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APS physics

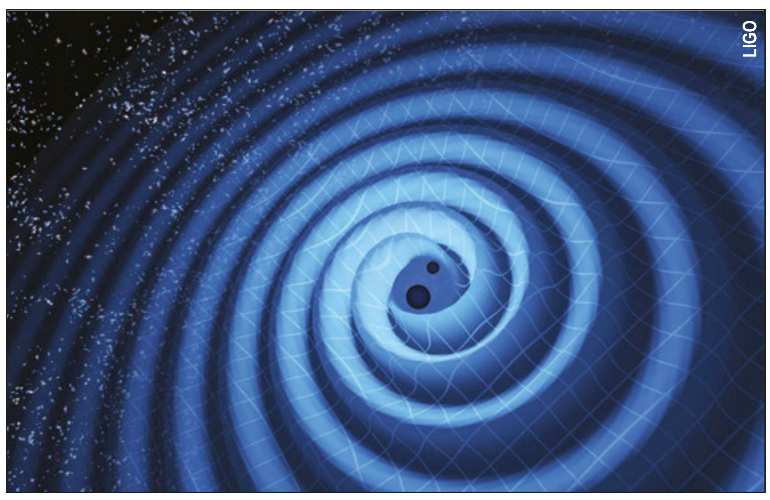
More on the 2016 APS Division of Fluid Dynamics Meeting
Pages 2, 4, 5.

Top Ten Physics Newsmakers of 2016

Each year, APS News *selects the top ten physics stories that made it into newspapers and onto televisions in the U.S. and across the world. While the selections may be scientifically important, the main criterion is how much coverage they generated.*

Ripples in Spacetime

It was the black hole merger heard around the world. In February 2016, researchers announced the first direct observation of gravitational waves. The Laser Interferometer Gravitational Observatory Scientific Collaboration (LIGO) and the Virgo Collaboration attributed the signal to a merger of two black holes, whose death spiral could be heard as a "chirp" when converted to an audio waveform. Then in June 2016, the research teams presented results from a second merger, this time of two black holes with smaller masses. The LIGO detectors were shut down for upgrades and restarted in November for a second observing run. Also in June, the European Space Agency had a successful test run of the Laser Interferometer Space Antenna Pathfinder mission, showing the feasibility of operating gravitational wave detectors in orbit.



Making waves

Nobel Prizes

In October 2016, David J. Thouless, F. Duncan M. Haldane, and J. Michael Kosterlitz won the Nobel Prize in Physics for using topological concepts in theoretical condensed matter physics.

NEWSMAKERS continued on page 6

Careers Report

Playing with Physics Innovation and Entrepreneurship (PIE) Education

By Linda Barton

Innovation and Entrepreneurship (I&E) programs are springing up across the nation, and physics departments are showing interest in including I&E elements in undergraduate physics curricula. However, a full integration of physics innovation and entrepreneurship (PIE) programs would require a wholesale revamping of the traditional undergraduate physics curriculum. In most cases, departments would resist and change would always be a difficult, long process. Fortunately it is possible to revitalize undergraduate physics programs and invigorate undergraduate physics students through the inclusion of PIE activities, without disruption. "Playing" with PIE allows a department to test out some new ideas before committing to a broader scope of activity. Here are a few things we've tried with success at the Rochester Institute of Technology (RIT).

Invited Speakers: Every department has colloquia, but too often these talks are far too advanced and esoteric to engage the average undergraduate. If industry speakers are brought in, they are often far advanced in their careers, and undergraduates have a hard time relating to them. Instead, we invite recent graduates working

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Inside APS

Irene Lukoff: Director of Development

In this series of articles, *APS News* sits down with APS employees to learn about their jobs, their goals, and the things that make them tick. This month we chat with Irene Lukoff. She discusses her role as the director of development and future goals for the society and its development.

When did you join APS?

I started in August 2016. Prior to that I served briefly as vice president for philanthropic partnerships at the Aspen Institute. A significant portion of my career has been in service to the University of Pennsylvania, where I spent 26 years in various administrative and development roles across three of its major schools—Arts & Sciences, Wharton, and Perelman School of Medicine. I started as a major gifts officer for Basic Sciences and rose to senior director of development, overseeing a number of interdisciplinary centers and institutes with a focus on healthy aging and the neurosciences.

What does a Director of Development do?

I help organizations grow, develop, and make connections. My primary job is matching donors' philanthropic passions with the institution's mission, funding needs, and strategic priorities—what most folks associate simply with "fundraising"—but it's much more than that. Here at APS we are looking for donations to support outreach and educational programs that raise awareness about physics and what physicists do, and benefit not only our membership, but society at large. They strengthen the community of physicists as an advocate for science in general, and physics in particular.

Irene Lukoff

How is fundraising different for APS compared to the academic organizations you previously worked for? Penn Medicine in particular.

Unlike my previous positions, where I was raising funds for the production of basic, translational, or clinical research, here we are primarily raising funds to honor physicists and their professional legacy with the goal of inspiring others to those pursuits—somewhat different and more challenging, in that it is one step removed from the product.

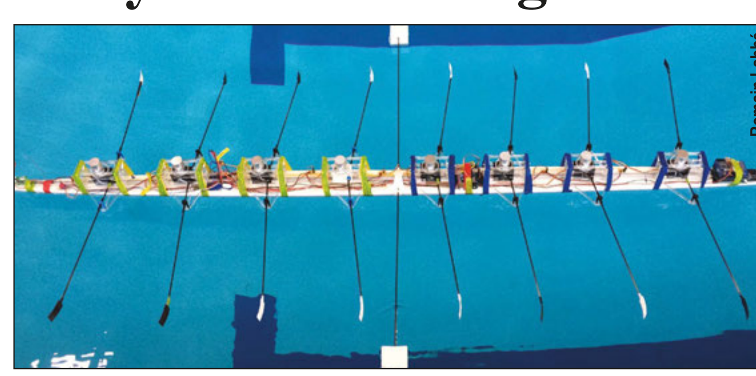
For example, I used to raise

LUKOFF continued on page 4

Robots Test the Physics of Rowing

By Katherine Kornei

2016 APS Division of Fluid Dynamics Meeting—Competitive rowing is the epitome of synchronization: oars dipping into and out of the water at exactly the same instant, human bodies bending and pulling together. Now, scientists have examined the effect of removing some of that synchronization. A team of physicists found that the speed of a boat depended on whether or not its rowers were out of step. They expect that these results, presented at the 2016 APS Division of Fluid Dynamics annual meeting in November in Portland, Oregon, can be applied to improve rowing performance and optimize the design of boat propellers.



Robotic rowers test the effects of oar synchronization.

Romain Labbé and Jean-Philippe Boucher, two researchers from the Sport Physics group at Ecole Polytechnique in France, built a 1/10-scale model of a racing shell containing eight robotic rowers. "We wanted to look at the effect of synchronization on the boat speed, an effect that is emphasized with a large number of rowers," explained Boucher. Boucher and Labbé, along with Timothy Mouterde and Christophe Clanet, placed the 2-meter boat in the Ecole Polytechnique's swimming pool and measured its speed as its robotic rowers moved in various degrees in synchronization.

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Cat Tongues Are the Ultimate Detanglers

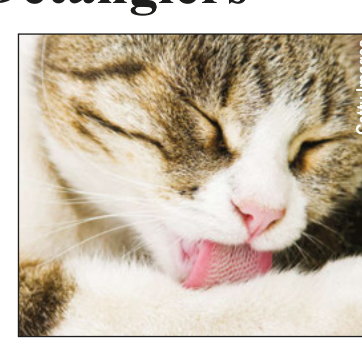
By Rachel Gaal

2016 APS Division of Fluid Dynamics Meeting—Knots and other nasty tangles are a nuisance to remove from human hair, and regular hairbrushes seem to make things worse. Perhaps the secret to better detangling is known by our furry feline pets. The question is: How do they groom their coats?

Alexis Noel from Georgia Institute of Technology started asking herself the same question while watching her pet cat at home.

"[My cat] was licking this microfiber plush blanket, and he got his tongue stuck … .", Noel told the crowd during her presentation at the 2016 APS Division of Fluid Dynamics meeting. "While it was hysterical, the scientist in me started thinking, 'Why does this happen?'" The answer seemed at first like something involving a fluid—saliva—but Noel's research went down a different path.

Currently a Ph.D. candidate in mechanical engineering, Noel wanted to know more about the forces and dynamics behind cat grooming, so she got a tongue tissue sample, brought it into the lab, and took an up-close 3D look using a computational tomography (CT) x-ray scanner.



"The tongue had these very interesting spines, called papillae, which were organized like roof shingles," Noel said. While the sharp spines are actually made of hard material similar to human fingernails, they are embedded within soft tissue that allows the papil-

TONGUES continued on page 4

One Year Later: *Physical Review Fluids*

By Rachel Gaal

One of the largest membership units of APS, the Division of Fluid Dynamics (DFD) recently hosted its 69th annual meeting in Portland, Oregon, where over 3,000 attendees participated in conference events. A feature at the APS exhibitors booth was the new journal *Physical Review Fluids* the most recent addition to the *Physical Review* collection.

The initial request to create a new fluids journal was presented to APS in 2014 and *Physical Review Fluids* journal completed its first volume at the end of 2016. Although *Physical Review Fluids* is still in its infancy, the editors are positive about the journal's progress.

"We are very happy with our first volume, both in terms of quality and the scope we have covered," writes John Kim of the University of California, Los Angeles, and co-lead editor of *Physical Review Fluids*, in an email to *APS News.* "[Our submissions] so far have ranged from fundamental fluid mechanics to applications, to energy creation and harvesting, biology, forensics, understanding of climate change, all the way to the implications of landing on Mars."

With help from the two lead editors, Kim and Gary Leal of University of California, Santa Barbara, 12 associate editors and 17 editorial board members, the journal has attracted hundreds of papers. About 75% of submissions are from the United States, Canada, and Europe, and a steady 60 submissions are being received each month. Kim and Leal are former editors of the journal *Physics of Fluids*, published by the American Institute of Physics Publishing.

"While this is a great result for a journal in this field, and especially for a new journal that has yet to be indexed, [the submission rate] is still about 30% less than the top competitors," says Luigi Longobardi, the *Physical Review Fluids* journal manager at APS. "What is more important for us is to attract a healthy number of papers, but we also want high quality content. From this point of view, we are about to close a very strong first volume at the end of 2016."

After enough citation data are collected, *Physical Review Fluids* will be included in the Science Citation Index (SCI)—a system that ranks a journal's "impact factor" in its respective fields.

"The current submission [rate] is about one half of what we used to receive in *Physics Of Fluids* … in large part due to the fact that *Physical Review Fluids* is not yet included in SCI, which is the major consideration for the authors in Asian countries. We hope that we will reach that point soon, and we expect that *Physical Review Fluids* will be indexed sometime early next year, [which] will certainly increase the total number of submissions," says Kim.

The editorial board of *Physical Review Fluids* hopes to maintain and leverage close ties with the APS Division of Fluid Dynamics. Beginning in 2017, *Physical Review Fluids* will feature the prizewinners of the Gallery of Fluid Motion (gfm.aps.org), and invited papers from the annual DFD meeting. The gallery is an array of short video clips and poster images that highlight the aesthetic beauty of fluid motion and typically draws in crowds of all backgrounds to the DFD meetings.

"Being part of the highly recognized *Physical Review* family is increasing our recognition," Kim adds. "...In the future, in addition to traditional fluid mechanics topics, we would like to expand more into areas such as bio-related fluid dynamics, including swimming and flying, micro- and nano-scale fluid dynamics, flows of complex fluids and soft materials, geophysical and environmental flows."

To learn more about *Physical Review Fluids,* visit journals.aps.org/prfluids

This Month in Physics History

January 15, 1919: Physics and the Boston Molasses Flood

One of the strangest historical tragedies of 20th century America is the Great Boston Molasses Flood of 1919, when tons of treacle from a burst storage tank coursed through the city's streets. The incident reveals some fascinating fluid dynamics, according to a presentation at the annual meeting of the APS Division of Fluid Dynamics in November 2016.

The owner of the faulty tank was the Purity Distilling Company. At that time, molasses was a vital commodity, not just because it could be fermented to make rum and ethanol, but also for its use in making munitions as World War I raged in Europe. Located in the North End of Boston, the tank was built hastily because of the war, with rather loose regard for safety regulations. Most notably, it was never filled to capacity to test for leakage, prior to being used to store molasses. Not surprisingly, the tank leaked from the start, showing brownish-red stains in stark contrast to the original blue paint job. Some people even collected the leaked molasses for their personal use. When a few local residents finally complained, the company painted the tank to match the stains, in order to camouflage the leaks.

In hindsight, a catastrophic failure was inevitable, and disaster struck on the afternoon of January 15, 1919. Witnesses heard a roar, a rumbling sound, and then a crash and a loud bang. The the tank — which had just been filled to near capacity a few days before — had collapsed under the strain, and 8.7 million liters of molasses rushed into the streets of Boston, peaking in height at 27 meters and flowing as fast as 56 kilometers per hour.

Aftermath of the rupture of a tank of molasses in Boston, January 15, 1919.

The onslaught was sufficiently powerful to flatten several buildings and do significant damage to the girders of the nearby elevated train. People caught in the flow struggled waist-deep in the molasses, and contemporary newspaper accounts describe people being picked up and hurled several feet, crushed by and drowned in molasses. Others succumbed to injuries and infections in the subsequent weeks.

The rushing wall of molasses carried enough force to damage a nearby elevated railroad.

All told, the flood killed 21 people (along with several horses) and injured 150 others. Rescue efforts were undertaken by several cadets from the USS Nantucket, which was docked at a local pier, as well as police officers, the Red Cross, and Army and Navy personnel in the area. Survivors were taken to a makeshift hospital, although the rescuers struggled to reach victims in time because of the difficulty of wading through the molasses. It took weeks to clean up the mess, using salt water to wash the stuff away and sand to absorb any remaining behind. Even so, people had tracked molasses through adjacent streets, subways, pay phones, streetcars, even into their homes.

Boston residents sued Purity Distilling's parent company, the United States Industrial Alcohol Company, which initially claimed that the flood had occurred because anarchists had blown up the tank as an act of terror. This initially seemed plausible, given how fast the molasses spread through the streets. But investigators concluded this was baseless. In the end, the courts found the company responsible, with survivors of the victims receiving roughly $7,000 each as compensation for their loss. And two decades later, physicists discovered that gravity acting on the viscous fluid provided sufficient driving force to account for the speed of the molasses.

Several factors contributed to the bursting of the tank. Some hypothesized that the fermentation process caused carbon dioxide to build up inside the tank, until its rivets burst. Alternatively, a 2014 structural engineering analysis by Ronald Mayville found that steel used to make the tank was half as thick as it should have been, given its size, and also was far more brittle than modern steel because of the absence of manganese. Furthermore, the rivet holes were not reinforced, making them more likely to deteriorate under stress.

Yet nobody had really studied the fluid dynamics of how the molasses behaved during the flood until

MOLASSES continued on page 3

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Michael Lubell Departs APS after 22 Years of Service

Michael Lubell has stepped down from his position as director of the APS Office of Public Affairs after more than 22 years of dedicated service. During this time he brought considerable experience, passion, and original thinking to his advocacy and advisory role. His efforts contributed to noteworthy successes of the Society, and benefited physicists and science significantly. Michael put his fine writing skills to work in his "Inside the Beltway" column in *APS News* and he lectured widely about APS activities and science policy issues at university campuses and national laboratories. Francis Slakey, APS Associate Director of Public Affairs, will serve as Interim Director of the APS Office of Public Affairs until the search for a permanent Director is complete.

APS Welcomes New and Current Fellows

In December, APS hosted a reception in Greenbelt, Maryland, to welcome new Washington area Fellows and greet current Fellows. (Left) Nobel Laureate John Mather of NASA. (RIght) 2017 APS President Laura Greene of Florida State University. For a complete list of fellows, visit aps.org/programs/honors/fellowships/

News from the APS Office of Public Affairs

APS's Office of Public Affairs Helped More than 2,000 Members Advocate for Science During 2016

By Tawanda W. Johnson

The APS Office of Public Affairs (OPA) worked with more than 2,000 Society members for a record-setting grassroots advocacy effort in 2016. They delivered a strong message about science to congressional representatives by writing op-eds, sending letters, making phone calls, and participating in local and Capitol Hill meetings.

"We had a nearly 20 percent increase in APS-member involvement from 2015," said Francis Slakey, interim director of OPA following the departure of director Michael Lubell. "But it's not just the numbers that matter. We're working to make sure that our members have constructive interactions with their elected officials."

OPA introduced several changes in the grassroots efforts in 2016 to enhance the impact of member engagement. "One shift we made," said Slakey, "was to focus more on state-based activities." Tactics included targeting local op-ed pages, and making phone calls and district visits in states such as South Dakota, Texas, and New York.

In New York, OPA worked with members and students at four different locations to organize congressional office visits during a three-day period. In the regional offices of U.S. Sen. Kirsten Gillibrand (D) and U.S. Rep. Louise M. Slaughter (D-25th), the meetings focused on research funding and STEM education issues.

"In Senator Gillibrand's office, I met with Niambe Tomlinson, and we had time for a much longer discussion—nearly 40 minutes—that rarely happens in a meeting in the D.C. office," said Scott Franklin, professor of physics and astronomy at Rochester Institute of Technology. "I was able to take a student, so the aide got a good idea of my work through both my eyes and those of a student. We're in the process of arranging a lab visit now."

The staffers were recep-

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aerospace-engineer-turned-science-communicator Nicole Sharp teamed up last year with Harvard graduate students Jordan Kennedy and Shmuel Rubinstein to conduct rheological studies of the substance and model the resulting data. Then they compared the models' predictions with historical accounts of the actual flood. And those predictions matched reasonably well with the details Sharp *et al*. gleaned from the archives.

By doing so, they gained some insight into highly viscous spreading flows. Molasses typically falls into the category of a shear-thinning non-Newtonian fluid, but Sharp *et al*. decided to use classical fluid models for their study because at sufficiently cold temperatures—like those on that fateful January day in Boston—it behaves more like a classical fluid. In other words, temperature has more of an effect on the viscosity of molasses at very cold temperatures than deformation. Additional research should shed light on likely convective mixing between warm and cold molasses inside the storage tank just prior to the structural failure, which may have also contributed to the accident.

Sharp believes that understanding the physics of the Great Molasses Flood could provide insight onto other structural failures, such as breached levees or industrial spills. But the flood is also a useful interdisciplinary educational tool, incorporating fluid dynamics, structural mechanics, and engineering, in addition to history, ethics, and law. "We hope that, by shedding some light on the physics of a fascinating and surreal historical event, we can inspire a greater appreciation for fluid dynamics among out students and the public," said Sharp.

Further Reading:

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Park, Edwards. 1983. "Without Warning, Molasses in January Surged Over Boston," *Smithsonian* 14:213–230.

Puleo, Stephen. 2004. *Dark Tide: The Great Boston Molasses Flood of 1919*. Boston: Beacon Press.

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Profiles in Versatility

FICO Scores with Chaos Theorist

By Alaina G. Levine

Predicting the seemingly unpredictable is the name of the game for FICO (originally named Fair, Isaac, and Company), one of the largest analytics firms in the nation. While it is best known for its FICO credit score that lenders use to determine loan interest rates, in fact the 60-year-old firm's business is much broader than that. It sells a whole suite of products and services for a range of customers, including financial institutions, non-financial corporations, and even individuals, with a very specific value proposition: FICO aims to foretell risk and stop fraud.

For FICO to maintain its brand as an industry leader in uncovering financial cons, it must stay innovative and agile. The solution is in the data analytics. In order to protect its clients from fraud and other malicious behaviors, FICO relies on terabytes of data, collected both in the past and in real time, to predict the next financial moves of individuals and organizations. This seemingly chaotic system has to be overseen by someone with both a keen eye and an appreciation for how to extract knowledge from credit card swipes and the other minutia of our daily lives. FICO's wrangler is Scott Zoldi, a Ph.D. physicist with a background in chaos theory who serves as the company's Chief Analytics Officer (CAO), a position he has held since 2015.

"Any behavior—of people, numbers or events—is ultimately unpredictable. Or is it?" Zoldi says with a wink. "From my postdoctoral work in chaos theory to a career in analytic science, I've been endlessly fascinated by the behavioral patterns and predictive insights that data can yield. I've watched, with great amusement, the business world's discovery of Big Data and subsequent obsession with it."

The author of over 35 patents in areas as diverse as self-learning models, cybersecurity, and preventing money laundering, Zoldi has in the last year advanced FICO's reach into new sectors. He is currently fortifying its cybersecurity infrastructure, and is working on the FICO Enterprise Security Score, a new set of products driven by machine-learning algorithms that identify cybersecurity risks across a company and its supply chain.

Zoldi's secret weapon is his physics education, and his fascination with the subject stems from his parents—his father taught physics at the University of Maine, near where he grew up, and his mother taught math at Husson College. He went to the University of Maine in Orono, graduating with a bachelors in engineering physics in 1994. He went to grad school at Duke University, where he became interested in areas of math and physics "where our ability to explain the world breaks down," he says. Chaos theory enveloped him, as he took a deep dive into simulations of condensed matter systems, which gave him his first taste of high performance computing.

Scott Zoldi

As a doctoral student, Zoldi received a Department of Energy Computational Science Graduate Fellowship, which required he complete a practicum, essentially an internship, at a federal government laboratory. He spent two summers at the Center for Nonlinear Studies at Los Alamos National Laboratory (LANL). "It was a perfect fit for me," he recalls. The problems were eye-opening. "One of the research areas was shadowing theories of numerical simulation" he explains. "We were trying to understand the point at which the simulations break down, the equations become unstable, and the system moves into unpredictability."

By the time he finished his Ph.D., he was convinced that he would continue as a researcher in complex systems and in fact became a Directors Postdoctoral Fellow at LANL, which helped fuel his motivation. "I had my own money, freedom, and autonomy," he says, "It was perfect."

But then, rather dramatically, his environment changed, and things became fractured and unpredictable. LANL became embroiled in an international incident in which hard drives went missing and serious concerns were raised regarding who had access to sensitive laboratory information. Suddenly, policies were put into place which significantly restricted lab employee collaborations with scientists from outside the U.S. Zoldi's work was negatively affected, as his partners were scattered across the planet.

Around the same time, Zoldi took a jaunt to San Diego to visit a friend, and "I fell in love with this place," he says. The strange attraction was immediate and encompassing, and rather impulsively, he says, he began plotting a getaway from the mesa to the sea.

HNC Software, a San Diego firm developing software based chiefly on artificial neural networks, came across his radar. It had a credit-card-detection product that seemed interesting. The product "needed to make predictions in real time," he describes. To prevent potential fraudulent purchases, "It had to be automated. It had to have an intelligent model that analyzed a large transaction history quickly and outputted a score into a system to make a decision."

"I saw parallels between my work and their needs," Zoldi says. When he joined the company in 1999, "I had been spending all of my time looking at patterns, and the transition from normal to abnormal. So now I was enthralled with how you could apply that to people, and capture that in an equation, because people are not as regular as physical systems. They are a lot harder to describe, but that was part of the fun."

The challenge of how to identify fraudulent credit card transactions was even more complicated than he expected. First of all, the data set was "humongous, consisting of nearly two-thirds of the world's credit card holders," he says. One of his first tasks was examining ways to segment the population into different categories of people to determine personas of both legitimate and fraudulent card usage. Then there was the fact that the company was doing streaming analytics, in which real-time decisions needed to be made about human

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money from alumni or friends of the University of Pennsylvania who wanted to invest in cures for illnesses like Parkinson's and Alzheimer's. APS is different, in that I am not directly advancing physicists' research, but rather raising awareness about and celebrating their work and legacy—with the hope of inspiring the next generation of physicists to pursue breakthrough science that will advance our civilization. A key focus of our activity here is to raise money for prizes and awards. It's exciting, because I am interacting with many distinguished scientists and Nobel laureates … . I'm constantly in awe.

Do APS membership dues help fund prizes and awards?

The membership dues don't cover everything. Membership dues pay for *Physics Today*, discounted meeting registration fees, and *APS News*, but they don't get you everything. I think we need to make a stronger case for why our members need to contribute over and above their membership dues; they are investing in APS as an invaluable educational and research resource. I think that most of our members know that memberships don't cover our extensive prizes and awards programs. But, we clearly need to do a better job of showing the benefit of investing in our programs (education and diversity, international, public affairs, and outreach) and be able to show what the value of giving is. This is the crux of the issue – that APS can make a difference to society through its programming, but that programming requires support over and above membership dues. We need to make this clear not just to members, but to other potential donors—foundations, corporations, and other individuals.

What other reasons do you think APS members should donate?

Beyond helping the other areas of APS, donating really goes beyond the services to you as a member ... it's about helping the physics community and getting our knowledge out there: "What is the value of physics to society?" There are a lot of physicists working in industry and academia who contribute to building incredible machines, like MRIs and CT scanners. They certainly help save lives.

What changes would you like to make as Director of Development?

We took up some advertising space on the APS homepage, and we want use that for things like highlighting any new gifts or awards ... but my hope is that we can get members to think in terms of their legacy and supporting APS into the future, to think of planned giving, and to think of putting the Society into their estate plans. I also think in the past, fundraising has been thought of as transactional. My hope is to move away from that process toward a relationship-building environment, so you are able to cultivate a relationship with people who have the means and capacity to give … but it requires time to understand what motivates their giving, get to know them, and engage them in the programs. The most rewarding aspect of development is when the donor is so engaged in the organization that you don't even have to ask them for a gift, but rather, a significant gift comes as a result of good relationship-building and long-term engagement.

What got you interested in this type of work?

I learned the craft of fundraising from the former President of the Chemical Heritage Foundation (CHF), Arnold Thackray, and founding chair of the Department of History and Sociology of Science at Penn. He was a consummate fundraiser. I learned from him to do this type of work for pretty complex subject matter while I worked at CHF. I'm not a scientist by training; I have an art history and museum studies background and started my career at the Smithsonian, thinking that I would become a museum director. As an undergraduate I spent time in Florence studying the Renaissance. I'm actually really interested in the intersection of the arts and sciences as reflected in the works of Michelangelo and Leonardo Da Vinci. Why were they such incredible artists and engineers? And then Steve Jobs, he was really into design … he was not a scientist per se, but I think it's why, in part, the iPhone sold so well. You can probably draw a connection to working with these scientific organizations and professional societies; hence, the APS.

What else do you like to do?

Read, visit museums, travel, and spend time with my family. I have grown kids—our daughter who is a second-semester junior, and a son who is working and getting married in July; and while they both live in New England, we love to spend time with them at holidays or whenever we can.

Have you been to Italy since your undergraduate days?

Not to Italy, but we have traveled to Europe in the past few years; both our kids did gap years between high school and college—through Rotary International. Our son was in Denmark and our daughter in Belgium, and we traveled with them throughout Europe I'm Romanian actually, although I was schooled in the States. English isn't my native language; I'm fluent in Romanian and Italian and can converse in French.

Bemused by the Blue Whirl

By Rachel Gaal

2016 APS Division of Fluid Dynamics Meeting—It all started with 800,000 gallons of bourbon and a lightning strike.

Elaine Oran and her colleagues at the University of Maryland were intrigued by video footage (youtube.com/watch?v=ELo7VtCN9s8) that surfaced of a Jim Beam warehouse that caught fire in a lightning storm. But the fire and alcohol spread to a nearby retention pond, creating a booze-fueled "fire tornado" over water.

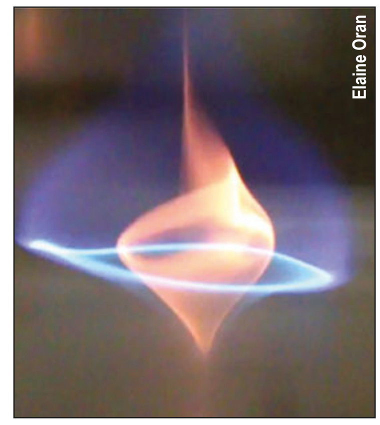
"We spent the whole time looking at this fire whirl," Oran exclaimed during her presentation at the 2016 APS Division of Fluid Dynamics Meeting. "We looked at each other and [asked], 'Why can't we use fire whirls to clean up oil spills?'"

Currently the Glenn L. Martin Institute Professor of Engineering at Maryland, Oran has done extensive research with reactive flows throughout her career.

"[My team and I] knew the combustion of these fire whirls was very efficient, but things changed when we saw this video," continued Oran. "We wanted to know if it was possible to use these for something beneficial instead of letting them be the nightmare of firefighters and people that live in the bush."

Fire whirls are a special kind of reactive flow that has been seen before over land, but investigating them in the lab requires a closer look on a smaller scale. With help from Michael Gollner, Sriram Hariharan, Huahua Xiao and Ajay Singh, Oran used a high-speed camera to film the flame within two offset half-cylinders over a shallow pan of water. This offset setup is commonly used to create fire whirls in a laboratory, with vertical openings that allow air to flow inward towards the flame region. A small copper tube under the water pumped the heptane fuel to the center region of the water surface.

A fire whirl starts when hot flammable gas diffuses into the surrounding air and combusts, producing a turbulent flame above a pool of fuel. As Oran



Researchers at the University of Maryland are studying fire whirls as a potential method for remediating fuel spills.

and her team began observing increased combustion within their setup, the unthinkable happened: "The fire whirl started to intensify, as it pulled in more and more air," explains Oran. "And then … what [appeared] is this little blue flame. You can hear my colleagues [Huahua and Ajay] saying 'Oh my god, what is that?!'"

This tiny hydrocarbon flame, named the "blue whirl" by Oran's team, is a new state of fire combustion. Since they released information about their discovery, it has been picked up by media worldwide, and countless videos (youtube.com/watch?v=kmwycbqiyRo) show the mysterious blue flame swirling on the water's surface. Oran describes it as a "beautiful" equilibrium between the airflow in the chamber and the evaporation of the fuel from the surface. "[The whirl] does it naturally … but we don't know how it all fits together," Oran tells *APS News*. "Pretty weird, huh?"

Although the bigger picture is still hazy, her team has been hard at work to figure out the fluid dynamics, thermal properties, and chemical kinetics of the blue whirl. Their understanding, based purely on fluid dynamics, suggests that the blue whirl forms from transitions called "vortex breakdown." As a fundamental concept in swirl combustion, vortex breakdown describes the drastic change of vortex structure, first spiraling outward and intensifying in speed to eventually "bubble out" and stabilize as a lower-turbulence structure.

So far, they've published their findings on the physical structure of the blue whirl, and have completed experimental testing of the temperature structure using thermocouples and hot-wire pyrometry. Their 2D thermal map, obtained from multiple images, confirms a temperature of 2000 K in the center of the blue whirl. They've also identified the whirl to be stable and soot-free burning, meaning that there is an abundance of oxygen to completely burn away the fuel from the water's surface.

"We [also] don't know how to make the blue whirl without the larger fire whirl first," adds Oran. "Is there a way to bypass that step? I'm not sure there is, but we won't know until we get a computer simulation … and we aren't likely to find this out by accident!"

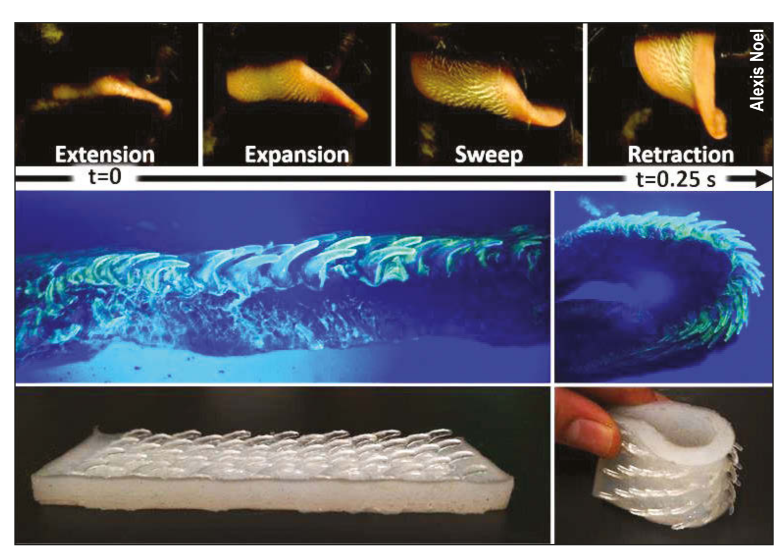
TONGUES continued from page 1

lae to rotate and lock onto tangles. "[Moreover] the surface of the spine itself [has] tips, which are slightly sharp," Noel added. She said that these "claw-like spines" helped catch hairs, but wasn't yet sure how cats used them during cleaning.

To investigate the function of the spines, she recruited a laboratory assistant (her cat), and filmed him grooming with a high-speed camera. Noel and her team were able to slow down the footage to identify different stages of grooming in which cats use the sharp spines to pull tangles out of their fur.

"The sweeping motion is the standard grooming motion everyone is familiar with," Noel commented. "[But in this motion], the retraction of the tongue in a v-shape formation [allows] the spines to catch onto the fur."

"The spines go from [making a] 20° to 30° angle with the surface of the tongue to almost 70° to 80° degrees just from the stiffening of the tissue," Noel continued. "As the tissue deforms it acts like a progressive spring [which has a nonlinear spring constant]. It doesn't spring back though: the spines actually stay relatively vertical after the [tissue] is deformed, [which] may help with grooming."



(Top) Images of how a cat's tongue moves. (Center) Spines embedded in a cat's tongue. (Bottom) Artificial 3D printed cat tongue structure.

As much help as her cat provided, Noel wanted to perform more systematic testing—so she used her favorite hobby (3D printing) to recreate a cat tongue at 400% scale. By hooking up the tongue model to an extensional rheometer and pulling it through a hair sample attached to a force plate, she could measure the force in all directions and mimic the grooming mechanisms observed on film.

"Like a heat-seeking missile for tangles, once [the spines] find a tangle, they rotate and pull," Noel stated. "After grooming faux fur, it was [also] very easy to clean the cat tongue. [Just] rub in the opposite direction of the spines … it all comes off in one sweep."

Although it's apparent that cats are equipped with heavy-duty hairbrushes, researchers are just beginning to untangle the science behind their grooming. Noel and her team hope to investigate how cats wet the spines on their tongues, and how this moisture affects grooming—depending on how many cat volunteers they can recruit.

Education & Diversity Update

APS/IBM Paid Research Internships for Undergraduate Women and Underrepresented Minority Students: Application Deadline February 15, 2017

APS and IBM co-sponsor two undergraduate research internship programs; one for undergraduate women and one for underrepresented minorities. The goals of the programs are to encourage women and underrepresented minority undergraduate students to pursue graduate studies in science and engineering. Both internship programs feature salaried positions at IBM research locations that are typically 10 weeks long and provide an opportunity for interns to work closely with an IBM mentor. Two letters of recommendation are required. For more information visit aps.org/programs/women/scholarships/ibm/

Joint Graduate Education and Bridge Program Conference: Registration Deadline January 20, 2017

The 2017 Joint Graduate Education and Bridge Program Conference will be held on February 10-12 in College Park, MD. This conference will feature plenary talks on physics graduate education, panels and discussions on diversity, a graduate student poster session, and networking opportunities. Register now at apsbridgeprogram.org/conferences/2017/

PhysTEC Conference: Registration Open

The PhysTEC Conference will take place February 17-18, 2017 in Atlanta, GA. The Physics Teacher Education Coalition's Annual Conference is the nation's largest meeting dedicated to the education of future physics teachers; it features workshops on best practices and panel discussions by national leaders, as well as excellent networking opportunities for physics teacher educators. Register now at phystec.org/conferences/2017/registration.cfm

Join the Conversation in the Women in Physics and Minorities in Physics LinkedIn Groups

Get updates about career development opportunities, jobs, conferences, and articles related to women and minorities in physics. Post your own opportunities, "like" the work of others, or start a discussion about what else you'd like to see in the women and minority physics community!

Join Women in Physics at linkedin.com/groups/313547
Join Minorities in Physics at linkedin.com/groups/3959050/

OPA continued from page 3

tive to the issues raised by APS members. In one case, a staffer offered to travel to the University of Buffalo campus to meet APS members, leading to a nearly two-hour discussion and tour of the physics department.

Slakey said OPA was especially effective in making inroads in the office of U.S. Sen. John Thune (R) of South Dakota. Piali De, CEO and co-founder of Senscio Systems, a health-technology firm in South Dakota, worked with OPA to participate in a Capitol Hill event, attend a meeting with Senator Thune, and write an op-ed linking science and innovation to jobs in South Dakota.

APS members also engaged their congressional representatives by sending letters to support science funding during the 58th annual meeting of the APS Division of Plasma Physics, held last fall in San Jose, California.

"We had 408 APS members sign and email letters to their congressional representatives, amounting to roughly 25 percent of the U.S.-based attendees who were eligible," said Greg Mack, APS government relations specialist.

Mack added that the percentage of members who signed the letters was significantly higher than at previous meetings.

"We are excited that more APS members are contacting their congressional representatives. Not only do elected officials become better informed about science because of this activity, but they also learn that it's a priority for their constituents," he said.

OPA will make additional changes in 2017 to enable stronger engagement from APS members. After researching the ways local and D.C. congressional staff most effectively receive information, OPA is broadening the technology available to APS members to contact their elected officials.

Beginning at the 2017 APS April Meeting (held this coming year in January), and building through the year, members will have the option to communicate with Congress using a range of social media platforms. "We plan to include opportunities for members to personalize their letters and tweet to their members of Congress," said Mack.

In addition, OPA will provide members with background information and legislative action guides on a broader range of policy issues, including education, energy, and the environment.

OPA will also unveil a new grassroots advocacy dispatch in 2017, called Signal Boost. The monthly newsletter will be sent via email, contain a short video briefing members on policy issues and identify opportunities to get involved.

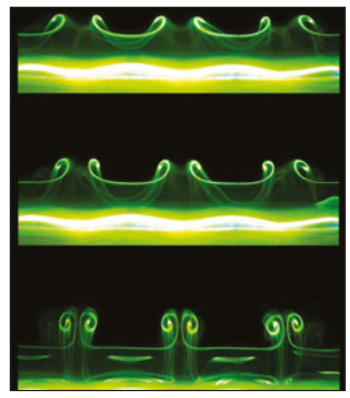
"We will also profile APS members who have terrific stories to tell about their advocacy efforts," said Mack. "There's no magic to effectively engaging with members of Congress; the key is having the right information and approach — Signal Boost will be a guide."

For more information about OPA's activities, visit aps.org/policy/. To receive Signal Boost and/or learn more about getting involved with grassroots advocacy efforts, contact Greg Mack at mack@aps.org.

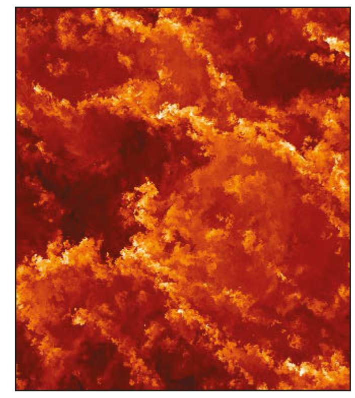
The author is APS Washington Office Press Secretary.

Gallery of Fluid Motion Winners from the 2016 APS Division of Fluid Dynamics Meeting

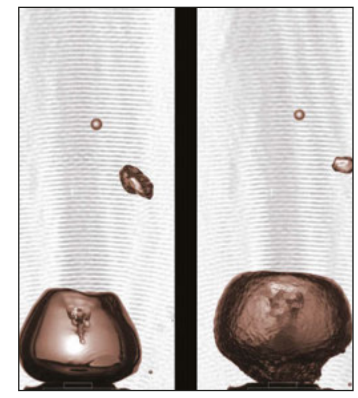
The APS/DFD Gallery of Fluid Motion features video and poster presentations that emphasize the aesthetic appeal of fluid dynamics. Among the entrants, six are chosen as Gallery of Fluid Motion Award Winners and six as Milton van Dyke Award winners. For detailed information on all of the submissions and awards, visit gfm.aps.org and *APS News* online. For more information on the submissions and winners visit aps.org/apsnews and gfm.aps.org



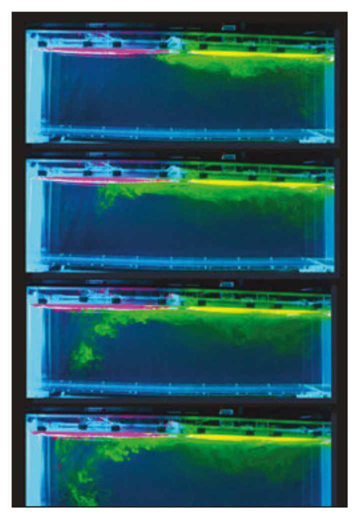
P0020: Formation of Mini Vortex Rings Arising from a Vortex Pair Impinging on a Wavy Wall (Milton van Dyke Poster Winner)



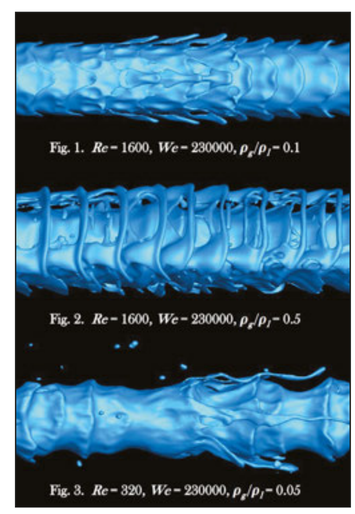
P0012: Large Eddy Simulation of a Stratocumulus Cloud (GFM Poster Winner)



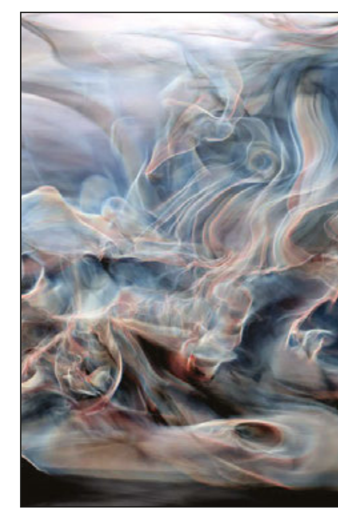
P0044: Accelerated Condensation in an Ultrasonic Field (GFM Poster Winner)



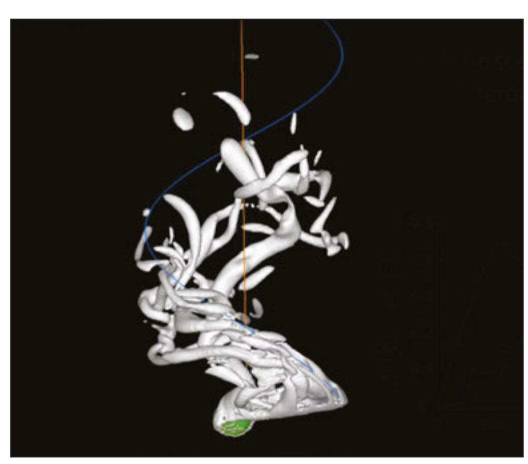
P0028: Turbulent Horizontal Convection at High Prandtl Numbers (Milton van Dyke Poster Winner)



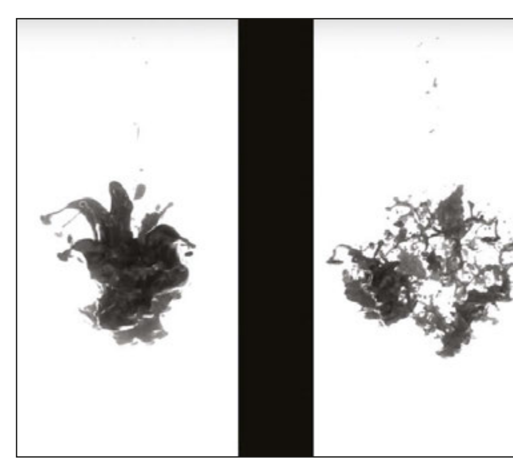
P0009: Computational Simulation of Liquid Jet Atomization (GFM Poster Winner)



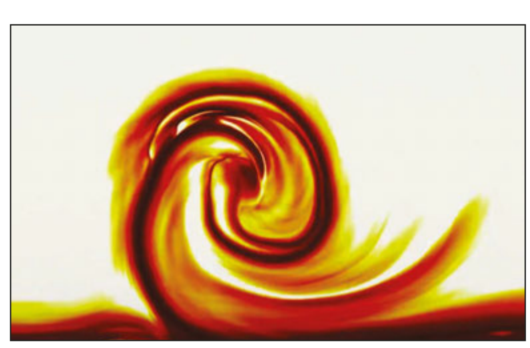
P0030: Progressive Monte-Carlo Rendering of Atmospheric Flow Features Across Scales (Milton van Dyke Poster Winner)



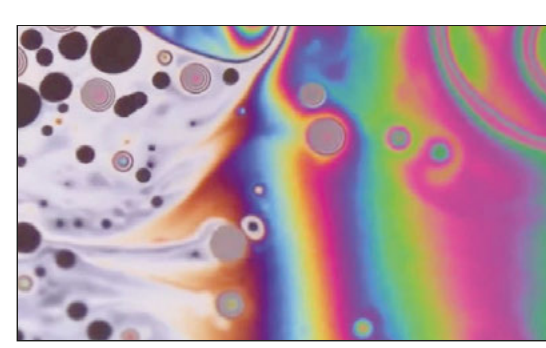
V0046: Flight of a Falling Maple Seed (GFM Video Winner)



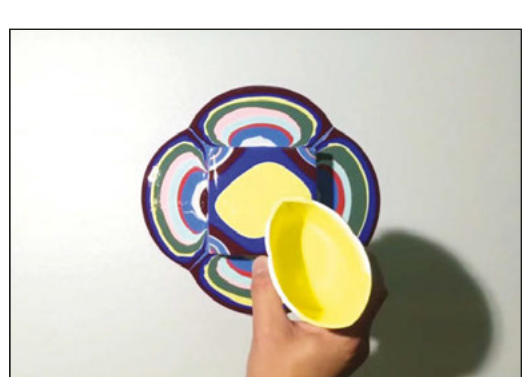
V0038: Fall and Fragmentation of Liquid Metal in a Viscous Fluid (GFM Video Winner)



V0076: Sweeping Jet from a Fluidic Oscillator in Crossflow (Milton van Dyke Video Winner)



V0092: Before the Bubble Ruptures (GFM Video Winner)



V0095: The Shear Joy of Watching Paint Dry (Milton van Dyke Video Winner)

V0055: Eat, Prey, Swim: Dynamic Vortex Arrays Created by Starfish Larvae (Milton van Dyke Video Winner)

PIE continued from page 1

locally in industry, many of whom have terminal BS degrees, to give informal talks to undergraduate physics majors about engineering development jobs, teaching jobs, or other "off the beaten path" positions. The talk is followed by informal meetings between the recent grad and current students. This gives the undergraduate students a direct view of what they could actually be doing in a few years, and what skills they need to develop. Often overlooked as a resource, such speakers can help with job placements, co-op or intern placements, as well as give practical advice for the next cohort of students. Often the invited speakers are honored and happy to be asked to come back and help.

Referencing Current Technologies: Too often we, as physics educators, are stuck in the mindset where "Modern Physics" means circa 1910. Our discipline favors systematic development of the building blocks of technological and scientific progress. All this scaffolding takes a very long time to develop, which can shortchange students, who need to see that physics plays an integral role in technologies we all use right now. RIT offers a seminar survey course for physics majors in which students give group presentations on truly "modern" technology (within the last 25 years). The groups not only spend time on the physics, but also the corporate processes, patents, personalities, and business decisions that went into bringing these products to market. I have learned a lot about OLED's, carbon fiber technology, Gorilla Glass, high-energy magnets, and other technologies by listening to these presentations. So often these students are amazed to find out that Nobel prizes go to industrial physicists, that corporations stumble into fascinating technologies, and that gizmos we count on every day rely on innovations grounded in basic physics. Students gain insight into the chaotic path toward development of real products, and also acquire an ability to give an interesting and germane talk on a subject they are not expert in.

Doing Pop-Up Classes: Another approach is to offer pop-up classes. These are extra-curricular, non-credit-bearing seminars or activities on any technical subject. One of the courses offered by RIT was a single two-hour session, while others have spanned several weeks. Pop-ups can allow you as an educator to test out new ideas, address weaknesses in the basic technical training of students, or just offer advice and help outside the usual classroom environment.

In the pop-ups offered at RIT, students have learned how to use Arduino microcontrollers, build basic electronic kits (thus developing students' soldering and fabrication skills), and use the machine shop. Some pop-ups even taught some materials characterization techniques. A variety of other short pop-up classes being planned for the spring are aimed at teaching computational skills. These proficiencies are directly transferable to industrial internships or co-op positions, and give students the tools to tinker on their own. Pop-up courses have also been offered on professional development topics, such as choosing graduate programs, resume writing, interviewing, and networking skills like "elevator speeches."

These pop-up courses have been very well received by students, and have required minimal faculty time investment, institutional buy-in, equipment or facilities. In addition to developing specific expertise, they have allowed our students to work together, "just for fun," which has built camaraderie and cooperation.

Practically speaking, the overwhelming majority of our undergraduate physics majors will not go on to graduate school and an academic career doing physics research. Many are headed for industrial R&D, teaching, engineering, or entrepreneurial ventures of their own. There are many ways that we can supplement their training to better prepare them for these futures, while maintaining the integrity and strengths of a traditional physics program. Change comes rather quickly, if only one or two faculty members in a department say "How can we add some stuff … ." to make our physics bachelor's program more useful for students headed for these common, exciting, and non-academic paths.

The author is associate professor in the School of Physics and Astronomy at the Rochester Institute of Technology.

Don't miss a special webinar on Pop-Up Classrooms featuring Professor Barton on January 24, 2017. Visit careers/guidance/webinars/popupclasses.cfm for more information.

NEWSMAKERS continued from page 1

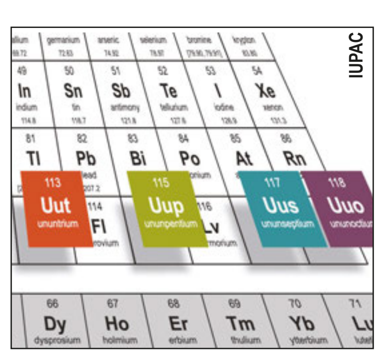
In the early 1970s and 1980s, they explained phenomena in quantum states of matter, such as the quantum Hall effect and superfluid phase transitions. The Nobel Prize in Chemistry was awarded to Jean-Pierre Sauvage, J. Fraser Stoddart, and Bernard L. Feringa for their work in designing and synthesizing molecular machines. In awarding the prize for these advances in nanotechnology, the Nobel committee singled out Richard Feynman's 1959 after-dinner speech "There's Plenty of Room at the Bottom."

Rise and Fall of the 750 GeV Bump

In 2015, researchers at the LHC at CERN saw an unexpected excess of so-called diphoton events at an energy of 750 GeV, raising hopes of a crack in the standard model and chances for new physics. Normally, such a bump in the night would be subjected to intense statistical scrutiny, but the fact that two independent LHC teams — ATLAS and CMS — observed the same excess raised hopes even further. Particle theorists got to work, generating hundreds of research papers explaining what the anomaly might be. A favored explanation was a new particle, the digamma, which decayed into pairs of photons. Alas, analysis in August 2016 of more data taken by both teams showed no bump, suggesting that the 2015 excess was a statistical fluke.

Celebrity Elements

The International Union of Pure and Applied Physics decided on names for 4 newly established elements: Nihonium (Nh), for the element 113, Moscovium (Mc), for the element 115, Tennessine (Ts), for the element 117, and Oganesson (Og), for the element 118. Picking names for these newcomers was completed in 2016, and officials settled on several honorary labels. Nihonium (Nh) credits the first element discovered in an Asian country, and is the Japanese name for Japan (the Land of the Rising Sun), and Oganesson (Og) celebrates physicist Yuri Oganessian.



Welcome to the table

Moscovium (Mg) and Tennessine (Ts) have slightly more obvious inspirations (the Russian capital Moscow and Tennessee, home of Oak Ridge National Laboratory, respectively).

Neutron Holography

In 2016, researchers reported using neutrons to make holograms based on the same principles used in optical holography. A neutron enters an interferometer and is separated into two paths by a beam splitter, generating reference and object beams. The object beam was given a spatially varying phase after passing through a test object called a spiral-phase plate (a device that imparts helicity), while the reference beam, as in optical holography, is unaltered. The two beams were combined at another beam splitter, and the resulting beams sent to an imaging detector. The unique setup may offer a new way to study neutrons and use neutron imaging for characterizing properties of materials.

The Solar System's 9th Resident?

Just when we thought the controversy over Pluto's status was past, researchers announced that a 9th planet may exist, and it might be throwing things in the solar system off balance. According to the calculations of Konstantin Batygin and Mike Brown at Caltech, Planet 9 appears to orbit at about 30 degrees off from other planets' orbital planes, and would travel almost 93 billion miles from the sun. It may have evaded detection owing to its faraway orbital path, but its mass (about 10 times that of Earth) seems to have created some perturbations in the observations. Batygin and Brown announced their results during the joint meeting of the American Astronomical Society's Division of Planetary Sciences and the European Planetary Science Congress in October 2016.

Kokabee Freed

"Prisoner of conscience" Omid Kokabee was released on parole from Iran's Evin prison at the end of August after serving only half of his original sentence. Kokabee, who was convicted of "communicating with a hostile government," was initially sentenced to 10 years at Evin. Kokabee wrote to his family from Evin prison saying that he was jailed for repeatedly refusing to agree to Iranian government requests to work on military research. The first-year physics doctoral student at the University of Texas at Austin received support from the scientific community since his imprisonment, but he then developed cancer while incarcerated. He was granted medical furlough to recover from surgery to remove his cancerous kidney.

CERN's First Female Director

One of the scientists who took a leading role in the Higgs boson discovery of 2012, Fabiola Gianotti is now in charge at the European Council for Nuclear Research (CERN) as the lab's 15th director-general and the first woman in that position. Gianotti received her Ph.D. in experimental particle physics from the University of Milan in 1989 and officially became director general in January 2016. She says that one of her top priorities is to continue to collect high-quality data during LHC's Run II, which began in 2015 and is achieving collision energies of 13 TeV. And in 2016 she has signed on new associate members Cyprus, India, Slovenia, and Ukraine, and welcomed Romania as a new member state.

Rosetta's Last Signal

After 10 years from launch to final landing, the Rosetta probe from the European Space Agency (ESA) made contact with its target—Comet 67P—on September 30, 2016. As the first probe to orbit around a comet and release a lander (named Philae) to the rock's surface, Rosetta's historical mission captured over 80,000 images, revealing big grains of water ice on the comet's surface, molecular oxygen in its coma, and diverse landscapes. Rosetta's pictures a month before its landing uncovered Philae's location, much to the relief of the navigation crew. Rosetta's sidekick had crashed on Comet 67P, and tumbled into a dark crevice, where it lost contact.

In Memoriam

The physical sciences community lost a number of notable individuals in 2016. Among them were human rights campaigner and physicist Joseph Birman (October 1); particle physicist James Cronin (August 25) and condensed matter physicist Walter Kohn (April 19), both Nobel Laureates; plasma physicist and former director of the Princeton Plasma Physics Lab Ronald Davidson (May 19); particle physicist Sidney Drell (December 21) well known for his work in nuclear arms control; former NIST deputy director Katharine Gebbie (August 17); and atomic physicist Deborah Jin (September 15), who lost her battle with cancer at age 47. The cosmology and astrophysics world also saw the passing of two leading researchers, Tom Kibble (June 2), who co-discovered the Higgs mechanism, and Vera Rubin (December 25), who with Kent Ford first analyzed the galactic stellar velocities that confirmed the existence of dark matter.

SCORES continued from page 3

behavior in 10 to 15 milliseconds. "So you have to anticipate what you can calculate recursively about purchase history," he says. "I'm going to have to anticipate if you make a purchase whether is it really you or is it a fraudster."

"Now when you make a purchase, the algorithm pulls up a card purchase profile—the math variables that summarize your purchase history," he says. There are about 100 or 200 key variables that are used to quantify whether a transaction is fraudulent or not, and Zoldi's role was to constantly fine-tune the models that process those variables and return a score regarding the validity of the purchase.

"That was really hard for me," he admits, thinking back to when he started in this business. "I was really, really good in coming up with an equation, understanding where the system becomes unstable or unpredictable, and even making unstable systems stable by adding perturbations. But here, there was no equation. It was an entirely different way to come up with hypotheses to describe people."

But he persevered, and when HNC was bought by FICO he advanced to an even higher level role in data mining. Today, as CAO of FICO Analytics, Zoldi's division has approximately 100 physicists, mathematicians, and statisticians, bigger than most university physics departments. "I feel it is a little like being in academia, perhaps even more supercharged," he says. Between the patents he files and the continued research he conducts in all areas of analytics, including one or two projects each year which are exploratory in nature and are not necessarily tied to a prospective product, "This allows me to be satisfied as a researcher."

But looking back, would he have been able to use his own predictive analytics to guess where he'd be today? The answer is a resounding no. "This has been a great move for me," he assesses, "I wouldn't have expected this career path, but in hindsight it's well correlated with my physics research and a big part of why I'm successful."

ANNOUNCEMENTS

ROWING continued from page 1

When the robotic rowers dipped their 30-centimeter oars in the water at the same time—like competitive rowers do—the researchers found that the boat's speed rose and fell by up to 20% every stroke. That's like a car repeatedly losing and gaining 20 kilometers per hour on the highway. Real boats with human rowers also exhibit this same variation, which is caused by rowers all moving their bodies forwards and backwards together as they complete a rowing stroke. These speed fluctuations can significantly slow down a boat. "Large fluctuations in boat speed increase the friction on the hull," Boucher explained.

The team next investigated whether they could reduce these speed fluctuations. Inspired by nature, they instructed their robotic athletes to row asynchronously by not dipping their oars in the water at the same time. Some animals move their legs one after the other for propulsion, and the researchers wondered whether the same asynchronous movement might increase the speed of a rowing shell. "Shrimp swim in a desynchronized way probably to avoid fluctuations of speed and thus reduce the power dedicated to swimming," noted Boucher.

The researchers programmed each robot to row out of phase from its neighbors by one eighth of a rowing cycle. When they released the boat, they found that its speed fluctuations were roughly an order of magnitude lower than when the robots rowed synchronously. Asynchronous rowing reduces hull friction compared with rowing in synchrony, the authors noted, but asking human rowers to row like shrimp legs isn't advisable. For starters, there's the increased likelihood of clashing oars, a real possibility given that they're nearly four meters long. Tangling oars can eject rowers from their seats, tumbling them into the water. Boucher and Labbé also showed that asynchronous rowing resulted in a lower average boat speed than synchronous rowing. The difference in speed—roughly 8%—is significant and translates into a margin of several boat lengths in a race. That's an enormous distance considering that most elite rowing competitions are won by only a few seat lengths. "The overall balance between friction and propulsion makes the synchronous rowing mode the fastest," said Boucher. (In fact, there's only one record of asynchronous rowing, which was attempted by a British rowing crew in 1929.)

To understand why synchronicity appears to be favorable, the researchers are now examining another aspect of rowing: the recovery stroke. This motion occurs when the rower moves his or her body opposite the direction of the boat's movement while preparing to place the oar in the water again. It's during this time that the boat slows down the most, but the motion is necessary to "reset" the rowers and allow them to take another stroke. The physicists are studying how changing the speed of the recovery stroke affects boat speed. Boucher and Labbé expect that their findings will lead to improved rowing techniques and more efficient propulsion through the water.

The author is a freelance science writer based in Portland, Oregon.

The Back Page

The Physics of Skateboarding: Making Science Relevant, Engaging, and Motivational

By William H. Robertson

Although I am a professor at the University of Texas at El Paso, I'm also known as Dr. Skateboard. People often ask, "Why are you Dr. Skateboard?" or "What's up with the Dr. Skateboard thing?" So let me give you the backstory.

I'll begin with the skateboard. I have been a skateboarder now for almost 40 years. I started skateboarding when I was thirteen years old, because it was something fun to do with my friends. When I was in middle school in Richmond, Virginia, I also decided that I wanted to be a professional skateboarder. As I progressed in the sport I competed as an amateur, and this allowed me to travel up and down the East Coast and even out to California.

In the 1980s, I made my living as a professional skateboarder through endorsements and prize money while participating in contests and demonstrations, as well as traveling around the U.S. and abroad. In the late 1990s and early 2000s, I did shows at many interesting venues, including state fairs, skateparks and music festivals. Today, I continue to do demonstrations, mostly in schools. I am a skateboarder. It is part of who I am.

But what about the "Dr."? You might think that since I have been skateboarding for so long, it would make me a doctor. Well it goes a little further than that. When I was in middle school, I set some goals to try and achieve success in my education as well as my sport. Really, no one in my circle had a doctorate. One skateboarding buddy said, "Dude, I don't know anyone with a Ph.D." I had a dream of going to college, and that dream took me all the way to getting a Ph.D., something I never thought would happen. My persona as Dr. Skateboard became a path for me to connect with students about setting high goals in all that they do. It is a way of bringing together high achievement in your education and in what you enjoy.

For me, skateboarding became the vehicle that led to my success in education. In fact, the skills I learned in skateboarding, such as practice, creativity, discipline, persistence, and setting goals, later made me successful in school. Young people can in effect learn more when they can see practical applications in their own lives. My inspiration for choosing skateboarding to teach physics came from my work with middle school students who were not interested in the topics of science class until I showed how much of physics, such as forces and motion, were found in things they did regularly — such as skateboarding. So, this idea that there was a lot of physics in skateboarding led me to coin the phrase Action Science. It has the action of action sports, and has the science of motion, forces, and simple machines.

Often, students will ask their teacher, "What is the point of this?" or "Why are we doing this anyway?" They want to know exactly how the material they're learning in class will apply to their everyday lives because, at times, it seems disconnected from what they do. Physical science concepts are often taught quite traditionally in school, and in an almost clinical manner, isolated to a specific circumstance within a classroom. This is what disconnects the tools and the content from the students' experiences. There is a real need for educators to explore and connect content in settings that are both authentic and relatable for students.

Where does learning occur? Learning takes place when you go to areas of high risk and high ambiguity. When you are learning something, there is usually something you are laying on the line, and that is where real learning occurs. I see education as less about what you know, and more about what you can master. Because if you can master one thing, you can probably master something else. In skateboarding, you have to master the Ollie, which is a skater's technique for flying through the air. The Ollie showcases the principles of flight by demonstrating that you have to overcome gravity, and counter friction (or drag) with thrust. When students understand the physics, they're not just skateboarders. They become scientists riding around in a field laboratory, engaging in concepts in motion, forces and simple machines. A skateboarder in a skatepark is actively analyzing, synthesizing, and evaluating the environment, while making small adjustments built around trial and error.

The skateboard itself has a number of simple machines that make it functional and fun. Modern decks (the board you stand on) have an upturned nose and tail. Each end of the deck can act as a lever for the rider, and help a skateboarder to lessen the force exerted while performing tricks on ramps, in the street or on flat ground. Additionally, the trucks (the structures that attach the wheel assemblies to the deck) on a skateboard deck are fulcrums, and they allow the rider to control the movement of a trick by applying or releasing force on the nose or tail. Another simple machine on the skateboard is the wheel and axle, consisting of the urethane wheels with sealed bearings and the axle that extends through the truck. On a skateboard, the wheels and axles help the rider to perform standard moves like rolling, spinning, grinding, and carving. By definition, the skateboard is a compound machine, as it has more than one simple machine.

So, I put it all together and called it *Dr. Skateboard's Action Science*, which is a curriculum supplement that teaches physics in a fun way that integrates skateboarding and BMX (a kind of stunt bicycle technique). It has also been used to engage students all over the U.S., in Canada, Mexico, and into South America. I also wrote a book for teachers entitled *Action Science: Relevant Teaching and Active Learning* that integrates teaching methods, video, and hands-on activities within an approach that focuses on immersing students in experiences and then providing content. Action Science is the use of familiar objects, materials, and experiences to teach concepts in STEM.

On my website, I integrated Facebook, Twitter, Instagram, and YouTube in order to communicate to students in a variety of media. Action Science is all about making concepts in STEM real to students and making things relevant and in context. We shot a lot of video, we have tried to make it educational, and the program continues to grow. Today, on my YouTube channel, I have over 70 videos that present educational content in engaging formats.

Connecting with students and teachers through live action speaks to my roots and allows me to do interesting things in the community. Recently, we developed "Skatepark Mathematics" to present concepts in algebra and geometry; students collected data, using the athletes as the projectiles in experiments. We also have done large arena presentations to over 8000 local middle school students, to present STEM concepts in innovative ways. We wanted students to see themselves on a university campus, and that college is a place where learning is cool.

But you might ask, what keeps me motivated? Why is *Dr. Skateboard's Action Science* my passion today? I'm trying to reach out to the kid who's maybe not that interested in school, maybe a bit marginalized, and find pathways for those people to learning. It is about helping skateboarders to see themselves as scientists. It's about mentoring young people in order to help them succeed, and to make college part of that plan. It's about helping boys and girls to set goals and to achieve them in STEM. It's about everyone working together in our communities so that your zip code doesn't have to be your final destination. I believe if we can tap into what kids like to do and help them to make connections to their learning, and we can carefully and caringly guide them through this process, they can really achieve success. It's about inspiring others to use their gifts to achieve success and to help one another.

Brief Bio

William H. Robertson is a professor in the Teacher Education Department in the College of Education at the University of Texas, El Paso. His academic areas of expertise are in science education, curriculum development, and technology integration in the K-12 levels. A long-time participant and performer in skateboarding with over 40 years in the sport, Dr. Robertson has developed Dr. Skateboard's Action Science *(drskateboard.com), which addresses physical science concepts for middle school students utilizing skateboarding and bicycle motocross (BMX). He is the author of* Action Science: Relevant Teaching and Active Learning.

Online Resources

1. Dr. Skateboard website: drskateboard.com
2. Dr. Skateboard on Facebook: facebook.com/drskateboard
3. Dr. Skateboard on Twitter: twitter.com/drskateboard
4. Dr. Skateboard on Instagram: instagram.com/drsk8board/
5. Dr. Skateboard YouTube Channel: youtube.com/user/drsk8board

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