junior and senior—from all over the world, both personally and professionally. And the ten-minute student presentations gave us an understanding of the types of mathematical problems of interest to our newly made friends. Thanks to Gene Golub, we experienced all these things and had a great deal of fun while doing it. For this we are very grateful. Surely the summer of 2013 in Shanghai will be unforgettable for all of us.

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Selected photos of the 2013 school can be found at http://www.cs.ucdavis.edu/~bai/g2s3/Photos/. Also worth a visit is Nick Higham's blog post on the school at http://nickhigham.wordpress.com/2013/08/09/gene-golub-siam-summer-school-2013/.

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