Newsjournal of the Society for Industrial and Applied Mathematics sinews.siam.org

siam news

Volume 51/ Issue 7
September 2018

SIAM Annual Meeting Issue

Check out prize photos and articles recapping various invited presentations and panel discussions from the 2018 SIAM Annual Meeting.

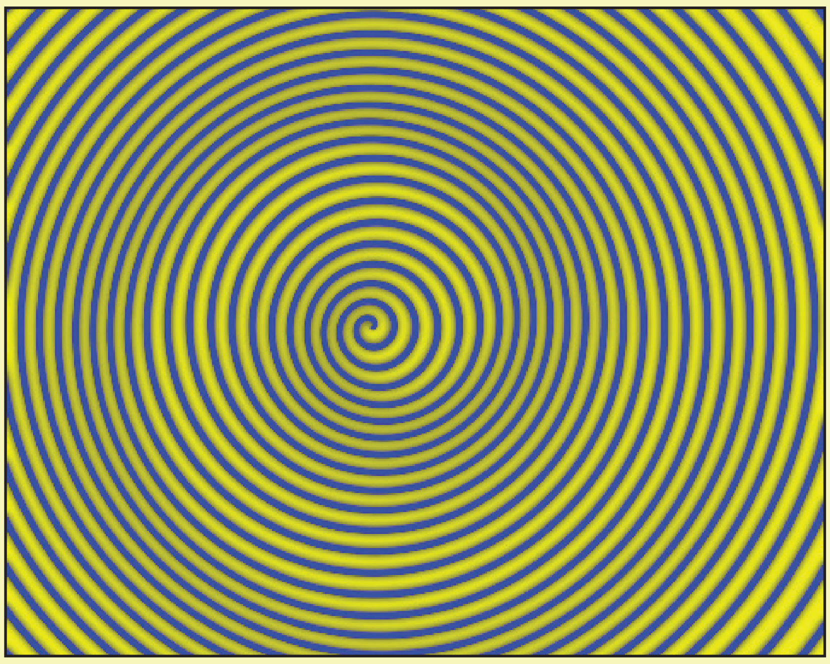


Figure 2. *Some chemical reactions propagate in spiral waves that expand outward in space and time from a source. Image courtesy of [2].*

In the article "Leopard Spots, Frog Eggs, and the Spectrum of Nonlinear Diffusion Processes" on page 3, Matthew R. Francis reports on Björn Sandstede's invited presentation about nonlinear patterns and waves.

Towards Model-based Automatic Vehicle Transmissions

By Paul Davis

Volker Mehrmann of the Technische Universität Berlin received the W.T. and Idalia Reid Prize at the 2018 SIAM Annual Meeting, which took place in Portland, Ore., this July. The award recognized Mehrmann "for his fundamental contributions to the broad area of differential-algebraic equations (DAEs), their control and optimization, and their practical applications."

Early in his lecture, Mehrmann displayed a photo of William T. Reid's well-known 1972 monograph titled *Riccati Differential Equations*, which he first encountered as a postdoctoral researcher in 1984. Mehrmann's overview of his own prize-winning work with DAEs hewed to the spirit of Reid's classic publication: the search for mathematically rigorous and tractable approaches to increasingly broad families of optimal control problems.

DAEs—a generalization of ordinary differential equations—arise in many aspects of control. A standard tool for modeling multiphysics systems, researchers use them to express conservation laws. "Black-box" or automatic system modeling also generates DAEs that impose constraints at the interfaces of communication between coupled systems or solvers. Mehrmann observed that this widespread "black-box" DAE modeling approach overlooks all of the difficulties in numerical methods and control techniques, thus causing substantial challenges in numerical integration methods, stability analysis, scale discrepancies, consistent initialization, etc. These complications highlight the need for improved DAE modeling, simulation, and control procedures.

To set the stage for his talk's punchline—the power of the so-called port-Hamiltonian formulation—Mehrmann described an industrial problem: development of a controller for a novel automatic transmission via a model-based approach (see Figure 1, on page 5). This research project, which was sponsored by German automotive corporation Daimler AG, involved nine Ph.D. candidates, including Mehrmann's former student Peter Hamann [1].

Challenges included multiphysics modeling (e.g., multi-body systems, hydraulics, and the dynamics of the traction (or transmission) fluid as essential features),

See **Vehicle Transmissions** *on page 5*

A Simple Class Assignment Exemplifies Computational Linear Algebra

By Paul Davis

The John von Neumann Lecture is among SIAM's oldest and most prestigious prizes, recognizing "outstanding and distinguished contributions to the field of applied mathematics." In that sense, the lecture is similar to a mathematical version of highlights from the Winter Olympics — a collage of victorious moments over mathematical challenges as varied as slalom runs, half-pipes, ski jumps, and ice rinks.

Charles Van Loan's prize lecture at the 2018 SIAM Annual Meeting, which took place this July in Portland, Ore., had an entirely different feel. The Cornell University professor's audience was treated to a view from Van Loan's helmet camera as he navigated down an expert slope, beginning with a deceptively simple problem statement and culminating in a rich set of discoveries and conjectures about untangling random polygons. In that single run, he exhibited the insights, skills, and accomplishments that comprise the recognition in his prize citation: "pioneering contributions to research in numerical linear algebra and to the exposition of the subject…a brilliant communicator…(whose) book *Matrix Computations*… has shaped and influenced the way we think about matrix computations."

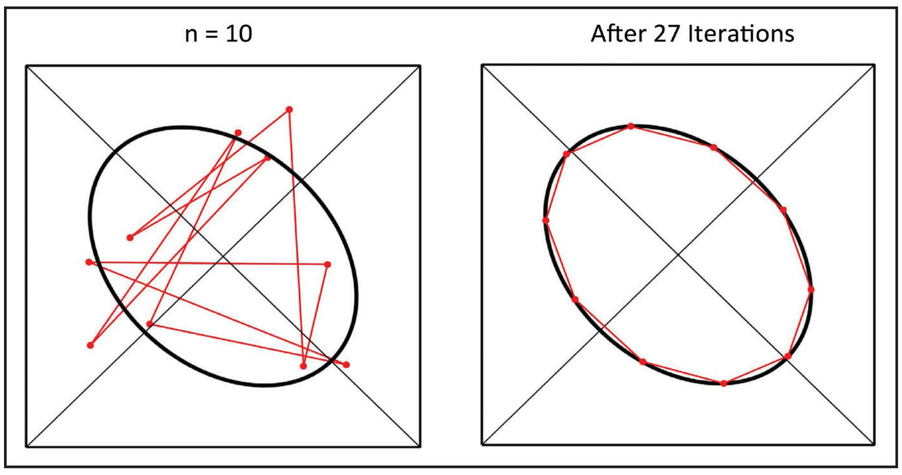


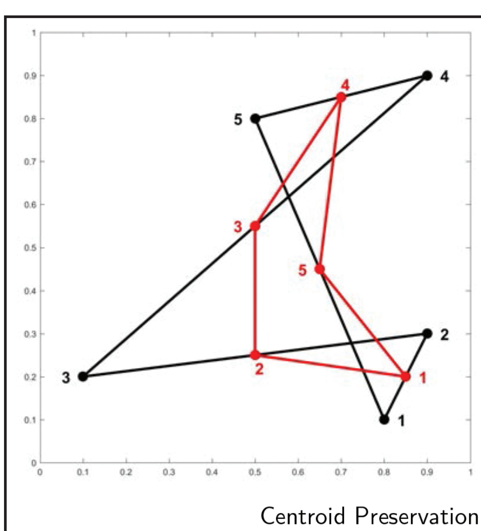
Figure 2. *After 27 iterations of averaging and renormalization, the 10 vertices of an initial random polygon lie close to an ellipse that is tipped 45 degrees from the coordinate axes.*

The crux of Van Loan's exemplary lecture originated 10 years ago in a burst of inspiration on the eve of a first-year undergraduate class called "Introduction to Computing." He prepared the following assignment: *Display a sequence of polygons where each polygon is obtained from its predecessor by connecting the midpoints of its sides. Let the original polygon be random.* Figure 1 illustrates the averaging process for five vertices and reveals that every polygon shares the same centroid.

After seeing these polygons shrink around their common centroid, Van Loan added an additional requirement: that the new arrays of averaged x and y coordinates be renormalized to unit length: $\mathrm{x}{=}\mathrm{x}/\mathrm{norm}(\mathrm{x}),\ \mathrm{y}{=}\mathrm{y}/\mathrm{norm}(\mathrm{y})$. He also fixed the centroid at the origin: $\mathrm{x}{=}\mathrm{x}{-}\mathrm{mean}(\mathrm{x}),\ \mathrm{y}{=}\mathrm{y}{-}\mathrm{mean}(\mathrm{y})$.

The normalized version of the problem produces a limiting polygon inscribed in an ellipse tilted at a 45-degree angle (see Figure 2). The vertices appear to crawl around the ellipse as the iteration proceeds. Van Loan asked his students to provide explanations of these observations, and posed questions drawn from a computational mathematician's repertoire of reflexive queries: How long does it take the iterations to converge? Will they always converge? What is the inverse of this process?

See **Linear Algebra** *on page 4*



$$(\tilde{x}_1,\tilde{y}_1) = \left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$$
$$(\tilde{x}_2,\tilde{y}_2) = \left(\frac{x_2+x_3}{2}, \frac{y_2+y_3}{2}\right)$$
$$(\tilde{x}_3,\tilde{y}_3) = \left(\frac{x_3+x_4}{2}, \frac{y_3+y_4}{2}\right)$$
$$(\tilde{x}_4,\tilde{y}_4) = \left(\frac{x_4+x_5}{2}, \frac{y_4+y_5}{2}\right)$$
$$(\tilde{x}_5,\tilde{y}_5) = \left(\frac{x_5+x_1}{2}, \frac{y_5+y_1}{2}\right)$$

Centroid Preservation: $(\bar{\tilde{x}},\bar{\tilde{y}}) = (\bar{x},\bar{y})$

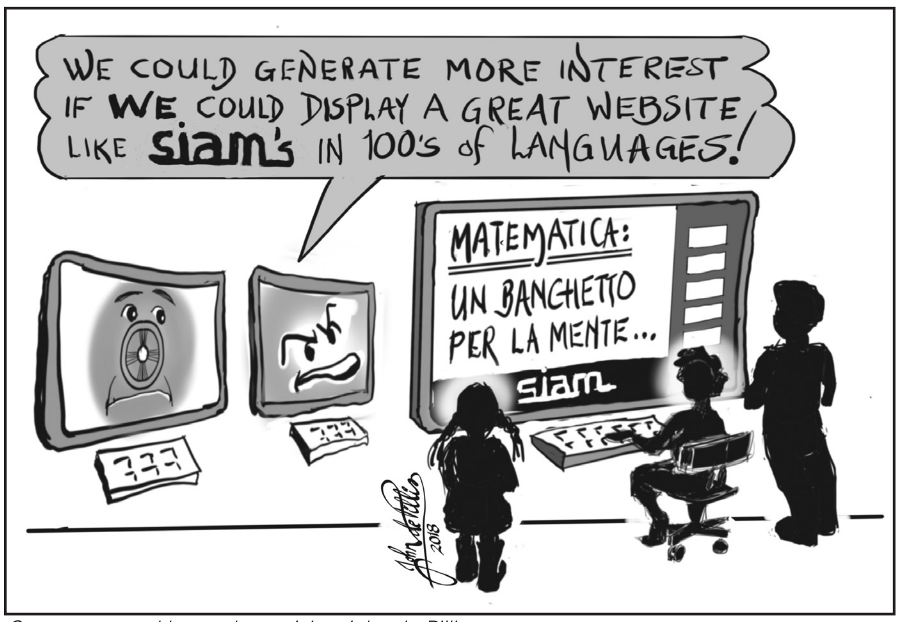
Figure 1. *The simple averaging process that delivers a rewarding run through key ideas of computational linear algebra; the red polygon's vertices are the average of the black polygon's vertices. The centroid is invariant.*

Nonprofit Org
U.S. Postage
PAID
Permit No 360
Bellmawr, NJ

SOCIETY for INDUSTRIAL and APPLIED MATHEMATICS
3600 Market Street, 6th Floor
Philadelphia, PA 19104-2688 USA

siam news
Volume 51/ Issue 7/ September 2018

Exploring the New SIAM Website



Cartoon created by mathematician John de Pillis.

SIAM launched a new website in early June, though you may not have noticed. Unless you have had to visit a conference web page or look at prize specifications or committee memberships (as I frequently do in my role as president), you probably have not had much reason to regularly visit the SIAM website. But now you do.

One of the site's new features is a grid near the top of the homepage that displays 17 research areas. Clicking on any topic (for example, "Computational Science & Numerical Analysis") directs you to a page that curates all relevant activities, events, and publications in the area, such as upcoming conferences; recent papers from (in this case) the *SIAM Journal on Scientific Computing*, the *SIAM Journal on Numerical Analysis*, and *Multiscale Modeling and Simulation*; and pertinent job opportunities, prize deadlines, *SIAM News* articles, and related SIAM activity groups (SIAGs).

In the future, the new site will also offer options for personalization through its integration with the SIAM membership system. Logging in with a SIAM member password will provide users with personalized content based on past conference attendance, book purchases, SIAG memberships, and journal subscriptions.

The previous version of the SIAM website dated back to 2005. While it served us well for 13 years, it had become outdated and bloated. The old site was designed for full-sized screens and had grown to 17,000 pages, only about 5,000 of which were active. The new site is responsive—automatically reformatting itself for viewing on handheld devices—and houses only essential content.

FROM THE SIAM PRESIDENT
By Nicholas Higham

Initial thinking about a new website began in 2011, when I was vice president-at-large. The process has been lengthy for several reasons. Developers and SIAM personnel put much effort into understanding the website's provisions for different types of users. The site coexists with other SIAM IT infrastructures, such as the conference management system and the membership database, changes to which had to be coordinated. Putting *SIAM News* online (and integrating SIAM Connect and SIAM Blogs into that site) took priority and provided valuable experience with new web technology. Auditing the old website, designing the new one, working with a vendor for implementation, generating content, and iterating based on feedback from alpha testers was a huge task. Tremendous credit should go to participating SIAM staff, led by Becky Kerner (digital communications and brand manager).

Although the content has been greatly reduced (to about 800 pages), much of the old website is still available at archive.siam.org, which preserves important historical information, including the conference archive.

Here are a few less obvious features of the new site that I particularly like.

1. A Google Translate button at the bottom right of each page will translate that page into one of more than 100 languages, and the setting is sticky. So you can read the website in your favorite language.

2. A number of useful links are collected in the dark gray footer of every page. These include an FAQ section, a Newsroom (where you can download a selection of professional photos from SIAM events or photos for your Twitter or Facebook profile), and links to teaching materials.

3. A "SIAM Around the World" section on the home page displays a map of the world on which you can overlay SIAM student chapters, sections, upcoming conferences, and membership data. Hover the mouse for detail about any item on the map.

The website is not perfect. Developers continue to iron out remaining bugs, and various improvements are planned for a second phase of development.

SIAM now has an easy-to-maintain website that meets modern web standards and provides a much better experience for all classes of users. Go to https://www.siam.org and give it a try. If you would like to offer feedback, click the "Feedback" widget pinned to the left side of each page.

To learn more about additional features of the new website and view before and after screenshots, please see page 7 of this issue.

Nicholas Higham is Royal Society Research Professor and Richardson Professor of Applied Mathematics at the University of Manchester. He is the current president of SIAM.

Errata and Clarifications

The article "Anomalous Localized Resonance and Associated Cloaking" by Graeme W. Milton and Ross C. McPhedran, which appeared in the 2018 July/August combined issue of *SIAM News*, carried two small errors.

1. In the phrase, "that a slab of material with thickness d, dielectric constant ε_0, and magnetic permeability $-\mu_0$—surrounded by a medium of dielectric constant ϵ_0 and magnetic permeability μ_0—would behave like a perfect lens," the first ε_0 should actually be $-\varepsilon_0$.

2. The phrase "a coated disk—with a core of radius r_c and dielectric constant ϵ_c, a shell with outer radius r_s and dielectric constant $-\epsilon_0$, and outer radius r_s—surrounded by a medium with dielectric constant ϵ_0" references "outer radius r_s" twice. Instead, it should read "a coated disk—with a core of radius r_c and dielectric constant ϵ_c, and a shell with outer radius r_s and dielectric constant $-\epsilon_0$—surrounded by a medium with dielectric constant ϵ_0."

siam news

ISSN 1557–9573.

Obituary: Ivar Stakgold

By Pam Cook and W. Edward Olmstead

Mathematician Ivar Stakgold, professor emeritus at the University of Delaware (UD), passed away on May 29, 2018, at the age of 92. He specialized in boundary value problems, was a well-known bridge player, and served SIAM in multiple roles — most notably as president from 1989 to 1990.

Ivar was born in 1925 near Oslo, Norway, and spent much of his early childhood in Brussels, Belgium. To escape the onset of World War II in 1940, his family embarked upon a torturous journey through France, Spain, and Portugal to reach the Dominican Republic. They immigrated to the U.S. in 1941 and settled in New York.

Ivar earned a B.S. (in 1945) and an M.S. (in 1946) in engineering from Cornell University. In 1949, he received a Ph.D. in applied mathematics from Harvard University under the direction of Léon Brillouin. Ivar taught at Harvard until 1956, when he became head of the mathematics and logistic branches at the Office of Naval Research in Washington, D.C.

In addition to his prowess as a mathematician, Ivar was a world-class bridge player. He played on teams that won national championships in the late 1950s and early 1960s, and even represented the U.S. in the 1959 Bermuda Bowl, a biennial bridge world championship. His team finished second to the famous Italian "Blue Team."

In 1959, Ivar joined the faculty at Northwestern University with a joint appointment in the Department of Engineering Sciences and the Department of Mathematics. He developed a sequence of courses based on Green's function methods and transform techniques to solve applied problems involving differential and integral equations for the McCormick School of Engineering. In an era when computers were not as prevalent, applied mathematicians developed various analytical methods to determine the key features of engineering and scientific solutions. Ivar organized the material from his courses into a two-volume set of graduate-level textbooks entitled *Boundary Value Problems of Mathematical Physics*, which were published in 1967 and 1968. These volumes appeared in SIAM's *Classics in Applied Mathematics* series in 2000, demonstrating the enduring value of his contribution.

While at Northwestern, Ivar formed the Committee on Applied Mathematics, which offered engineering graduate students the opportunity to earn a Ph.D. in applied mathematics. In 1969, he became chair of the Department of Engineering Sciences — the forerunner of Northwestern's current Department of Engineering Sciences and Applied Mathematics.

In 1964, Ivar married Alice Cox. They welcomed their daughter Alissa in 1965 and remained married until Alice's death in 1994. Alice shared Ivar's interest in high-level bridge competition, and they played as partners on a team that won a national mixed team championship in 1969.

In the late 1960s, applied mathematicians expressed a growing interest in nonlinear problems that exhibited bifurcating solutions. Ivar combined the essential contributions of various researchers in the field to write a seminal review paper for *SIAM Review* entitled "Branching of Solutions of Nonlinear Equations," which was published in 1971. This highly-cited paper contributed significantly to the widespread investigation of bifurcation phenomena in the subsequent decades.

In 1975, Ivar left Northwestern to become a professor of mechanical engineering and professor and chair of UD's Department of Mathematical Sciences. He was a highly-skilled administrator. In anticipation of expanding mathematics at UD, Ivar began his tenure by negotiating for added space to accommodate the burgeoning graduate program and an active visitor program. As chair, his impressive presence, quick mind, acerbic wit, and keen analytical powers helped him motivate and maintain peace among the members of his department.

Ivar Stakgold (left) with former SIAM president Gene Golub. SIAM photo.

Ivar continued as chair of the department until 1991. During his 16-year stewardship, the department's reputation grew among the worldwide mathematical community; this elevation of prestige was certainly due in part to the new faculty members that he recruited.

While serving as chair, Ivar maintained his own active research program and wrote another graduate-level textbook in 1979 called *Green's Functions and Boundary Value Problems*. Later editions of this book, which are still widely used, appeared in 1998 and 2011, the latter co-authored with Michael Holst of the University of California, San Diego.

Ivar also contributed to SIAM in many ways. He was a member of the Board of Trustees from 1975 to 1984 (the maximum allowable term), served as chair of the Board, and was president from 1989 to1990. Ed Block, founder and longtime managing director of SIAM, described Ivar as particularly skilled in conducting Board meetings during contentious discussion. When SIAM initiated its Fellows Program in 2009, Ivar was among the inaugural class of members.

Additionally, he was chair of the Conference Board of the Mathematical Sciences, served as director of the Washington Office of the American Mathematical Society, and held various visiting professorships at institutions around the world, including in Italy, Spain, Switzerland, New Zealand, and England. Following his retirement in 1995, Ivar was appointed professor emeritus at UD.

In 2008, Ivar moved to California and took a position as a research scientist at UC San Diego. He is survived by his daughter Alissa and his fiancée Lainie Lesser-Mark, who was a close companion during the last decade of his life.

We will miss Ivar's personality and continuing contributions to applied mathematics.

Pam Cook is Unidel Professor of Mathematics, associate dean of engineering, and professor of chemical engineering at the University of Delaware (UD). She succeeded Ivar Stakgold as chair of the Department of Mathematical Sciences at UD, and later as president of SIAM. W. Edward Olmstead is professor emeritus of applied mathematics at Northwestern University, where Ivar was one of his Ph.D. mentors. When Ivar left Northwestern in 1975, Olmstead assumed his role in developing the graduate program in applied mathematics.

Leopard Spots, Frog Eggs, and the Spectrum of Nonlinear Diffusion Processes

By Matthew R. Francis

Stripes, spots, or a mix of both appear on the skin of many animals — from tigers to beetles to whale sharks. These patterns are typically unique to individual creatures, and biologists often use them for identification. While distinct patterns may seem random, they obey certain rules that suggest a common underlying description. Striping and spotting occur in many unrelated species, implying that both evolutionary advantages and simple biochemical mechanisms drive such patterns.

Figure 1. *Pillars of vibrating copper beads are much higher than the surrounding material and appear to stand independently of each other. Image courtesy of [4].*

As Björn Sandstede of Brown University noted during his invited address at the 2018 SIAM Annual Meeting, held in Portland, Ore., this July, similar patterns appear in certain chemical reactions and granular material under vibration. Nonlinear reactions and diffusion describe biological and non-biological patterns, producing stable concentrations in this space.

Alan Turing—best known for his work in computer science and cryptography—first made the mathematical connection between nonlinear diffusion processes and animal stripes in the 1950s. Many researchers have applied the resulting model to demonstrate how various species get their spots and describe nonlinear waves in chemical reactions.

Sandstede and his colleagues study the mathematical stability of these nonlinear waves and the means by which they might interact with one another. This work necessitates an understanding of the wave spectrum, which describes the nonlinear behavior of many systems quite well.

Sandstede's talk focused on stable spatial peaks and spiral waves, which have clearly-defined crests that propagate outward from a source. These systems display interesting behavior even when limited to one spatial dimension.

How the Leopard Kept its Spots

Laboratory research on embryos shows that spots and stripes on skin originate very early in development. The stripes of a danio fish arise within three weeks of fertilization, and a leopard's spots develop while the embryo is still hairless. Even melanistic leopards (called black panthers) carry traces of spots despite the blackness of their coats.

What processes yield these patterns to begin with? Stripes and spots have distinct boundaries and do not continuously shade into each other. This arrangement indicates the presence of chemical concentrations—which produce discrete wave peaks separated by low concentration regions—during development.

The one-dimensional reaction-diffusion equation describes a wide variety of stable spatial structures:

$$\frac{\partial u}{\partial t} = D\frac{\partial^2 u}{\partial^2 x} + f(u), \text{ where } u \in R^n.$$

The vector-valued function u represents the relevant physical quantity: the concentration of chemicals or displacement of materials. The diffusion coefficient D and reaction function f—the sources of the system's nonlinearity—control the dynamics specific to each system.

In linear systems, interactions and perturbations obey the superposition principle: if a and b are both solutions to the equation, then $a+b$ is as well. For example, two interfering linear waves create a new waveform, and traveling waves pass through one another. Nonlinear waves, however, can collide or produce other effects that are not simply additive combinations of the two original waves.

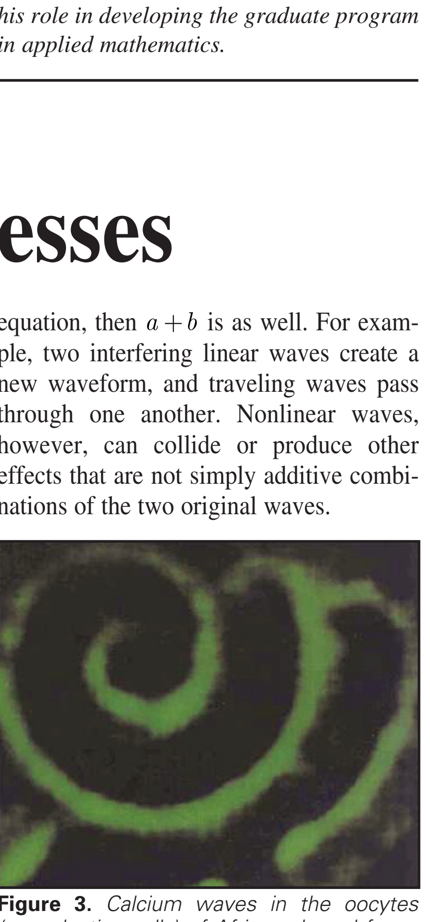


Figure 3. *Calcium waves in the oocytes (reproductive cells) of African clawed frogs. Image courtesy of [1].*

It is the reaction-diffusion equation's nonlinearity that generates stripes and spots in the first place. Nonetheless, the spots' distinctness means that one can treat them as independent objects to a certain level of approximation. Another of Sandstede's examples is particularly useful for visualization: pillars of copper beads produced by vibrations (see Figure 1, on page 3). These pillars are much higher than the surrounding material and appear to stand independently of each other.

See **Diffusion Processes** *on page 4*

Linear Algebra

Continued from page 1

The original just-in-time problem formulation debuted in a 2008 freshman-level MATLAB course at Cornell and resurfaced in its normalized form in a 2009 upper-level course on matrix computations. Van Loan and then-undergraduate Adam Elmachtoub answered those aforementioned questions and posed others in a 2010 *SIAM Review* article [1]. This entire adventure in computational linear algebra came full circle as the subject of this year's John von Neumann Lecture.

When speaking to his SIAM audience, Van Loan sought to "explain it all using matrix computations." The problem he posed to his first-year students in 2008 was part of a strategy to help beginning computer scientists "see n things as one" and get them "thinking at the vector level before they headed over to the math department," he said. Van Loan aimed to stimulate a hunger for mathematics in his students that could explain their observations, opening the door to one of the core experiences of applied mathematics. At a basic computational level, he led them to recognize matrix-vector operations lurking implicitly within algorithms.

Establishing the matrix-vector formulation of the vertex update was the first important turn in Van Loan's run. The second was recognizing that the iterative process of averaging polygons amounts to the power method for the update matrix M_n, whose five-vertex version appears in Figure 3; the kth x-vector is the product $M_n^k \cdot (\text{initial } x\text{-vector})$, and the kth y-vector is obtained similarly.

$$\begin{bmatrix} (x_1+x_2)/2 \\ (x_2+x_3)/2 \\ (x_3+x_4)/2 \\ (x_4+x_5)/2 \\ (x_5+x_1)/2 \end{bmatrix} = \underbrace{\frac{1}{2}\begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 \end{bmatrix}}_{M_5} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix}$$

Figure 3. *The matrix-vector formulation of the x-vertex coordinate array's update in the averaging process for a polygon with five vertices.*

An analysis of the eigenvalues and eigenvectors of M_n now lay ahead; the linear algebra was picking up speed. Van Loan noted that one can write the update matrix as $M_n = (I_n + S_n)/2$, where S_n is the upshift matrix, i.e., the identity matrix with its last column shifted to the first position and all other columns displaced one spot to the right. Its eigenvalues and eigenvectors are completely known. With the exception of the details—a Schur decomposition—needed to actually cross the finish line, this race was over.

$$Q = \begin{bmatrix} x & x & x & x & x \\ x & x & x & x & x \\ x & x & x & x & x \\ x & x & x & x & x \\ x & x & x & x & x \end{bmatrix} \qquad T = \begin{bmatrix} x & 0 & 0 & 0 & 0 \\ 0 & x & x & 0 & 0 \\ 0 & x & x & 0 & 0 \\ 0 & 0 & 0 & x & x \\ 0 & 0 & 0 & x & x \end{bmatrix}$$

M_5 has three invariant subspaces of interest:

Invariant Subspace	Associated Eigenvalue(s)
Black	λ_0
Red	λ_1 , $\bar{\lambda}_1$
Blue	λ_2 , $\bar{\lambda}_2$

Figure 4. *The structure of the Schur decomposition of M_5, $Q^T M_5 Q = T$, showing the three invariant subspaces of M_5.*

As an example, Figure 4 shows the structure of the Schur decomposition of M_5. To follow the effects of powers of the update matrix on an array of x or y coordinates of an initial polygon, one can expand those arrays in terms of a real Schur basis, as in Figure 5.

Because the polygon's centroid is at the origin, each coordinate array averages to zero. Hence, the principle (black) eigenvector drops out of the orthonormal expansion in Figure 5. Applying powers of M_5 to a vertex coordinate array amounts to applying those powers to the red and blue basis vectors. Since both pairs of complex conjugate eigenvalues have magnitude less than one, the successive averaged polygons collapse to the origin.

If each iteration renormalizes the vertex coordinate arrays to unit vectors, only the red component survives because the complex conjugate pair of red eigenvalues has larger magnitude. At that point, we might as well have started with coordinate arrays that are norm-one linear combinations of the red vectors in Figure 5's Schur basis expansion. With just a touch more analysis via a singular-value decomposition, the limiting ellipse emerges — tilted 45 degrees from the coordinate axes.

$$x = \alpha_0 \begin{bmatrix} x \\ x \\ x \\ x \\ x \end{bmatrix} + \begin{bmatrix} x & x \\ x & x \\ x & x \\ x & x \\ x & x \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \beta_1 \end{bmatrix} + \begin{bmatrix} x & x \\ x & x \\ x & x \\ x & x \\ x & x \end{bmatrix} \begin{bmatrix} \alpha_2 \\ \beta_2 \end{bmatrix}$$

Figure 5. *One can expand the x- and y-vertex vectors in a real, orthonormal Schur basis, as shown here for the x-vector.*

There is still more before the finish. The vertices appear to move around the limiting ellipse because they alternate between even and odd steps. Iterating in reverse yields starburst polygons instead of the smoother, ellipsoidal polygons of forward iteration; the invariant subspace associated with the complex eigenvalues of smallest magnitude dominates, and the components of its basis vectors tend to flip-flop in sign. Computational evidence also points to a conjectural version of Kepler's second law: the centered "pizza slice" triangles lying on the limiting ellipse have equal area.

Having quickly negotiated this trail through the highpoints of computational linear algebra, Van Loan crossed the finish line with a graceful verbal embrace rather than the familiar arms-raised victory salute. He was explicit in his appreciation of the opportunity to speak and the presence of so many students in the audience. Recalling his first SIAM meeting—at Newport News, Va., in 1973—Van Loan spoke with the conviction of personal experience. "SIAM does [student involvement] better than any other professional society," he said.

Van Loan's lecture is available from SIAM either as slides with synchronized audio or a PDF of slides only.[1]

Since 1960, SIAM has annually recognized a John von Neumann lecturer "for outstanding and distinguished contributions to the field of applied mathematics, and for the effective communication of these ideas to the community." The award honors John von Neumann (1903-1957), one of the most prolific and articulate practitioners of applied mathematics in the 20th century. It includes an honorarium of $5,000 from a fund established by IBM and maintained by SIAM.

The figures in this article were provided by Charles Van Loan.

References

[1] Elmachtoub, A.N., & Van Loan, C.F. (2010). From Random Polygon to Ellipse: An Eigenanalysis. *SIAM Rev., 52*(1), 151-170.

Paul Davis is professor emeritus of mathematical sciences at Worcester Polytechnic Institute.

[1] https://www.pathlms.com/siam/courses/8264/sections/11788

Diffusion Processes

Continued from page 3

Sandstede simplified the system by beginning with known steady-state (time-independent) concentrations q and finding solutions to the reaction-diffusion equation of the form

$$u(x,t) = q(x) + e^{\lambda t} v_0(x),$$

where $|v_0|$ is a small perturbation. This transforms the reaction-diffusion equation into an ordinary differential equation in x, with the eigenvalue λ characterizing the system's spectrum. These eigenvalues come in two classes: zero (or very close to zero), or complex with real part negative. The spectrum describes decaying and oscillatory perturbations, signifying that the steady-state solutions are largely stable under perturbation. Once the embryonic leopard has its spots, the spots stay.

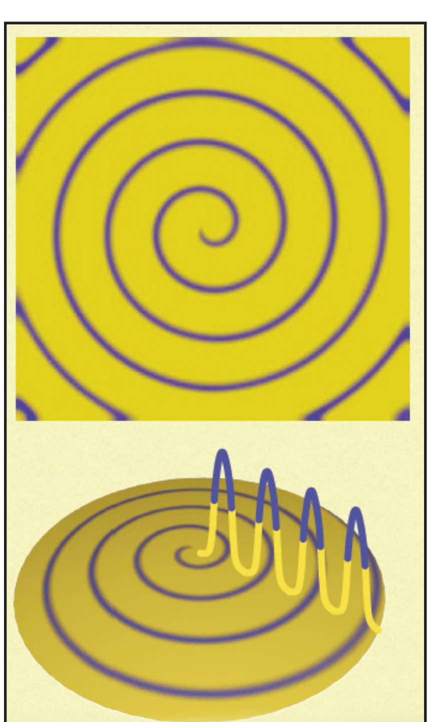


Figure 4. *Wave peaks travel outward from the source at varying rates in one-dimensional spiral waves. Image courtesy of [3].*

Similarly, interactions between neighbors along the line are treated perturbatively. Overlap occurs at the tails of the mathematical peaks. Like with stability analysis, the spectrum of the operator governing the perturbations completely describes the interactions. As a result, the spots can exchange concentrations in an oscillatory fashion and even attract each other. However, the interaction's strength decays exponentially with distance, meaning that steady-state spots interact less when they are further apart.

Of Frogs and Spiral Waves

Though the copper pillars and leopard spots do not move in time, the math that describes them can also describe some nonlinear waves. For instance, certain chemical reactions propagate in spiral waves (see Figure 2, on page 1), expanding outward in space and time from a source. Each wave peak resembles a closely-packed, moving version of the concentrations in the steady-state example.

One particularly striking example is calcium transport in the oocytes (reproductive cells) of African clawed frogs. The creation of these cells from fertilized eggs releases a wave of calcium into the cell, which forms a clear spiral pattern within the surrounding material (see Figure 3, on page 3).

Nonlinear waves differ from their linear versions in important ways. A nonlinear wave clearly does not add linearly, but the wave's frequency also varies nonlinearly with the wavenumber (which is inversely proportional to the wavelength). This means that the velocity of the peaks varies; in contrast, a linear wave's velocity is fixed.

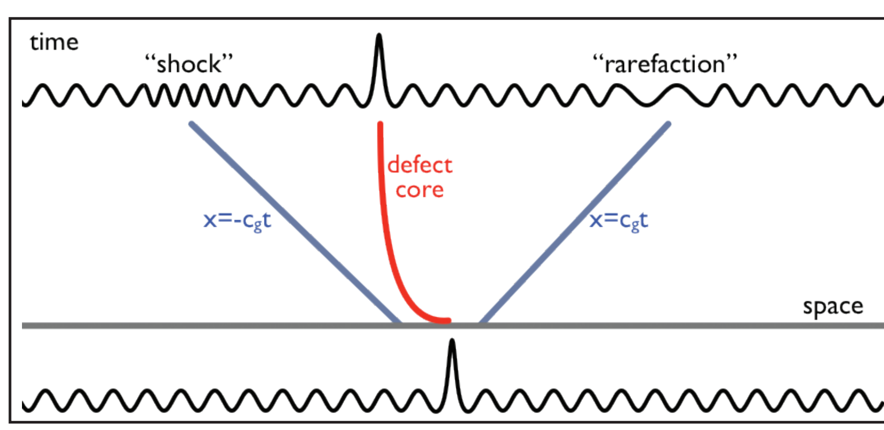


Figure 5. *Perturbing a spiral wave changes its pattern, shifts the source, and affects the wave's peak velocity. One can describe the disturbance's propagation as a "shock" that travels along the spiral wave at the speed of the wave itself. Image credit: Björn Sandstede.*

Sandstede and his collaborators studied one-dimensional spiral waves, which are basically cross-sections of the spiral. In Figure 4, the wave peaks travel outward from the source at varying rates. Sandstede treats the waves one-dimensionally using the same mathematical tools as in the steady-state spot model.

The team found that perturbing a spiral wave changes its pattern, thus shifting the source and affecting the wave's peak velocity. Sandstede described the disturbance's propagation as a "shock" that travels along the spiral wave at the speed of the wave itself (see Figure 5). Unlike with the steady-state perturbations, a small disturbance at the wave's source can therefore affect the entire wave train.

For spiral waves, as with spotting and striping, Sandstede and his colleagues found that the spectrum of the operator defining the system generally described the system's nonlinear dynamics — at least in one dimension. Real-world spots, stripes, and spiral waves are at minimum two-dimensional phenomena on surfaces, and the second spatial dimension complicates matters.

Nevertheless, researchers continue to study reaction-diffusion processes in higher dimensions, so the one-dimensional case's tractability is cause for hope. After all, we know that real-world stripes and spots are stable. The spectral description of these two-dimensional phenomena may follow as well.

References

[1] Lechleiter, J., & Clapham, D. (1992). Molecular Mechanisms of Intracellular Calcium Excitability in X. laevis Oocytes. *Cell, 69*, 283-294.

[2] Sandstede, B., & Scheel, A. (2001). Superspiral Structures of Meandering and Drifting Spiral Waves. *Phys. Rev. Lett., 86*(1), 171-174.

[3] Sandstede, B., & Scheel, A. (2007). Period-Doubling of Spiral Waves and Defects. *SIAM J. Appl. Dynam. Syst., 6*(2), 494-547.

[4] Umbanhowar, P.B., Melo, F., & Swinney, H.L. (1996). Localized excitations in a vertically vibrated granular layer. *Nature, 382*, 793-796.

Matthew R. Francis is a physicist, science writer, public speaker, educator, and frequent wearer of jaunty hats. His website is BowlerHatScience.org.

Vehicle Transmissions

Continued from page 1

real-time simulation and control, modeling as a network of subcomponents, and model reduction. Ultimately, Daimler AG strove for improved fuel economy, smoother shifting on the road, and looser manufacturing tolerances on the production line.

These modeling requirements and the system's overall complexity naturally led to an optimal control problem for a DAE formulation. For analysis purposes and enhanced formulation for simulation and control, researchers typically group control inputs, system state variables, and selected derivatives into one large "state" vector. They then extract an improved (regularized) model from an array of equations and some derivatives.

Using this framework, Mehrmann and his colleagues establish conditions sufficient for the local existence of a so-called regularized system: a pair of implicit equation systems. One set describes the modeled dynamics while the other captures all of the algebraic constraints, the solution manifold's definition, and the consistency requirements for the initial conditions. The corresponding optimal control problem seeks the minimum of a standard cost functional involving the state and control, subject to DAE constraints presumed to exist in such a regularized form.

However, neither the classic results from Reid's monograph (the optimal feedback control is lurking in a Riccati equation's solution) nor Pontryagin's maximum principle (the optimal control maximizes a Hamiltonian) apply directly; the DAEs may not be uniquely solvable, and researchers must constrain the solution variable to a locally constructed manifold.

Adding to these mathematical difficulties, the pure model-based approach to Daimler's transmission control problem did not work as anticipated; e.g., modeling the traction fluid required a completely different timescale from the rest of the system. Researchers derived the controllers for the actual transmissions now in dealers' showrooms by taking measurements from a prototype and realizing a model of the input-output behavior via system identification — an approach that is classical but time-consuming and expensive (due to the need for a prototype).

Nonetheless, when one door closes, another door—or perhaps more fittingly, "port," as in "port-Hamiltonian,"—opens. Conceptually, a port-Hamiltonian formulation begins with a network of elements that can store (a capacitor in an electric network), dissipate (a resistor), or transfer (the network's topology) energy. A port is a point where energy enters or exits the system. The Hamiltonian records the distribution of energy among the energy-storing components.

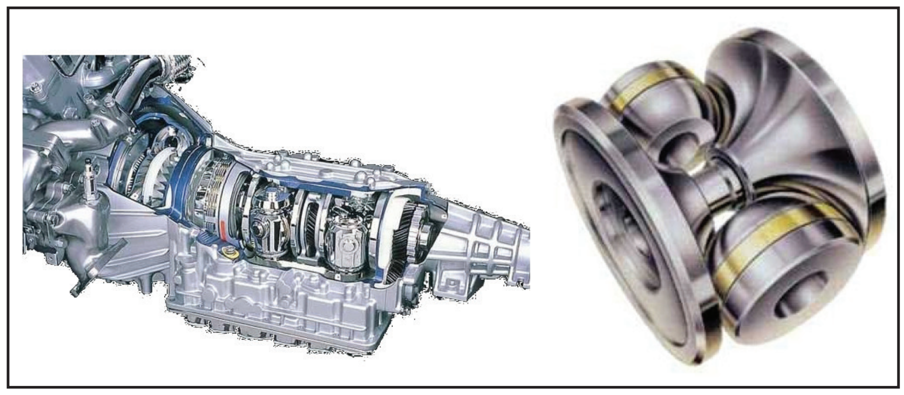


Figure 1. *Views of a half-toroid automatic transmission. Traction (transmission) fluid and multiphysics modeling challenges are apparent. Image courtesy of [2].*

A dissipation inequality replaces the energy conservation requirement found in classical Hamiltonian systems. Port-Hamiltonian systems are closed under power-conserving interconnections; an assembly of port-Hamiltonian systems is itself port-Hamiltonian, and the structure is invariant under Galerkin discretization and model reduction.

These apparently modest ideas extend powerfully, even to infinite-dimensional spaces, to enable enormously complicated models of control systems that connect vastly different physical domains and various "black-box" simulators. Naturally, a potpourri of well-structured DAEs—some describing system behavior and some constraining it—can result from a port-Hamiltonian formulation.

Since port-Hamiltonian-DAE systems are ideal for energy-based, modular modeling, Mehrmann and his colleagues developed linear and nonlinear formulations. Their results prove a dissipation inequality as well as the power-conserving connections that enable modeling via interconnected modules. Furthermore, these representations are very robust to structural perturbations.

Mehrmann and his team's current work is enriching the mathematical and computational infrastructure that supports port-Hamiltonian-DAE systems: modeling, data acquisition, mathematical analysis, numerical simulation, and optimal control techniques based on this structure. Thanks to these tools, a model-based, software-controlled transmission may not be too far down the road.

Mehrmann's Reid Prize lecture is available from SIAM as slides with synchronized audio or a PDF of slides only.[1]

The W.T. and Idalia Reid Prize was established in 1994 and is awarded in the broadly-defined areas of differential equations and control theory. Since 2000, SIAM has presented the prize annually with support from a bequest from Idalia Reid in memory of her late husband, William T. Reid. The award includes a $10,000 monetary prize and an engraved medal. W.T. Reid worked in differential equations, the calculus of variations, and optimal control, sharing naming rights for the workhorse Gronwell-Reid-Bellman inequality. He held faculty appointments at the University of Chicago, Northwestern University, the University of Iowa, the University of Oklahoma, and the University of Texas. Reid was an important figure in the optimal control community and a beloved mentor to his students.[2]

References

[1] Hamann, P. (2009). *Analyse regelungstechnischer Methoden zur modellbasierten Regelung von Toroidgetrieben/ Analysis of control methods for the model-based control of toroid transmissions.* (Doctoral dissertation). Technische Universität Berlin, Berlin, Germany.

[2] Nissan Motor Company, Ltd. (2000). Extroid CVT: For Application to Rear-Wheel-Drive Cars Powered by Large Engines. *Nissan's CVT Technologies*.

Paul Davis is professor emeritus of mathematical sciences at Worcester Polytechnic Institute.

[1] https://www.pathlms.com/siam/courses/8264/sections/11795

[2] John Burns, a student of Reid and the 2010 recipient of the W.T. and Idalia Reid Prize, provided a personal account entitled "William T. and Idalia Reid: His Mathematics and Her Mathematical Family" as his Reid Lecture. A PDF of his lecture and slides with synchronized audio are available from SIAM at https://www.pathlms.com/siam/courses/3609/sections/5154.

Photos from the 2018 SIAM Annual Meeting

SIAM President Nicholas Higham (left) presents The John von Neumann Lecture to Charles F. Van Loan of Cornell University at the Prizes and Awards Luncheon during the 2018 SIAM Annual Meeting, held in Portland, Ore., this July. After the luncheon, Van Loan gave a talk about "Untangling Random Polygons and Other Things." Read about the lecture on page 1. SIAM photo.

SIAM President Nicholas Higham (left) and Association of Women in Mathematics (AWM) President Ami E. Radunskaya (right) present the AWM-SIAM Sonia Kovalevsky Lecture to Éva Tardos of Cornell University during the Prizes and Awards Luncheon at the 2018 SIAM Annual Meeting, which took place in Portland, Ore., this July. The previous day, Tardos spoke about "Learning and Efficiency of Outcomes in Games." SIAM photo.

The Class of 2018 SIAM Fellows were recognized at the Business Meeting during the 2018 SIAM Annual Meeting, held in Portland, Ore., this July. First row (from left): Juan M. Restrepo (Oregon State University), J.A.C. Weideman (Stellenbosch University), Helen Moore (AstraZeneca), Madhav V. Marathe (Virginia Tech), and Alex Pothen (Purdue University). Second row (from left): Helmut Pottmann (Technische Universität Wien), Margot Gerritsen (Stanford University), Bojan Mohar (Simon Fraser University and IMFM), Homer F. Walker (Worcester Polytechnic Institute), and Panayot S. Vassilevski (Portland State University and Lawrence Livermore National Laboratory). Third row (from left): Ralph C. Smith (North Carolina State University), David A. Field (General Motors Corporation), Tamas Terlaky (Lehigh University) and John N. Shadid (Sandia National Laboratories and University of New Mexico). SIAM photo.

SIAM President Nicholas Higham (left) awards Volker Mehrmann of the Technische Universität Berlin with the W.T. and Idalia Reid Prize during the Prizes and Awards Luncheon at the 2018 SIAM Annual Meeting, held in Portland, Ore., this July. Mehrmann's prize lecture was titled "Modeling, Simulation, and Control of Differential-Algebraic Port-Hamiltonian Systems." Read about the talk on page 1. SIAM photo.

Peter Gangl (right) of the Technische Universität Graz accepts the Richard C. DiPrima Prize from SIAM President Nicholas Higham during the Prizes and Awards Luncheon at the 2018 SIAM Annual Meeting, held in Portland, Ore., this July. SIAM photo.

SIAM Past President Pam Cook (right) of the University of Delaware receives the Julian Cole Lectureship from current SIAM President Nicholas Higham at the Prizes and Awards Luncheon during the 2018 SIAM Annual Meeting, which took place in Portland, Ore., this July. The following day, Cook gave a lecture entitled "Modeling of Complex Fluids: Wormlike Micellar Solutions, Polymers, and Mucins." SIAM photo.

Welcome to the New SIAM Website

By Becky Kerner

Over two years ago, SIAM set out to update its main website: www.siam.org. The project's primary goal was to increase the site's usability, functionality, and value for the community. Through surveys, focus groups, and hundreds of conversations, we talked to you—our community members—about what features would be most helpful. With an updated look and feel, better organization of information, and more robust technological integrations, we hope that we have delivered. Read on to discover more about the new website, and please take some time to peruse it yourself.

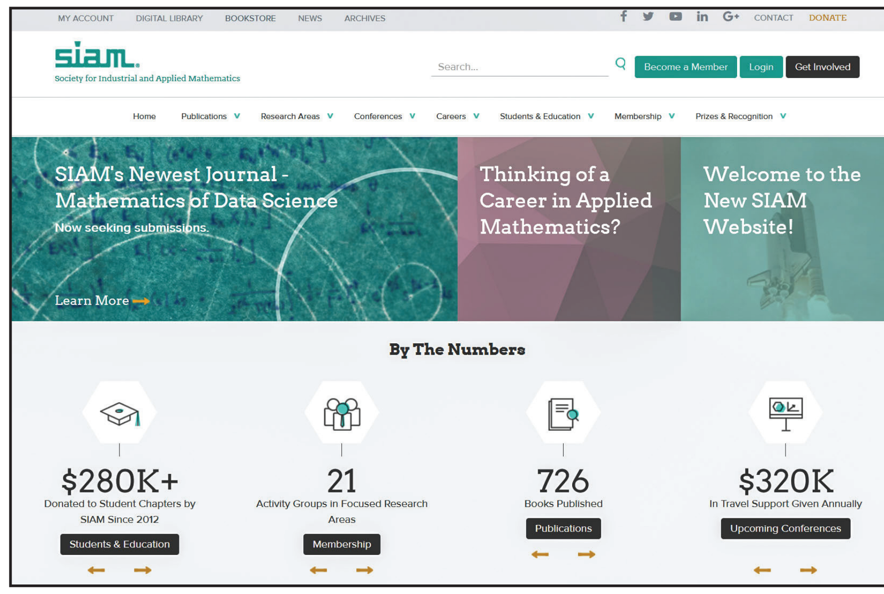
Responsive/Mobile Friendly

Our website is officially smartphone-friendly! If you visited our old site on your mobile phone, you know that navigating it productively was nearly impossible. The new site, on the other hand, was strategically designed with a mobile user in mind. Notable features include readable text without the need for zoom, adequate space for tap targets, and no requirement for horizontal scrolling.

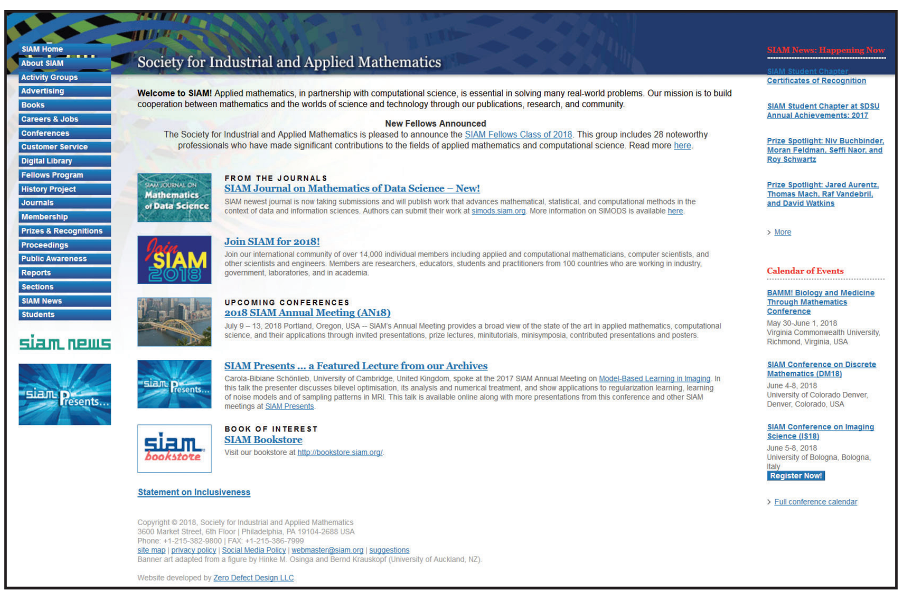
Emphasized Areas of Research

Through countless conversations with members of the community, we learned that people found the content on the old siam.org useful but struggled to access pertinent information. A significant focus of this redesign project was to better gather and organize relevant content. We mapped all SIAM publications, conferences, activity groups, and general fields of community interest to 17 core research areas,[1] such as data science, linear algebra, optimization, etc. These pages cross-pollinate materials regarding SIAM publications, activity groups, and related events.

[1] https://www.siam.org/research-areas



New SIAM website.



Old SIAM website.

Synchronization with SIAM's Database

New integrations with our database allow information about key volunteers on SIAM committees, editorial and activity group boards, prize selection committees, student chapters, and things like affiliations or email addresses—which have historically been displayed on the website—to update automatically as soon as users revise their profiles. Remember to always keep your information up-to-date[2] so that it displays accurately on our website and SIAM knows how to best contact you.

Comprehensive Cross-Domain Site Search

If you ever wished that there was one place to search for content spanning all SIAM web domains—our journals and books sites, the SIAM Job Board, and *SIAM News*—the new website has made that wish a reality. The search function on the top right delivers results from all of these important information hubs, making it easy for you to find anything of interest. We plan to iron out a few outstanding kinks involving search results over the next few months, and appreciate your patience as we work to improve this feature.

Archive.siam.org

Do you use our website to reference historic data? It would not surprise us if you did, considering our conference archive alone gets over 20,000 views every year. We have ensured that you will not lose access to the decades of information from our previous site by creating **archive.siam.org**. This is essentially a duplication of our prior website, where you can access old content that is now frozen in time. Some sections will pop you over to the new site for updated information, while others will keep you on the page in reference to older content. A link to the archive is available on the top left of the new website.

[2] https://my.siam.org/login/

Resources for Getting Involved

Not only are we providing more information about SIAM's participation in the global applied math and computational science communities, now you can also more easily discover opportunities for involvement. From volunteering your time and making a donation to simply spreading the word about SIAM and the fields we represent, you can have an impact. Check out the pages on collaborations,[3] getting involved,[4] and our Newsroom[5] for resources—flyers, videos, logos, social media photos, etc.—to share with your own networks. And do not forget that you can now share helpful content via email and social media right from our website through the "ShareThis" widget (a black circle with an arrow), which resides on the bottom left of our key resource pages.

If you would like to offer feedback on the new site, simply click the "Feedback" widget on the bottom right side of your browser.

Read more about the new website in SIAM President Nick Higham's column on page 2 of this issue.

Becky Kerner is the digital communications and brand manager at SIAM.

[3] https://www.siam.org/about-SIAM/collaborations
[4] https://www.siam.org/get-involved
[5] https://www.siam.org/newsroom

From the Foundations of Mathematics to Eugenics and Beyond

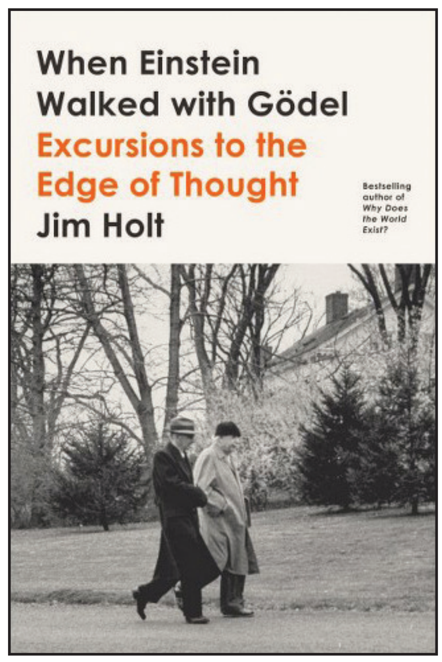
When Einstein Walked with Gödel: Excursions to the Edge of Thought. *By Jim Holt. Farrar, Straus and Giroux, New York, NY, May 2018. 384 pages, $28.00.*

BOOK REVIEW

By James Case

The dust jacket of this collection of lightly-edited essays features an image of Albert Einstein and Kurt Gödel, dressed in overcoats and walking together. They regularly walked between their Princeton, NJ homes and offices at the Institute for Advanced Study in both good and bad weather. This custom began soon after Gödel's arrival at the institute in 1940 and continued until Einstein's 1955 death became imminent. While one cannot truly ascertain their topics of conversation, it seems safe to assume that general relativity was a recurrent theme. A student of both math and physics at the University of Vienna, Gödel was naturally curious about the subject and—during his acquaintance with the master—discovered a new set of solutions to Einstein's field equations, which described a rotating universe that could accomodate time travel. This unexpected development inspired Jim Holt to reprint (from *Lapham's Quarterly*) his own related essay, "Time — the Grand Illusion?" in his most recent book.

When Einstein Walked with Gödel is a collection of *New Yorker*-style essays,[1] some 12 to 15 pages long, grouped in nine parts. The sole exception is Part VIII, which offers 15 op-ed-length "quick studies." One such essay, "The Cruel Law of Eponymy," bemoans the fact that mathematical and scientific discoveries—such as Pythagoras' theorem and the Gaussian distribution—are seldom named for their actual discoverers, but rather for a subsequent developer. A more mundane example is the flush toilet, which was *not* invented in the 19th century by plumber Thomas Crapper, but by Sir John Harrington at the court of Queen Elizabeth I. Crapper merely made them available to middle-class buyers. Holt's other short essays concern Heisenberg's uncertainty principle, the law of least action, and Emmy Noether's beautiful theorem. The latter, he explains, reveals an unexpected duality between the symmetries of a physical system and the conservation laws that apply to it. Richard Feynman calls her discovery "a most profound and beautiful thing," one that "most physicists still find somewhat staggering."



When Einstein Walked with Gödel: Excursions to the Edge of Thought. By Jim Holt. Courtesy of Farrar, Straus and Giroux.

Yet another of Holt's quick studies examines overconfidence in light of the Monty Hall problem. Named for the original host of the game show *Let's Make a Deal*, the problem was first publicized by *Parade* columnist Marilyn vos Savant. Contestants on the show were offered three doors, one of which harbored a valuable prize (the other two concealed relatively worthless consolation prizes). After a contestant chose what he/she thought was most likely the winning door, the host opened a different door, revealing a worthless consolation prize. The contestant then had to decide whether to revise his/her guess before the host opened a second door. Should the contestant (A) assume his/her original guess was mistaken and switch, or (B) assume it was correct and stand pat? Since the initial guess was a one-in-three proposition, it was twice as likely to be wrong as right; hence option A. More than a few professional mathematicians, including Paul Erdős himself, have refused to accept this seemingly-counterintuitive conclusion until shown a formal proof.

The essay quotes a variety of psychological studies finding that people often claim to be "absolutely certain" of issues they know little about, while better-informed individuals are more likely to concede doubt. In one such study, experimenters administered tests in logic, English grammar, and humor (where respondents' ratings of jokes were judged against the opinions of a panel of professional comedians) to a group of subjects. In their exit interviews, the lowest scorers tended to express confidence in their performance, while the highest scorers were more skeptical of themselves. For this and other reasons, Holt concludes that high levels of confidence correlate with high levels of *over*confidence.

Part II of the book—entitled "Numbers in the Brain, in Platonic Heaven, and in Society"—is more representative of its overall content and consists of three essays. The first addresses the neuroscience of mathematics and features the work of French researcher Stanislas Dehaene. Dehaene sought to discover the way in which numbers are coded in our minds, and used brain scanning techniques to determine where our numerical skills reside among the folds and crevices of our cerebral cortices. He also examined the extent to which certain natural languages, such as Chinese, facilitate the learning and use of arithmetic.

The second essay pertains to the Riemann zeta function and what Holt calls "the laughter of the primes." After an introductory discourse on laughter—as practiced by children, chimpanzees, and the rest of us—he explains prime numbers and reveals that infinitely many of them exist. He then introduces Leonhard Euler's discovery

$$\zeta(s) = 1 + 2^{-s} + 3^{-s} + 4^{-s} + \ldots$$

$$= \frac{1}{1-2^{-s}} \times \frac{1}{1-3^{-s}} \times \frac{1}{1-5^{-s}}$$

$$\times \frac{1}{1-7^{-s}} \times \frac{1}{1-11^{-s}} \times \ldots .$$

See **Eugenics and Beyond** *on page 11*

[1] Several of these did originally appear in the *New Yorker*, and several others appeared in the *New York Review of Books*. In his acknowledgements section, Holt names the publications in which each essay originally appeared.

Orthocenter, Archimedean Style

MATHEMATICAL CURIOSITIES

By Mark Levi

The concurrency of altitudes in a triangle (at the point called the *orthocenter*) has been known since the times of Euclid, if not before. A couple of millenia later, Leonhard Euler, Carl Friedrich Gauss, and other mathematicians came up with different proofs [2]. Vladimir Arnold [1] observed that the Jacobi identity

$$(\mathbf{a}\times\mathbf{b})\times\mathbf{c}+(\mathbf{b}\times\mathbf{c})\times\mathbf{a}$$
$$+(\mathbf{c}\times\mathbf{a})\times\mathbf{b}=\mathbf{0}$$

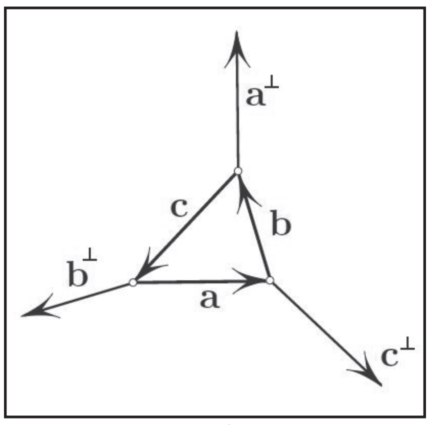


Figure 1. *The three forces balance; their lines are therefore concurrent.*

for the cross product of vectors in $\mathbb{R}^3$ implies the concurrency of altitudes.

Writing the previous issue's column, "A Perspective on Altitudes,"[1] led me to the following physically-motivated proof of the concurrency of altitudes.

Our triangle is a rigid frame, free to slide within the plane. To each vertex of the triangle, let us apply the force perpendicular to the opposite side and of magnitude equal to that side's length (see Figure 1). I claim that *the triangle will remain in equilibrium*, i.e., the sum of these forces vanishes, as does the sum of their torques (relative to some pivot and hence to all pivots; the sum of torques is pivot-independent if the sum of forces is zero). Apart from being perhaps of independent interest, this equilibrium statement implies (and also follows from) the altitudes' concurrency.

Indeed, the contrary assumption—that the lines of forces are not concurrent, as in Figure 2—implies a nonzero torque relative to P, a contradiction.

It remains to prove that the forces and the torques in Figure 1 do indeed balance out. The total force

$$\mathbf{a}^\perp+\mathbf{b}^\perp+\mathbf{c}^\perp=\mathbf{0} \qquad (1)$$

since $\mathbf{a}+\mathbf{b}+\mathbf{c}=\mathbf{0}$. And the total torque vanishes according to Figure 3, where one of the vertices is chosen as a pivot. This completes the proof.

Thus, one could loosely say that the root cause of the altitudes' concurrency is the symmetry of the torque's magnitude under permutation of the lever and the force.

Incidentally, (1) is one of many corollaries of a perpetual motion machine's impossibility. Indeed, let our triangle be surrounded by the two-dimensional gas of pressure $p=1$ (units of force per unit of length). The sum in (1) is then the total force on the triangle, and must vanish since the alternative is a functioning perpetual motion machine.

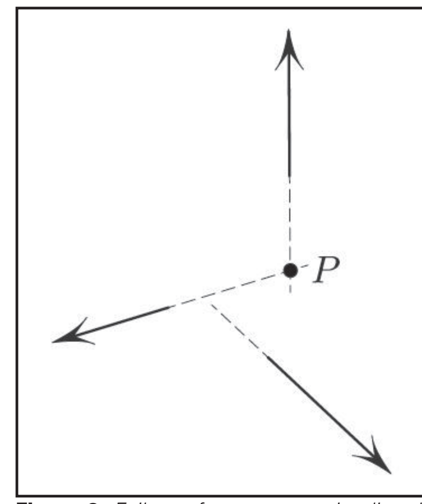


Figure 2. *Failure of concurrency implies the nonvanishing of the torque.*

The sum of torques of these forces vanishes as well, again by the perpetual motion argument. This also implies the concurrency of the midpoint perpendiculars — an alternative proof of the simple fact well known since antiquity.

I would not be surprised if someone in ancient times—Archimedes, perhaps—already came up with the above proof; we will probably never know. This suggests that if one waits long enough, an old idea becomes original.

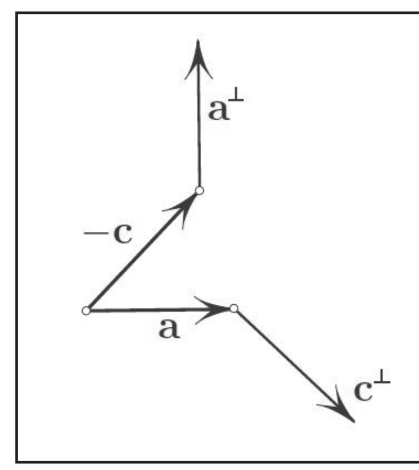


Figure 3. *The torque's magnitude does not change if the force and the lever are interchanged and rotated by $\pi/2$.*

The figures in this article were provided by the author.

[1] https://sinews.siam.org/Details-Page/a-perspective-on-altitudes

References

[1] Arnold, V. (2005). Lobachevsky triangle altitude theorem as the Jacobi identity in the Lie algebra of quadratic forms on symplectic plane. *J. Geom. Phys., 53*(4), 421-427.

[2] Ivanov, N.V. (2011). Arnol'd, the Jacobi Identity, and Orthocenters. *Amer. Math. Mon., 118*(1), 41-65.

Mark Levi (levi@math.psu.edu) is a professor of mathematics at the Pennsylvania State University.

Announcing the Upcoming SIAM General Election

The SIAM General Election is quickly upon us. This year, we will be electing three SIAM Board of Trustees members and four SIAM Council members to serve as part of SIAM Leadership.

Polls open on September 11, 2018; don't forget to vote! And look out for an insert featuring detailed candidate bios in the October issue of *SIAM News*.

Eugenics and Beyond

Continued from page 8

It had little immediate impact, because Euler never noticed his result's application to both complex and real values of the exponent s. Full implications did not begin to emerge until Bernhard Riemann entered the field.

The laughter in Holt's rendition relates to the fact that each zero of the zeta function is associated with a musical note, the amplitude and frequency of which depend on the zero's location in the (complex) s-plane. Only if all of the zeros lie in the vertical strip $0<IM(s)<1$ will the "orchestra of the primes" be in balance, with no one note drowning out another. Riemann's hypothesis then asserts that all of the zeta function's complex zeros lie on the center line of that strip.

The final essay in Part II is entitled "Sir Francis Galton, the Father of Statistics… and Eugenics." One of the 19th century's great innovators, Galton is deemed the father of fingerprinting. He also coined the phrase "nature versus nurture." His motto became, "Whatever you can, count." As a young man in search of a career, Galton heeded the advice of his cousin Charles Darwin to "read mathematics like a house on fire." He exerted himself at the University of Cambridge until suffering a breakdown from overwork.

Keenly aware of Darwin's theory of natural selection and the results achieved by selectively breeding farm animals, Galton never doubted that nature would dominate nurture in the development of human talent and virtue. He believed that one could improve and enhance humanity itself by selective breeding, early marriage, and high fertility among the "genetic elite." His work in statistics and eugenics were not separate endeavors, but rather parts of a single program "for the improvement of the breed."

In Galton's day, statistical inference was a dreary enterprise riddled with population numbers, trade figures, and the like. The field was entirely devoid of mathematical interest, save for the ubiquity of the Gaussian (normal) distribution. Galton invented his eponymous "Galton Board" (available from Amazon for $49.99) to demonstrate the connection between sums of random variables and normal distribution. It was but one of his many contributions to science.

Though primarily interested in the inheritance of intelligence, Galton wisely concentrated on more readily measureable characteristics. After obtaining the heights of 205 pairs of parents and 928 of their offspring, he plotted the average height of each couple against that of their children and drew a straight line through the resulting cloud of data points in an attempt to quantify the evident trend. Finding the slope of the line to be two-thirds, he concluded that exceptionally tall/short parents tend to have slightly less exceptionally tall/short children. He dubbed this tendency "regression toward mediocrity" and coined the term "correlation" to describe the observed relationship. Regression and correlation, says Holt, spawned a genuine revolution in science by drawing attention to "statistical" laws. Researchers previously assumed scientific laws to be deterministic.

Other parts of *When Einstein Walked with Gödel* concern pure and applied mathematics, maps, infinity, computers, the cosmos, and the nature of truth itself. Holt discusses all in a manner that is both erudite and accessible, interspersing passages of mathematical exposition with items of personal interest—including a healthy dose of plain old gossip—about prominent mathematicians.

James Case writes from Baltimore, Maryland.

Professional Opportunities and Announcements

Send copy for classified advertisements and announcements to ***marketing@siam.org****. For rates, deadlines, and ad specifications, visit* ***www.siam.org/advertising****.*

*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****.*

Williams College

Department of Mathematics and Statistics

The Department of Mathematics and Statistics at Williams College invites applications for a new **tenure-track position in statistics**, beginning fall 2019, at the rank of assistant professor. A more senior appointment is also possible for a qualified candidate at a later stage in their career. The candidate should have a Ph.D. in statistics or a closely-related field by the time of appointment. We are seeking candidates who show evidence and/or promise of excellence in teaching and a strong research program that can engage undergraduate students. The candidate will become the seventh tenure-track statistician in the department, joining a vibrant and innovative group of statisticians within an established statistics major. For more information on the Department of Mathematics and Statistics, visit **http://math.williams.edu/**.

Candidates may apply via **https://apply.interfolio.com/50978** by uploading a cover letter addressed to Professor Richard De Veaux, a curriculum vitae, a teaching statement, a description of research plans, and three letters of recommendation on teaching and research. The department is committed to building a diverse and inclusive community. In your application materials, we also ask you to address how your teaching, scholarship, mentorship, and/or community service might support Williams' commitment to diversity and inclusion.

Expectations: The teaching load is two courses per 12-week semester and a winter term course every other January. The candidate will be expected to teach introductory statistics, core courses for the statistics major, and elective courses in their areas of interest. The successful candidate will establish an independent research program that results in scholarly publications. Williams College provides broad support for startup funds, funding for student research assistants, faculty professional development funds, and a shared computer cluster for parallel computation.

Review of applications will begin on or after **October 1st** and will continue until the position is filled. All offers of employment are contingent upon completion of a background check. Further information is available at **https://faculty.williams.edu/prospective-faculty/background-check-policy/**.

Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts. The college has built its reputation on outstanding teaching and scholarship, and on the academic excellence of its approximately 2,000 students. Please visit the Williams College website at **http://www.williams.edu**. Beyond fully meeting its legal obligations for nondiscrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

Society for Industrial and Applied Mathematics

Director of Programs and Services

The Society for Industrial and Applied Mathematics (SIAM) seeks a creative, strategic director of programs and services to support the technical activities of the society. Reporting to the executive director, the director of programs is responsible for the oversight and management of programs and projects mostly concentrated on the society's membership program and conference program, including the administration of grants in those areas. This position plays a central role in assuring the continuity and reliability of SIAM activities and ensuring timely response to changing needs and new opportunities, taking a leadership role in advancing these programs with the proven ability to be innovative and original in the development and enhancement of member and conference programs and services.

The position has two direct reports. The individual selected for the position must have excellent written and verbal communication skills and be able to interface with SIAM governance, including officers, board members, and members of related committees. The position requires a knowledge of applied mathematics and/or computational science; advanced degree preferred. Please submit a cover letter and either a CV or resume to Susan Palantino, chief operating officer, 3600 Market Street, 6th Floor, Philadelphia, PA 19104, or via email to **palantino@siam.org**. EOE.

The Society for Industrial and Applied Mathematics (SIAM) is an international community of 14,500+ individual members. Almost 500 academic, manufacturing, research and development, service and consulting, government, and military organizations worldwide are institutional members. SIAM was incorporated in 1952 as a nonprofit organization to convey useful mathematical knowledge to other professionals who could implement mathematical theory for practical, industrial, or scientific use. Today, SIAM continues to advance the application of mathematics and computational science to engineering, industry, science, and society.

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

Tribulations and Triumphs of Women in Mathematics

By Lina Sorg

In recent years, society has made great strides toward improving diversity and gender equality in the workforce. Even so, succeeding as a female in a male-dominated discipline is not without challenges. This is especially true in the field of mathematics, where demands and expectations for research, mentoring, and leadership are already high. At the 2018 SIAM Annual Meeting, held in Portland, Ore., this July, a panel of women from both academia and industry—sponsored by the Association of Women in Mathematics—spoke candidly about the difficulties and successes of being a female mathematician and fielded questions about gender bias, professional development, and work-life balance.

A recurring theme of discussion was the perpetual value of self-confidence and assertiveness, which are particularly important when searching for internships. "Be 10 percent shy of annoying," Laina Mercer of the Institute for Disease Modeling said. Lalitha Venkataramanan of Schlumberger-Doll Research agreed, and encouraged attendees to approach companies directly and inquire about internship opportunities. She also emphasized that—contrary to popular belief—there is rarely an inappropriate time in one's career for an internship; an acquaintance once postponed her thesis defense to accept a promising opportunity, then successfully defended her thesis afterwards.

Internship experience is crucial in helping early-career mathematicians determine the focus areas that best align with their research interests. Nina Amenta of the University of California, Davis originally received a B.A. in classical civilization, but turned to computer programming when she had trouble finding a job. She went back to school for computer science and ultimately earned her Ph.D. Stellar faculty connections led Amenta to an internship in computational geometry. "Here was a piece of computer science that was tailor-made for me," she said. "Internships are a great way to dive into something in-depth and find out if you love it."

An internship was also transformative for Mercer, who completed a Research Experience for Undergraduates program through the National Science Foundation and fortuitously ended up working with a biostatistician. "I thought I would go to grad school for math, but that experience changed my whole trajectory," she said. Instead, Mercer earned a master's degree in biostatistics and a Ph.D. in statistics.

Other panelists found themselves pursuing unexpected career paths as well. "I am from a very traditional family," Chiu-Yen Kao of Claremont McKenna College said. "My mom thought that females should get an education, but not a high education." Undergraduate mentors, however, pushed Kao to seek out internships and pursue academia.

All four speakers urged audience members to thoroughly research salaries and benefit packages when applying for postgraduate positions. Candidates should prepare to negotiate. "In industry, the only negotiating power is the human resources manager," Venkataramanan said. "You need to ask for the upper end of the cost distribution. They'll want to put you at the lower end, so do your research. Ask for 20 percent more than what you're worth." If salary negotiation is impossible, she suggested bargaining for more vacation time or a flexible work-from-home policy. In fields such as the oil industry, female employees are particularly desirable and thus have high bargaining potential.

The value of negotiation extends far beyond the initial hiring process. When Venkataramanan felt that she was unable to properly commit to industry research in an office setting, she spoke to her manager and spent six months working regularly in the library to heighten her productivity. Mercer gained permission to work individually offsite—and without distraction—two days a week. While this type of freedom is not uncommon, candidates must ask about such flexibilities when interviewing. "I feel lucky that there's support for that," Mercer said. "As long as you can make the case that the work is applied and helpful to others, you do have some flexibility."

Discussion then moved to the challenge of balancing research with administrative growth, as technical and managerial ladders exist in both academia and industry. For example, Amenta likes working with people and recognizes her own aptitude for organization. While this might imply administrative propensity, there is always a tradeoff. When working with students, for instance, one might begin to neglect her own mathematics. "If you get far into management, you lose the ability to do your own thing and your own research," Amenta said. "There is a tendency for women in STEM to be drawn into management because of the stereotype of great people skills. Finding the right balance there is a difficult thing."

From left: Laina Mercer (Institute for Disease Modeling), Chiu-Yen Kao (Claremont McKenna College), Lalitha Venkataramanan (Schlumberger-Doll Research), and Nina Amenta (University of California Davis) address the audience during the Association for Women in Mathematics workshop panel, which took place at the 2018 SIAM Annual Meeting in Portland, Ore., this July. SIAM photo.

Panelists also warned future academics about the unavoidable demands—both emotional and physical—of early-career academia. "The first few years of teaching were amazingly stressful," Amenta recalled. "People are going to want as much from you as you're willing to put into it. You're going to have to set some boundaries on that." She suggested that attendees have someone or something—i.e., a regular appointment with a research partner—holding them accountable for their time and keeping them on track.

Kao manages her calendar closely, blocks off designated times for research, and never gives that time away. As a budding mathematician, she initially set her alarm in the middle of the night to maximize research output — and quickly realized the ineffectiveness of this approach. Now that she has a family, Kao refrains from working at home to maintain a healthy work-life balance.

Mercer employs a similar time management strategy. She knows that she cannot accomplish anything worthwhile without at least two uninterrupted hours, and thus arranges her schedule accordingly. She also removed her work email from her phone. "This way I don't think about it," Mercer said. "Because even if you don't actually do work, having access to your email can affect your quality of life."

Venkataramanan looks at each day as an optimization problem with an objective function to maximize the day and make the most of her time. When presented with an unexpected task, she determines whether it fits with her professional goals, moves her closer to a desired achievement, or involves mentoring or giving back to the community. If it does not fit any of these categories, she declines. "The first 'no' is the hardest," Venkataramanan said. "Then you get used to it." The women collectively agreed that waiting 24 hours to deny or consent to a request is sufficient; if the project is still appealing the next day, then it is likely a good choice.

While disappointing people can be tough, Mercer assured the audience that saying "no" becomes easier with time. "I had to get used to the idea that people won't be happy with that answer," she said. "But I also get fewer requests for things that aren't as relevant to me, or things I don't want to do." She also pointed out that saying "no" can come with stipulations depending on one's employment. "In an industry role, you're not always in a position to have a strong 'no,'" Mercer observed. "Segment your time and say, 'if you want me to do this, what gets down-prioritized, bumped, or missed?'" This response alerts colleagues to the finite time in one's workday.

Managing a busy workload is increasingly arduous if one has a family, and multiple attendees inquired about the gender stereotypes of motherhood. "Be ready for that," Mercer said. "I have totally been asked inappropriate questions about whether or not I have a spouse, where their job might take them, and whether or not I'm going to have kids." Though employers should not ask these types of questions in interviews, they do come up from time to time.

In an act of transparency, Venkataramanan keeps pictures of her children in her office and is happy to answer questions about work-life balance from curious students. Amenta stressed the importance of inquiring about policies, benefits, and parental leave at an early stage. "It's very easy to let this benefit stuff wash over you, but universities vary quite a bit," she said. "It's really not at the top of your mind when you're job-searching, but it's something you should definitely consider. If you get a tenure-track position, there are almost universally well-defined parental leave policies that are there to support you."

While all panelists agreed that their overall experiences were decidedly positive, succeeding as a female in a male-dominated field is often challenging. "One of the pros is that you're very visible," Amenta said. "Everybody knows you. But people are always questioning your competence in a way that I don't think is justified." She added that taking ownership of original ideas—which constitute one's livelihood—is especially imperative.

Amenta encouraged attendees to persistently speak up for themselves when colleagues intentionally or inadvertently dismiss their contributions. "People assume that you can be intimidated because you're female," she continued. "I think you just have to realize what's happening, breathe deeply, remain calm, and keep moving through it."

As discussion wound down, Mercer reminded the audience to have fun despite the inevitable stressors. "I felt pressured to work all of the time in grad school, and I never appreciated the finishing returns," she said, adding that she could not fully enjoy free time or non-work activities due to self-imposed burdens. Amenta asserted that the frustrations and pressures are offset by the satisfaction that accompanies the final result. "You are undergoing this crazy transformation from a lay person into a scientist and expert," she said. "It's very difficult, and you have to give yourself space for the transition from caterpillar to butterfly. There are a lot of painful parts to it; don't panic."

Lina Sorg is the associate editor of SIAM News.