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# Plan S Tries to Flip the Open Access Switch

*By Leah Poffenberger*

In September, Science Europe, an association of funders, announced the formation of cOAlition S and its Plan S (coalition-s.org), a 10-point program aimed at expediting a global transition away from subscription-based scientific publishing.

Spearheaded by Robert-Jan Smits, the Open Access (OA) Envoy of the European Commission, the initiative would require grantees to publish exclusively in journals that make all of their articles OA immediately upon publication. The requirement for full OA publishing would go into effect in 2020. To date, thirteen European funding agencies have expressed various levels of support for Plan S.

Amid favorable response to the proposal by some OA advocates, there is a growing backlash among researchers to the Plan S requirements. More than 1,400 scientists have signed an open letter stating that the plan goes "too far" and is "too risky" (go.aps.org/2UacdUa). According to the letter organizers, the "views of researchers who will be directly affected by Plan S do not seem to have been solicited during its creation."

The original Plan S did not allow publishing in so-called "hybrid" journals—subscription journals that offer an option to have individual papers published OA upon payment of an article processing charge (APC). In response to ongoing comment and criticism, cOAlition S issued more detailed implementation guidelines on November 27 (go.aps.org/2QB2QxG).

The new guidelines allow cOAlition S–funded papers to be published in hybrid journals that commit by the end of 2021 to transform to full OA by 2023. In addition, authors may comply with Plan S by immediately making available the final published version (the "Version of Record") or the final version, accepted by the journal, that includes any changes made after peer-review (the "Author's Accepted Manuscript") in an OA repository under a Creative Commons CC BY license. However, this option is not commonly available for articles published under a subscription model (including those published in APS journals) and it remains to be seen how publishers respond.

For now, Plan S is largely considered aspirational and is limited to a subset of funding agencies in Europe, but journal publishers are already assessing likely impact of its aims.

"Many people who heard about this plan may have been perturbed, but those of us in publishing, and especially open access publishing, have seen increasing pressure from funders to move away from the hybrid open access model for some time," says Matthew Salter, APS Publisher. "The announcement of

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# APS Membership Unit Profile: The Division of Biological Physics

*By Abigail Dove*

Approximately 2,000 members strong, the APS Division of Biological Physics (DBIO) supports all of the ways physical science can help understand biological systems—from nanoscale biological proteins all the way up to organisms and their behavior. Research within DBIO encompasses not only what physics can elucidate in biology, but also what biology can reveal about physics: After millions of years of evolution, biological systems are rich with processes that showcase, for example, mechanics, geometry, and quantum physics in interesting and unexpected ways.

Current DBIO chair Jennifer Ross, associate professor of physics at the University of Massachusetts, Amherst, and an APS Fellow, says the division is a natural home for self-proclaimed "big tent physicists" like herself.


Jennifer Ross

"What has allowed us to thrive is that we're very open to new fields that are part of biophysics, and we're not too controlling about precisely what 'biophysics' or 'biological physics' means," Ross explains.

Consistent with this open approach, DBIO is a notably interdisciplinary division, and one that draws many non-physicists into

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# International News

## Physicists in Lebanon: Passion and Talent Striving to Overcome Adversity

*By Alaina G. Levine*

Growing up in Lebanon, engineer and materials scientist Hussein Zbib would challenge other youngsters to a game of stick ball and algebra. If you solve for X, you win the game. The harder the problem, the more joy he and his classmates felt. "This excitement about the sciences and mathematics has always been there," says Zbib, a professor in the School of Mechanical and Materials Engineering at Washington State University in Pullman. "The country has always been engaged in science."

In a nation of only six million people, there are over 30 universities but only a handful of physicists and less than five physics departments that offer degrees in the subject. In an October 2006 *APS News* article, Bassem Sabra, APS member and physics professor at Notre Dame University-Louaize in Beirut, wrote that there were about 500 physicists in the country, including 100 professors and 400 students. More than 10 years later, Sabra notes that the numbers have remained fairly constant, with some changes. There are more graduate programs in physics, more physics disciplines being taught, and more research. "Some people outside of Lebanon might not think there is physics here," says Sabra. "What has changed is that the human capacity has increased a lot. We are producing more PhD students." There is also more collaboration with institutions beyond Lebanese borders, which have led to fruitful innovations and advancements in knowledge.

For the small but committed group of physicists who reside in Lebanon, their dedication to the field is paralleled by their strength in adversity. "Doing physics or science in Lebanon requires a lot of grit," explains Sabra. "You have to want it ... Research is difficult

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PHYSICAL REVIEW APPLIED

# Applied Physics with Fundamental Foundations

*By Stephen Forrest*

We are very pleased to celebrate the fifth anniversary of the launch of *Physical Review Applied* (PRApplied)—and what an exciting five years it has been! PRApplied is a groundbreaking member of the prestigious *Physical Review* family of journals: It is the first (and only) journal published by APS focusing entirely on applied physics—physics that has the prospect of leading to practical applications, founded on fundamental physical principles.

Applied physics is an exceptionally broad and interdisciplinary field and the label is generally used to describe work bridging the gap between a fundamental physics discovery and its use for a practical purpose. In short, applied physics is an essential link between the physical sciences and applications.

To serve such a broad set of authors and readers, the scope of PRApplied is equally expansive, in ways that are only exceeded by *Physical Review Letters*, *Physical Review X*, and *Reviews of Modern Physics*, our partners in the quest to bring applied physics to a broad cross-section of the physics community. Given its scope, it is not surprising that PRApplied is also the fastest growing journal in the *Physical Review* family, at a compound annual growth rate in submissions of about 25%. In 2017, the journal published 430 top-quality research papers; both submissions and publications have grown substantially in 2018.

Rapid growth is only one of several indicators of our success. PRApplied boasts a 2017 Impact Factor of 4.782, which is substantially higher than that of well-established journals covering these same fields. We believe that the journal's success is based on several factors.

First and foremost is that PRApplied fills the needs of the applied physics communities for a premier publication venue that serves our diverse discipline. As one example of our taking proactive steps to broaden the scope, we have reached out to the community by publishing focused Review Articles on topical areas of special interest, covering such broadly ranging subjects as thin perfect absorbers [1], invisibility and cloaking [2], spintronics [3], self-assembly of a strain-engineered flexible layer [4], and organic light-emitting diodes [5].

We pride ourselves in providing a publication that never compromises on the quality of its content while having a clear focus on presenting the most exceptional work in a broad range of applied sciences. In this sense, PRApplied has the same values of quality, excellence, and timeliness that are well-known as the hallmark of the *Physical Review* family of journals, which has been celebrating its 125th anniversary throughout this year.

Our vision for PRApplied extends far beyond the conventional metrics of impact factor and journal growth. The success of any scientific publication should be measured by its actual *impact*: its ability to make a tangible difference in the way we think. Impact is also defined when a work becomes a jumping-off point for subsequent advances that ultimately bring a new understanding or serves an application that positively impacts quality of life.

Although impact requires a subtler assessment than easily calculated quantitative metrics, a

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# Argonne National Laboratory Named APS Historic Site

*By Amanda Babcock*

The most recent APS Historic Site recognizes the second woman to receive a Nobel Prize in Physics. In a ceremony on November 2, APS President Roger Falcone presented the APS Historic Site plaque to Argonne National Laboratory, where Maria Goeppert Mayer carried out her research in nuclear physics.

The citation on the plaque reads:

*While working at Argonne National Laboratory in the late 1940s, Maria Goeppert Mayer developed the "shell" model of the atomic nucleus that is the basis for our modern understanding of nuclear structure. She determined that there are certain "magic numbers" of nucleons that constitute complete shells with maximum binding energy at different energy levels, analogous to the stability of full shells of orbital electrons.*

"We are delighted to receive this honor on behalf of a highly esteemed former Argonne scientist. Dr. Mayer was an amazing contributor to the profession," said John Arrington, interim director of the Physics Division at Argonne.

Goeppert Mayer joined Argonne in 1946, and the results of her work were published in *The Physical Review* in June 1949. She shared the Nobel prize in 1963 with Hans Jensen, who independently came up with the same result, and Eugene Wigner for unrelated work.

"Maria Goeppert Mayer, only the second woman to receive the Nobel Prize in Physics, made extraordinary contributions to nuclear physics, including the co-discovery of the shell model. The APS Historic Sites Initiative is delighted to honor her and the many accomplishments of the site where she worked, Argonne National Laboratory," said Paul

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**The APS Historic Site plaque presented to Argonne National Laboratory. L-R: Paul Halpern (Chair of APS Historic Sites Committee), Paul Kearns (Argonne Director), Roger Falcone (APS President), and Kawtar Hafidi (Associate Laboratory Director).**



# This Month in Physics History

## December 1925: Manne Siegbahn Wins Nobel Prize in Physics for X-ray Spectroscopy

X-ray spectroscopy encompasses many different techniques for characterizing materials on the basis of the high-energy photons the atoms absorb and emit. Among the Nobel laureates who worked with x-rays, a Swedish physicist named Karl Manne Georg Siegbahn stands out for his precision measurements of the electronic structure of atoms.

The saga begins in 1895 with the serendipitous discovery of x-rays by Wilhelm Roentgen during his experiments with cathode ray tubes. He was awarded the very first Nobel Prize in Physics in 1901 for this work. X-rays were understood to be part of the electromagnetic spectrum, but scientists initially struggled to demonstrate characteristics like refraction, polarization, diffraction, or interference common to light. Nonetheless, a physicist named Charles Barkla successfully used x-rays of various "hardness" (the degree of penetration, which is inversely related to the wavelength) to verify the atomic weight of chemical elements. He was inspired by the earlier work of Niels Bohr and Janne Rydberg (among others) on the connection between an element's emission spectra and its place in the periodic table.

Barkla's work established the principles governing the transmission of x-rays through matter and how so-called secondary x-rays were produced. Specifically, the penetrative power of the x-rays increased along with the atomic weight as Barkla worked his way through the periodic table. When the atomic weight became sufficiently high, he observed a new, softer kind of radiation that, in turn, became harder as the atomic weights continued to increase. He termed these emissions K and L radiation, and they formed the basis for distinguishing different elements from each other.

Henry Moseley conducted further studies of the x-ray spectra of elements, and derived a simple mathematical law by which an element's atomic number—a better metric to distinguish between elements than atomic weight—was related to the wavelengths of the x-ray spectra. Moseley was killed on the battlefield during World War I and thus was ineligible for the Nobel Prize, but his work drew renewed attention to Barkla's research. Barkla won the 1917 Nobel Prize in Physics for his discovery of the characteristic x-rays of many elements.

Among the earliest experiments splitting x-rays into a full spectrum of wavelengths were those performed by Max von Laue, who photographed x-rays as they passed through a set of crystals that acted as a diffraction grating. This garnered yet another Nobel Prize in 1914. William Lawrence Bragg worked out a much simpler theory of x-ray diffraction than Laue's to determine crystal structure. Based on that theory, his father, William Henry Bragg, built a bona fide x-ray spectrometer that relied on reflection instead of diffraction. The father and son then used the instrument to determine the structure of several different crystals—which won them the 1915 Nobel Prize.


**Karl Manne Siegbahn**

The stage was set for Siegbahn to make his mark. Born on December 3, 1886, Siegbahn was the son of a railway stationmaster in the town of Orebro, roughly 100 miles west of Stockholm. Following an obligatory stint in the military, he earned his PhD from the University of Lund, with a thesis on the measurement of magnetic fields, and remained there as a faculty member until 1923.

Siegbahn initially used the same kind of spectrometer as Moseley when he started this line of research in 1914 but then made significant improvements when he built his own versions of the instruments. He made even more accurate measurements of the x-ray wavelengths produced by different atomic elements and quickly realized there were more components to the spectral lines Moseley had observed. As a result, Siegbahn was able to provide a near-complete description of the electron shell, among other accomplishments. Siegbahn and his pupils subsequently came up with an apparatus for analyzing an unknown substance to determine all the elements it contained, using a pair of two-hour x-ray exposures.

Siegbahn was awarded the 1924 Nobel Prize in Physics "for his discoveries and research in the field of x-ray spectroscopy," but he received the prize the following year. The Nobel committee had rejected all 23 of the original nominations in 1924, declining to award the prize that year. So the prize was still open when Siegbahn won the following year. Max von Laue was among the colleagues who nominated him, stressing in a November 1924 let-

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# Profiles in Versatility

## Physicist Dives Deep

*By Katherine Kornei*

Jim Bellingham's first expedition to the Arctic took him, in his words, "a long way from doing superconductivity on the second floor at MIT." Bellingham, now the director of the Center for Marine Robotics at the Woods Hole Oceanographic Institution, remembers carrying a gun on that trip to northern Alaska to protect himself against polar bears. That expedition started the PhD physicist-turned-marine-roboticist on an adventurous path.

Bellingham didn't always have his eye on the ocean. He credits his interest in marine science to a chance meeting with Harold Eugene "Doc" Edgerton, a professor of electrical engineering at MIT. Edgerton was experimenting with underwater cameras in Boston Harbor in the 1980s when Bellingham was a physics graduate student at MIT.

Edgerton invited Bellingham along on his boat one day, and Bellingham became hooked on the idea of using instrumentation like autonomous underwater vehicles (AUVs) to explore an unseen part of the world. "That led to me taking a class in sonar systems," Bellingham says. When Bellingham finished his thesis in experimental physics, he received several job offers in low-temperature physics, including a coveted one at IBM. "Jobs were raining from heaven," he says, "but I wanted to try something else." The ocean was calling.

Bellingham soon accepted a position running the MIT Sea Grant AUV Laboratory. He and his team tested their first underwater vehicle—the bright yellow, roughly 80-pound *Sea Squirt*—in the nearby Charles River in early 1989. (Bellingham once traded a four-stroke outboard motor in exchange for space at one end of the MIT sailing pavilion dock to launch *Sea Squirt*.)

*Sea Squirt* paved the way for new vehicles capable of diving deeper and for longer periods of time: Bellingham and his colleagues next produced *Odyssey*, a vehicle rated to a depth of 6,000 meters. In 1992, Bellingham and his colleagues took *Odyssey* to Antarctica and tested the vehicle and its underwater video camera—stuffed inside a scuba tank that had been cut in half and outfitted with an acrylic cover—in the Bellingshausen Sea, near Palmer Station, and in the Drake Passage. The researchers photographed the bottom of the ocean and captured images of penguins streaking through the water.

Bellingham and his team built on the success of that expedition to design another vehicle, *Odyssey II*, capable of diving under sea ice and returning to a hole in the ice for retrieval. The MIT Sea Grant AUV Laboratory eventually produced six *Odyssey IIs*, but Bellingham was eager to keep developing new vehicles. "Once you become successful, everyone wants you to keep doing exactly what you've been doing," he says. "It becomes really hard to break loose."

Bellingham found his next challenge in entrepreneurship—in 1997 he co-founded a private company, Bluefin Robotics, to develop underwater vehicles. Nearly his entire team from MIT joined him, including his secretary, which helped to ease the transition into industry. Bellingham worked hard to land new clients, including those from the oil and gas industry and the military. Bluefin Robotics' flagship vehicle, the Bluefin 21, was a versatile platform whose payloads and

**Jim Bellingham**

batteries could be easily swapped out, says Bellingham.

In 1999, Bellingham accepted a job as Director of Engineering at the Monterey Bay Aquarium Research Institute (MBARI). There, he oversaw the development of the Monterey Accelerated Research System, an array of scientific instruments on the seafloor connected to the mainland by a 52-kilometer-long cable.

After 15 years at MBARI, Bellingham returned to Massachusetts to be the director of the Center for Marine Robotics at the Woods Hole Oceanographic Institution. He likens part of his current job to being an event organizer. "I'm trying to build communities of ocean scientists," Bellingham says, "and foster initiatives that are bigger than just one underwater vehicle or research project. I'm building a sense that we're all pulling together."

Bellingham left superconductivity behind long ago, but he's proud to be a physicist. "Physics gives you a foundation," he says. Bellingham credits the physicist mindset with helping him succeed as an entrepreneur and director of large teams. "It's often easier for physicists to take a step back and look at the bigger picture."

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



**SIEGBAHN continued from page 2**

ter to the committee how crucial a role Siegbahn played in measuring the wavelengths of the Roentgen spectrum so precisely.

Siegbahn went on to have a long and illustrious career, joining the faculty of the University of Uppsala from 1923 to 1937, where he proved that x-rays refract when they pass through a glass prism. In 1937 he moved to the University of Stockholm and also became the first director of the fledgling Nobel Institute of Physics. "In his contacts with people Siegbahn was a man of few words, but what he said was always to the point and his quiet manner was not to be taken as a sign of timidity," his former pupil, Bengt Edlen, later recalled of his mentor. "On the contrary, he possessed a large amount of contagious self-confidence needed for bold enterprises."

Siegbahn retired in 1964. His wife, Karin, passed away in 1972, and Siegbahn himself died six years later, aged 91. He was survived by two children, Bo Siegbahn and Kai Siegbahn. (Kai won the Nobel Prize in Physics in 1981, also for contributions to x-ray spectroscopy.) The standard length used to describe the wavelengths of x-rays bears his name, and there is still a Manne Siegbahn Laboratory at Stockholm University—two lasting reminders of his seminal contributions.

**Further Reading:**

Atterling, H. (1991) "Karl Manne Georg Siegbahn: 3 December 1886-24 September 1978," *Biographical Memoirs of Fellows of the Royal Society* 37: 428-444.

**SITE continued from page 2**

Halpern, Chair of the APS Historic Sites Committee, who also attended the ceremony.

The APS Historic Sites Initiative recognizes important and interesting events and locations in the history of physics. These sites provide an engaging way to bring physics before the general public and increase awareness of past scientific advances.

For more information and to nominate a 2019 site, visit the Historic Sites Initiative page: aps.org/programs/outreach/history/historicsites/

*The author is the Science Writing Intern at APS in College Park, MD.*

## What Works in Physics Teaching?

*By Leah Poffenberger*

In October, APS received a $10 million grant for the Inclusive Graduate Education Network, in collaboration with other scientific societies including the American Chemical Society and the American Geophysical Union (see *APS News*, October 2018). Now another APS collaboration, this time with the American Association of Physics Teachers (AAPT), aimed at improving undergraduate physics education has received substantial support from the National Science Foundation.

"Physics programs are all required to undergo external review — often because of requirements of their school's accreditation. APS would like to use this process to improve student learning," said Theodore Hodapp, Director of Project Development at APS. "We're creating a guide to be a place to shop for ideas on how to improve the health of a program or solve common problems."

The Effective Practices for Physics Programs (EP3) project (go.aps.org/2FTBZJ1) has secured a 5-year $2.2 million grant from NSF to produce a guide of effective educational practices for use by physics departments across the country. The resulting *EP3 Guide* will collect experiences from the broader physics community to enrich undergraduate education with proven methods of education and assessment.

"The purpose of the EP3 Project and the *Guide* it is creating is to gather research-based knowledge, tools, and information in one place and in an easily accessible format to assist department chairs and other program leaders to meet challenges physics departments face," said David Craig, EP3 Project Co-Chair and Physics Professor at Le Moyne College in New York and at Oregon State University. "Whether the task is increasing the number of physics majors, improving departmental climate and inclusivity, implementing effective learning assessment, introducing research-based pedagogical practices into physics classrooms, or preparing for program review, the *EP3 Guide* will synthesize the research and collective experience of the physics community and help make that up-to-date know-how readily available as part of the toolkit of every physics department in the US."

The effort to create the *EP3 Guide* originated in 2016 with the Best Practices in Undergraduate Physics Programs Task Force that began developing a self-assessment guide for undergraduate physics programs under the oversight of the APS Committee on Education. The *EP3 Guide* will include both metrics for physics departments to evaluate themselves and a set of effective practices based on the latest education research. This guide aims to address specific challenges within physics as a whole that may not be considered by individual, independent departments, such as diversity issues and under-production of qualified physics teachers.

"We believe this project has the potential to transform how physics departments engage students in their education," said Michael Jackson, EP3 Project Co-Chair and Dean of the College of Science and Technology at Millersville University. "The EP3 guide will assist departments in the ongoing review and improvement of their individual programs within the context, and constraints, of their local environment. This guide will gather practices from a range of resources and national reports, deemed effective by the disciplinary community and informed through current research, into one location so that department chairpersons and other program leaders can readily identify initiatives they would like to pursue along with strategies for their implementation."

For more information see the EP3 website at go.aps.org/2FTBZJ1

# The APS Office of Government Affairs

## 2017 APS Congressional Fellow Reflects on Impactful Experience

*By Tawanda W. Johnson*

Lauren Aycock's scientific background served her well as the 2017 APS Congressional Fellow in Illinois Senator Dick Durbin's office.

As a researcher, Aycock earned her PhD from Cornell University in physics and is an experimental physicist who studied excitations in quantum matter.

As a member of Durbin's energy and environment team, she worked on policy issues pertaining to scientific research, the national laboratories, energy, and the US Environmental Protection Agency.

"I am most proud of drafting a letter Senator Durbin sent to the Environmental Protection Agency, requesting the agency require monitors at facilities that are contributors to manganese air pollution," recalled Aycock.

Manganese, a neurotoxin, had been detected at harmful levels at various facilities in southeast Chicago. Residents and businesses asked Durbin's office to advocate for the monitors. After receiving the letter, sent by Durbin, Senator Tammy Duckworth, and Representative Robin Kelly, all of whom represent either all or parts of Illinois, the EPA required installation of the monitors.

"I felt proud that I was able to help amplify the voices of the local community. It was a powerful experience," said Aycock.

Shown with Lauren Aycock (third from left) are members of the Illinois delegation; Sen. Tammy Duckworth (far left), Rep. Robin Kelly (2nd-IL), and Sen. Dick Durbin.

Jasmine Hunt, a senior policy advisor in Durbin's office who also served as Aycock's mentor, commended her work.

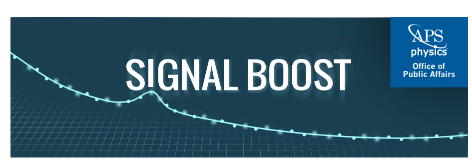
"Lauren was a terrific Fellow who worked to forward Senator Durbin's environmental agenda, especially in Southeast Chicago. Lauren's efforts and work helped the people of Illinois address pressing issues and helped encourage increased funding for scientific research," said Hunt.

Added Francis Slakey, Chief Government Affairs Officer in the APS Office of Government Affairs, "We're delighted that Lauren Aycock's scientific skills were put to excellent use in work that advanced issues benefiting the scientific enterprise."

Another key highlight of Aycock's congressional fellowship: raising awareness of climate change and supporting policies to mitigate its impact.

"I was the policy lead on climate change. I drafted talking points for a climate change speech-a-thon on the Senate floor, organized by Senator Sheldon Whitehouse of

**FELLOW continued on page 6**

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**Join Our Mailing List: visit the sign-up page at go.aps.org/2nqGtJP.**

# FYI: Science Policy News From AIP

## The 2018 Midterm Elections: Outlook for Science Policy

*By William Thomas*

Although the results of the US midterm election are now mostly known, their implications for science policy will only unfold with time. Some of the most immediate changes will occur in the committees of the House of Representatives, where on January 3 the Democrats will take power for the first time in eight years.

The predominant forum for science policy debate and legislation in the House is the Committee on Science, Space, and Technology. Eddie Bernice Johnson (D-TX) is expected to become committee chair, having served as its top Democrat since 2010. She has already identified a number of specific priorities for the coming Congress such as engaging underrepresented groups and blue-collar workers in STEM fields, guarding science from "political attacks," and challenging "misguided or harmful" actions by the Trump administration.

Over the past several years, the Science Committee has often been embroiled in controversy, particularly on occasions when its Republican leadership used it as a platform for challenging mainstream climate science. Johnson states she would like not only to address climate change, but also "restore the credibility of the Science Committee as a place where science is respected and recognized as a crucial input to good policymaking."

Climate change is apt to be a significant focus beyond the Science Committee as well. It and two other committees are already planning two days of hearings on the subject in early 2019. Current House Minority Leader Nancy Pelosi (D-CA) has also suggested reinstating a special committee on climate change that the Republicans disbanded in 2011, though not all Democrats believe such a move is necessary.

Meanwhile, nearly half the 45 Republicans in the Climate Solutions Caucus, including co-chair Representative Carlos Curbelo (R-FL), are departing due to retirements and election defeats. Although the caucus has taken few concrete actions since its establishment in 2016, by admitting members only in bipartisan pairs it has spotlighted the existence of interparty interest in a subject that has been a persistent source of partisan conflict.

Below the radar, there will likely be some continuity in advancing legislation. In recent years, most of the science policy bills that have made headway in both the House and Senate have been bipartisan ones. During the current Congress, major bills setting policy for NASA, the Department of Energy Office of Science, and weather forecasting research have been signed into law. In addition, legislation to establish a National Quantum Initiative currently has significant momentum.

A point of particular interest is what the implications will be of the defeat of Representative John Culberson (R-TX). An influential appropriations subcommittee chair, Culberson has marshalled significant budget increases for NASA, including funding for two proposed missions to Jupiter's moon Europa, where he hopes signs of life might be discovered. Even in the minority, Culberson might have advocated forcefully for his priorities. In his absence, the second

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# First Recipients of the Irwin Oppenheim Award

Jordan M. Horowitz (University of Michigan) and Todd R. Gingrich (Northwestern University) have been chosen as recipients of the first Irwin Oppenheim award for best paper by early career scientists published in *Physical Review E*. The award citation reads

"*For the article, 'Proof of the finite-time thermodynamic uncertainty relation for steady-state currents,' published in* Phys. Rev. E **96**, 020103(R) (2017)*, which demonstrated significance, rigor, and broad impact in the general area of non-equilibrium thermodynamics.*" For more information on the Oppenheim Award and other APS honors, visit aps.org/programs/honors.

Jordan M. Horowitz

Todd R. Gingrich

# Toast with Jam and Quantum Mechanics

APS member Chad Orzel is a professor of physics at Union College in Schenectady, New York. But he is also a blogger for *Forbes* magazine, a sought-after lecturer, and author of four popular books on science. In two of his previous books, Orzel shared his excitement about quantum physics and relativity through "conversations" with his dog Emmy. *APS News* spoke with Orzel about his latest book, *Breakfast with Einstein*, a tour through the physics of everyday things. The interview, available in full online, has been edited for length and clarity.

***APS News*: Your previous books used this device of explaining physics to your dog. How did you approach this book?**

I didn't want to do the talking dog thing again. The sad reason is she died a couple of years ago, but I also don't want to get typecast and how much more can I wring out of talking to the dog? In communicating physics there's a big emphasis on things that are extremely exotic, right? There are lots of books about what's going on near the event horizon of a black hole or what's going on inside the Large Hadron Collider. And it leaves people with this impression that fundamental physics, quantum physics, particle physics are things that only matter in these really extreme environments that have nothing to do with everyday life.

This is to some extent self-inflicted. For those us who write popular books, that's the attention-grabbing stuff and we sort of gravitate to that. But it also distances the subject and allows the reader to turn it off. I realized, and it literally occurred to me while toasting bread, that if you look at the heating element in a toaster oven or an electric stove, it glows red and explaining why hot things glow a particular color is what kicked off quantum physics. That's the black body radiation problem and you can't solve it without quantizing the energy. And then I started trying to think of other aspects of ordinary everyday life where quantum things show up.

So, what do I do in the morning? I go check the internet and see what happened. You can't have the internet without fiber optics; you need lasers to make that work. Lasers are something you wouldn't conceive of without quantum physics. And what am I getting on the Internet? I'm getting photos of people's cats and kids on other continents. And those photos you take with a digital camera—the principle at work there is photoelectric interactions. And it all ends up tying back to quantum physics. My goal is to take really concrete things that you experience in the morning perhaps, and then use that as a jumping off point.

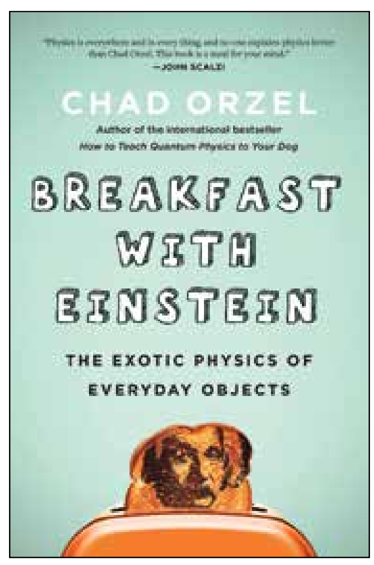
***APS News:* How did you decide which topics to pick for each chapter?**

It was a mix of stuff. I did a blog post around the same time about the Sun, so there is a chapter about how the Sun relies on all of the fundamental interactions. And quantum tunneling. Say you throw two protons at each other at the temperature that you have in the core of the sun. That's not nearly enough energy to get them close enough for fusion, but there's a tiny chance that a tunneling reaction can occur and allow fusion to happen. The sun wouldn't work without quantum physics. I moved from that to talking about smoke detectors. People aren't aware that commercial smoke detectors generally have a tiny bit of americium in there, that the alpha decay of that is part of a sensor that picks up certain kinds of fires. If you open it up, you see the little radioactive sticker. It works because an alpha particle is tunneling out of the nucleus.

***APS News:* The explanations that you have are non-mathematical in many cases and are nice concrete explanations for a particular phenomenon. You must have had to make tough decisions about how much detail to put in.**

In one chapter I talk about how chemistry comes from the Pauli exclusion principle and, in anything biological, you have these organic molecules. Their structures trace back to the electron shells, which are filled the way they are because of Pauli exclusion. It becomes really difficult to avoid falling down a giant rabbit hole of organic chemistry stuff that I don't know very well. So, I tried to keep the detail in that kind of thing to a minimum.

There are certainly places where I've probably simplified too much for people who work on that side of physics or chemistry. But that's not the purpose of the book—it's not a textbook. For example, writing about permanent magnets was really hard. And that chapter is the one where I had to learn the most stuff that didn't make it into the book because it's just a ridiculously complicated process. But magnetism always gets science writers in trouble.




***APS News*: Some scientists say they don't get credit for the science communication that they do, that the whole reward system in academia and other places is still geared toward how many papers you publish. Do you fight against that?**

I don't have a great read on how things are perceived. There are internal merit systems and I don't know how highly that part of the institution regards the books that I published because I also publish papers and scientific review articles. When I sold the first book, I had some really weird conversations with people: "I have a contract to write a book." "Oh really? What university press is it with?" "Um, Scribner? It's an imprint of Simon and Schuster." "Oh, where would I get a copy of that?" "Your local bookstore?" I checked—it's on the shelf at the local big box.

I mean, it never is black and white, but you're not getting actively dissuaded from doing it. I don't know if selling a book that's going to end up in Barnes and Noble carries the same weight as getting a contract for a book that's going to be bought by 100 university libraries and nobody else. The quantum book [*How to Teach Quantum Physics to your Dog*] has done really, really well over the years. It didn't explode publication-wise, but it has sold steadily since it came out. And that's almost 10 years ago.

***Breakfast with Einstein* by Chad Orzel, published by BenBella Books, is available December 2018.**

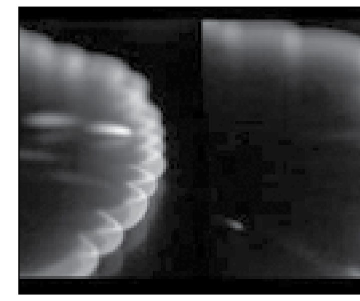
# Dramatic Drops and Fascinating Flows: the 2018 Gallery of Fluid Motion

*By Leah Poffenberger*

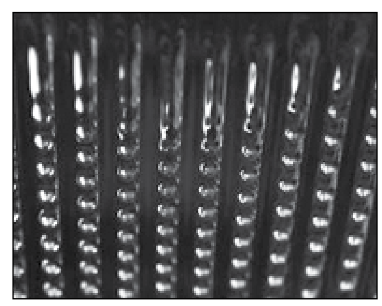
The Division of Fluid Dynamics meeting celebrates the interface of science and art through the Gallery of Fluid Motion, a yearly showcase of visually stunning fluids research. A panel of judges assessed this year's entries, selecting the top video and poster submissions that will be published in *Physical Review Fluids* in 2019. The video winners of the 2018 Milton van Dyke Award and the APS/DFD Gallery of Fluid Motion Award listed here, along with the poster winners, can be viewed at gfm.aps.org.

## 2018 Milton van Dyke Award Video Winners

***The shaky life of a water drop in an anise oil-rich environment (V0054):* A visually stunning phenomena arises when anise oil, ethanol, and water mix together.**

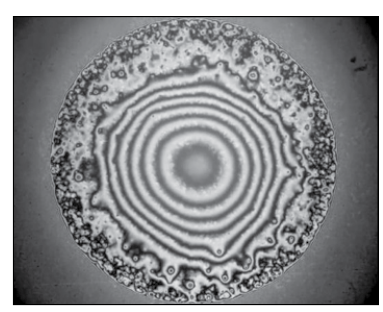


***Premixed-flame oscillations in narrow channels (V0018)*: Propagation of premixed flames react to thermo-acoustic oscillations.**



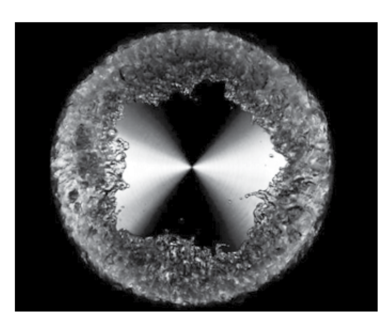
***Dripping down the rivulet (V0070):* At certain angles and flow rates, viscous liquids produce both rivulets and drops.**

## 2018 APS/DFD Gallery of Fluid Motion Award Winners

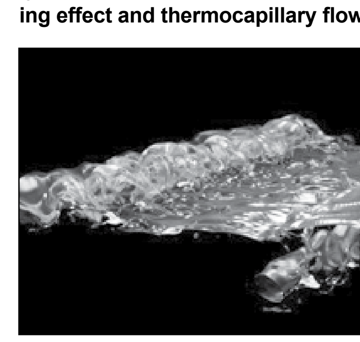


**Hoverdrops: Flying Fizzy Fluids (v0097): On a hydrophobic surface, CO2-filled soda water levitates until the gas dissipates.**

**The surfactant-free persistence of surface bubbles in a volatile liquid (V0057): Volatile liquids such as isopropyl alcohol have a surprising ability to sustain bubbles, thanks to a cooling effect and thermocapillary flow.**



**Nitrogen swirl: creating rotating polygons in a boiling liquid (V0032): Liquid nitrogen, when stirred at a boil, displays rotating pentagons, squares or triangles.**



**Birth of microbubbles in turbulent breaking waves (V0027): Ocean waves and ship wakes produce long-lasting microbubbles as simulated here.**

## DBIO continued from page 1

the APS community. Members are affiliated with a broad range of academic departments—including biochemistry, engineering, neuroscience, mathematics, and medicine, in addition to physics and biophysics. As DBIO member Moumita Das, associate professor of physics at the Rochester Institute of Technology, put it, "Nature doesn't care about boundaries. If you want to solve some of the outstanding problems in nature, you can't do it with just your knowledge of chemistry or biology or physics—you have to step across these disciplines and collaborate with other people."

DBIO's broad lens on biological physics has been a key feature of the division's culture since its founding in 1973. Princeton University professor and APS Fellow Shirley Chan was a graduate student at the time and recollected that DBIO was established "essentially out of frustration" by physicists whose forward-thinking ideas about applying physics approaches to biomolecules weren't widely embraced by the scientific communities in either physics or biology at the time.

An early pioneer in studying the spectra, structure, and dynamics of proteins and nucleic acids, Chan remembers the 1970s as an interesting era in physics, with many well-established nuclear and solid-state physicists shifting their interest toward biological systems—particularly the puzzle of how to comprehensively model the function of proteins and enzymes.

Her advisors, Hans Frauenfelder and Peter Debrunner, were two of the earliest examples. Their laboratory at the University of Illinois Urbana-Champaign studied the ligand effects of heme proteins in different oxidation states, by enriching the heme's iron with a radioactive isotope to make it detectable with Mössbauer spectroscopy. Later, the focus shifted to the dynamics of heme protein's binding to oxygen and carbon monoxide. Chan was among the graduate students tasked with developing flash photolysis methods to approach this topic, and other pioneers applied magnetic fields to study the quantum spin dynamics of biomolecules, ultimately leading to the development of magnetic resonance imaging.

Chan recounted that the Frauenfelder laboratory, and others pursuing similar lines of physics-based experimentation on biological systems, had difficulty publishing this work in the available biochemical and biophysical journals in those years, and were met with skepticism when presenting about these topics at the Biophysical Society Meetings. Without a niche in any existing academic society, a group of senior APS members decided to form a new division to cultivate this new subfield of physics, and the Division of Biological Physics was born.

Nearly 50 years later, what questions is DBIO now tackling? The research of Ross and Das provides an interesting cross-section.

The research carried out in the Ross lab explores the microtubule cytoskeleton and how it facilitates cells' remarkable capacity for self-organization. Microtubules both provide mechanical structure to support the shape of cells, and comprise tracks coupled with motor proteins that facilitate intracellular transport. Understanding fundamental properties of this system is a question that draws upon soft, active, and biological condensed matter physics. It also has implications for disease, as breakdown in the microtubule network underlies a host of cancers, brain abnormalities, and neuromuscular diseases.

Das' research examines the underlying principles and mechanisms that lead to the toughness of articular cartilage—a millimeters-thick material that, remarkably, routinely bears up to 10 times one's body weight over 100-200 million loading cycles, all without fracturing. A better understanding of this exceptionally tough biological material could help inform the development of materials for tissue engineering, tissue repair, and even soft robotics.

Other open questions in biological physics, always hot topics at DBIO's sessions at APS Meetings, include the mechanics of how brain tissue buckles to form wrinkles, the biomechanics of immune response, and the quantum biology of photosynthesis. "Science is not stagnant," noted Ross, "DBIO has been able to thrive by encouraging new and different aspects of biological physics."

DBIO has also left its mark at the highest levels of biomedical research. Lobbying from DBIO researchers led the National Cancer Institute to establish a network of 12 Physical Sciences Oncology Centers in 2009. These have since led to breakthrough insights into the role of biomechanics in cancer metastasis and a valuable rise in statistical- and mechanics-based thinking in many NCI-funded studies.

The division's spirit of inclusivity applies to its scientists as well as its science: DBIO features some of the highest participation from women and under-represented minorities in the APS community. Placing this proportion at well over 20 percent, Ross noted "We're a diverse and welcoming division of APS, and that's very visible." A distinct point of pride for DBIO is that this diversity goes beyond mere membership: The division works actively to ensure that women and underrepresented minorities—as well as early-career researchers—are well-represented in working group sessions and business meetings, as speakers at APS Meetings, and in division leadership. As it stands currently, DBIO's 12-person Executive Committee boasts a 50/50 split between men and women. "At DBIO you'll see the difference. Not only how many women and underrepresented minorities are present, but how many are speaking up," said Das.

Overall, DBIO stands out as one of APS' most lively and community-driven divisions, with plenty to offer members in terms of support, inclusivity, and encouragement. More information on the division can be found here: aps.org/units/dbp/

*The author is a freelance writer in Helsinki, Finland.*

## PRApplied continued from page 1

relentless focus on seminal results and lasting value by our outstanding professional staff and Editorial Board has been key to PRApplied's success. We have every intention during the years ahead to maintain that clear focus on excellence and impact. With this winning formula, we are assured of attracting the best papers in applied physics, of continuing our robust growth, and of growing the reputation of PRApplied among scientists and engineers the world over.

We thank all of our readers, authors and referees who give generously of their time and effort, for the support they have shown for PRApplied in its first five years. We look forward to the future with enthusiasm, confident in knowing that the journal will continue to live up to its ambitions of being the "go-to" journal for all of the applied physics community.

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*Stephen Forrest is the Peter A. Franken Distinguished University Professor, and the Paul G. Goebel Professor in Electrical Engineering, Materials Science and Engineering, and Physics at the University of Michigan. He has been Editor of PRApplied since August 2017.*

## FELLOW continued from page 4

Rhode Island. These talking points incorporated recent news stories about the impact of climate change in Illinois and around the world," said Aycock.

Aycock's experience also involved supporting local national laboratories.

"One of Senator Durbin's highest priorities was consistent, steady growth in funding for scientific research," said Aycock. "Two of the Department of Energy (DOE)'s Office of Science national labs—Argonne National Lab and Fermi National Accelerator Laboratory—are in Illinois. I enjoyed working with both the labs to move forward on mutual policy goals."

She continued, "I coordinated bipartisan sign-on letters with Senator Mike Rounds' office [in South Dakota] in support of Fermilab's Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment during the crafting of the president's budget request and congressional appropriations process."

Aycock added, "I coordinated letters with Senator Tammy Duckworth's office to support Argonne's upgrade of the Advanced Photon Source and real growth in funding for the DOE Office of Science."

As a graduate student working at the Joint Quantum Institute, a partnership of the National Institute of Standards and Technology (NIST) and the University of Maryland, Aycock was familiar with research taking place at US national laboratories. But after she began her congressional fellowship, she said she learned more about the depth of the research taking place at those laboratories.

"I really didn't get exposed to the DOE national laboratories until I participated in this fellowship. I've learned so much about high energy physics from visiting many of the national laboratories," she said, adding that she toured nine national labs, including SLAC and Fermilab. "On Capitol Hill, I was not a cold atom physicist. I was a physicist, and more broadly, a scientist. Colleagues looked to me to provide broad insight into science, not solely my research expertise developed in graduate school."

Aycock also had an opportunity to advocate for funding for the NIST.

"It was important to me that Senator Durbin had a big view of the science ecosystem," said Aycock, explaining that the senator stepped in to write a letter in support of funding for NIST after noticing that the agency had not received the same support as other scientific agencies.

Aycock also played a role in making sure that three scientists, who helped NASA's earlier research programs, gain recognition.

"I recommended that Senator Durbin co-sponsor the Hidden Figures Congressional Gold Medal Award Act to award Congressional Gold Medals to Katherine Johnson, Dorothy Vaughan, Mary Jackson, and Dr. Christine Darden in recognition of their contributions to NASA's success during the space race. Senators Chris Coons (D-DE), Lisa Murkowski (R-AK), and Kamala Harris (D-CA) introduced the legislation."

Additionally, Aycock put her analytic skills to good use.

"I performed a detailed policy analysis of Senators Lisa Murkowski and Cory Booker's (D-NJ) Nuclear Leadership Act to support advanced nuclear reactor research and encourage domestic civilian investment in research and development of advanced nuclear power. I made recommendations for improving the bill and recommended that Senator Durbin co-sponsor it."

Aycock said making sure the public understands the importance of science is a crucial lesson she learned during her fellowship.

"As the physics community, we need to make sure that we are communicating the importance of our research," she said.

Scientific research has led to the development of myriad innovations, including the Internet, MRI, and Doppler radar—all inventions that have changed the lives of Americans. And for that reason, scientists should communicate the benefits of their work, explained Aycock.

"We have so much to share about the value of science," she said.

Furthermore, she said, "all politics is local."

"We should make sure that our congressional representatives know about the cool research that we are conducting," she said.

*The author is the APS Press Secretary.*

Congressional Science Fellowship applications are being accepted at go.aps.org/apscsf.

LEBANON continued from page 1

in itself, but here you have other barriers, such as a lack of adequate funding."

And there are other challenges. Lebanese physicists describe an electrical grid that goes out in the middle of an experiment; when it will turn back on is anyone's guess. Telecoms has its troubles too. When Maher Dayeh of the Southwest Research Institute in San Antonio, Texas, participated in an APS exchange program with other Lebanese physicists, he had to drive one hour back to Beirut from his residence outside the city, if he wanted fast internet. "You can call the company and they don't do anything," he says. "The phone lines need to be replaced—they've been saying this for five years."

Physics professors at public institutions are civil servants—"they have to do research and publish in order to get promoted," notes Sabra. Teaching loads tend to be on the high side. And the professorships, no matter the type of university, are highly competitive.

But because there are so few positions for physics professors, pursuing a career is tough and as a result, many physics students go abroad to further their education and gain an advantage should they want to return to Lebanon. Physicist Amara El-Sayegh is currently pursuing an unpaid postdoc at the American University of Beirut (AUB) while serving as a lecturer at this university and others nearby. "At AUB it's very hard to get a job so I need a postdoc experience abroad," she says. "It's very competitive so people are required to do research abroad…It is a hard thing to do because there are not a lot of opportunities for physicists. There is no encouraging environment for research."

"If you do research [in Lebanon] you do it for the love of it," says Dayeh. "If you are not excited about knowing about the nature of matter, you can sit back and in most cases still have your job. Those who do research are really excited about it, and they want to find new solutions to problems and better understand the universe. This tells you that if there were more funding and infrastructure stability, they would be able to do more!"

Interestingly, physics research is done almost exclusively at universities, says Jihad Touma, professor of physics at AUB. "There is to be sure hardly any research done by industry for industry; research is conducted in universities but also in the Lebanese National Council for Scientific Research," he notes. "Applied physics research is conducted with technological applications in mind, but the absence of any related industrial sector in the country makes for little or no immediate convergence to the foreseen applications."

And there's war. "The lack of resources for scientists and engineers has been a hindrance. Resources are wasted because of war," says Zbib. "It's not that the country doesn't have resources, it's that the resources are being used somewhere else." And that includes human resources: "With the war things fell apart. The main people I looked up to had left in the war," says George Helou, research professor of physics at the California Institute of Technology.

"The infrastructure is a challenge—the power grid, internet access, internet speed, all of this. It's a real problem and it holds back not just research but the economy as a whole," says Helou. "It is remarkable that any activity can be achieved in that environment but people are resilient and keep going! I have a great admiration for the physicists who have a go at it and they do make a difference in making connections to the international community."

## Onward

Despite its challenges, this is an exciting time for physics in Lebanon. The Lebanese Academy of Sciences, known officially by its French name, the Académie des Sciences du Liban (ASL), is an independent and nonprofit institution founded by a decree from the Lebanese Government in 2007. It is modeled on the French Academy of Science.

"The ASL is an independent entity from the government," notes Zbib, "but acts as a catalyst for science, scientists, and engineers." Indeed, Helou, who served as President of ASL from 2014 to 2018, shares that much of the ASL's strategic plan concerns increasing its visibility within the Lebanese federal government to provide scientific insight for national programs. He and his ASL colleagues are facilitating targeted studies and study groups that look at how to deal with diverse issues of national concern, ranging from environmental issues, such as toxic waste removal and sustainable energy, to public health, to education and even tourism.

"The government has also asked us for advice about setting up a planetarium in the country as a science tourism and an educational tool," says Helou. "All of these are the kinds of issues the country has to deal with it and we believe that we could provide technical insight." Currently, ASL has approximately 30 members, all of whom are volunteering their time and efforts towards these undertakings.

In 2016, APS and the ASL, in a joint effort led by Zbib and Helou, launched the US-Lebanon Professorship/Lectureship Program, which supports scientists wishing to visit overseas to deliver a short course or a physics lecture series at a university. The first participants were Dayeh, who conducted a series of lectures on magnetic reconnection at AUB in October 2016, and Touma, who presented the Dix Planetary Science seminar at Caltech and a lecture at the Galactic Center group at UCLA on topics in planetary and galactic dynamics.

"We decided to begin modestly, because we all wanted a program that was of equal partnership, meaning we each would provide one travel award each year," says Amy Flatten, Director of International Affairs for APS. "We felt an equal partnership was the most appropriate. Even with fewer awards, it will help to build a baseline of contacts with the Lebanese physics community that we hope will expand and strengthen our connections to this physics community."

The program is modeled after other successful APS international endeavors with nations such as Brazil and India. "We appreciate the connections to some of the leaders in the region through the Lebanese Academy of Sciences and the chance to convey that APS is interested in working and collaborating with that community," says Flatten. "APS wants to strengthen its connections with the physics community in Lebanon and more broadly the Middle East."

To increase APS service to its international members and physicists worldwide, CEO Kate Kirby established the Task Force on Expanding International Engagement. The Task Force, composed of 13 senior physicists representing diverse physics fields and all parts of the world, has undertaken an extensive outreach to all parts of the Society, as well as its international partners. It gave its final report and recommendations to the APS Council of Representatives in November 2018.

Although Zbib left Lebanon 40 years ago to study at Michigan Technological University, he has always stayed connected. He served on the APS Committee on International Scientific Affairs and was one of the architects of the U.S.-Lebanon Professorship/Lectureship Program, which he views as an invaluable first step in advancing cross-national partnerships. One especially relevant issue: "There are more Lebanese scientists outside Lebanon than in Lebanon," he notes. "There is much more scientific involvement outside Lebanon. I see a lot of students from AUB go to the US, and students from other Lebanese universities going to French-speaking countries."

Lebanese physicists recognize that they are in a unique position. "The country is filled with contradictions," says Touma. Despite challenges of infrastructure and war, Lebanese physics students garner top positions in grad programs and postdocs around the world, and Lebanese physics researchers regularly achieve results on the cutting edge of the discipline. "These are reasonable expectations [in a typical setting]," he adds. "What is unreasonable is that we are able to produce such excellence under these conditions. I'm proud to be associated with this bunch."



PLAN S continued from page 1

Plan S is bold, but not surprising."

APS Editor in Chief Michael Thoennessen adds that "APS has long been a proponent of OA publishing that is financially sustainable and does not compromise the high standards of quality and peer-review of the APS journals," referring to a commitment in the official APS statement on OA issued in 2009 (go.aps.org/2Ph81ya). Salter and Thoennessen wrote about the impact of open access on the integrity of science earlier this year (See *APS News,* February 2018, go.aps.org/2si7MwC).

Currently, three of the 12 APS primary research journals—*Physical Review X*, *Physical Review Accelerators and Beams,* and *Physical Review Physics Education Research*—are published fully OA. The other APS journals are published under the hybrid model.

Under the stringent requirements imposed by Plan S, researchers funded by cOAlition S members who choose to publish in the *Physical Review* journals would currently only be allowed to do so in three fully OA APS titles. The original Plan S requirement to publish only in fully OA journals puts most APS Journals, including *Physical Review Letters,* off-limits, along with other prestigious journals such as *Science* and *Nature*, and some commentators have estimated that under Plan S, researchers would be banned from publishing in about 85 percent of existing journals.

"The restriction to publish only in fully OA journals brings up critical questions around author freedom and choice, and could have a profound effect on the way researchers collaborate across international boundaries" says Salter. These questions, as well as likely impacts on mission-driven scientific societies such as APS, were among those raised by Salter, Thoennessen, and APS Chief Government Affairs Officer Francis Slakey, when they met with Smits in Washington DC at the beginning of October.

Financial considerations are also at the heart of Plan S. OA journals flip the traditional journal model, placing the responsibility of meeting publishing costs, such as editing and management of peer review, on article authors through payment of APCs. These costs have traditionally been borne by library and institutional subscribers.

Another key aspect of Plan S is the introduction of a maximum APC. According to Salter, although cOAlition S is yet to spell out the level of the cap, APS already offers very competitive APCs and it is likely that these would fall within the limits being considered by the authors of Plan S. The November guidelines did not offer much greater detail although Plan S signatories have indicated that they will commission studies of APC levels and the academic publishing landscape to assess which disciplines require more OA publishing options. Subsequent initiatives to provide financial incentives to create new OA journals or flip existing ones to OA are also being considered.

Given that many of the details of the plan have not yet been released and, so far, many large funders have not joined the coalition, Plan S is still a moving target. With this in mind, Salter counsels against a precipitate response and pledged that APS would pursue a journal program focused on offering the best publishing choices to authors in the community. "As part of our strategy to develop further the APS journals we have been actively considering how to expand choice of fully OA publishing venues for some time," says Salter. "We want all authors, including those who prefer to publish OA, those who are mandated to do so, and those who collaborate with colleagues or co-authors wanting or needing an OA publishing model, to find suitable options within the APS journals portfolio."

OUTLOOK continued from page 4

Europa mission, a controversial lander, could languish. The fate of the funding he has secured for NASA's Planetary Science Division also remains to be seen.

The fate of science funding as a whole is apt to hinge on high-level negotiations over what level statutory budget caps should be set at. A two-year agreement reached in February to raise the caps, which has enabled significant funding increases across science programs, expires in October 2019.

Since budget sequestration was imposed in 2013, Congress has always reached bipartisan agreements to raise the caps and avert any further across-the-board budget cuts. Republicans and Democrats will doubtless work to reach another agreement next year, but no result can be taken for granted in the present politically volatile climate.

*The author is a science policy analyst with* FYI *at the American Institute of Physics.*

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# The Back Page

## Listening to the Skilled Technical Workforce

*By Christina Maranto and Mateo Munoz*

On the heels of the announcement that LIGO pioneers Barry Barish, Kip Thorne, and Rainer Weiss had been awarded the 2017 Nobel Prize in Physics for the direct observation of gravitational waves, we, as AAAS Policy Fellows supporting the National Science Board (NSB) joined members of the NSB, the governing body of the National Science Foundation, on a visit to LIGO in Livingston, Louisiana to learn about the research, the facility, and the dedicated scientific workforce that made this groundbreaking discovery possible.

After a captivating presentation on the events leading up to the historic detection, we accompanied the NSB on a facility tour. Alongside a bright undergraduate intern and a group of energetic postdoctoral researchers, our group met David Barker, the person who maintains LIGO's impressive, two-story heating, ventilation, and air conditioning (HVAC) system. Barker is a skilled technician whose skillset and dedication are essential to the function of this technically complex facility.

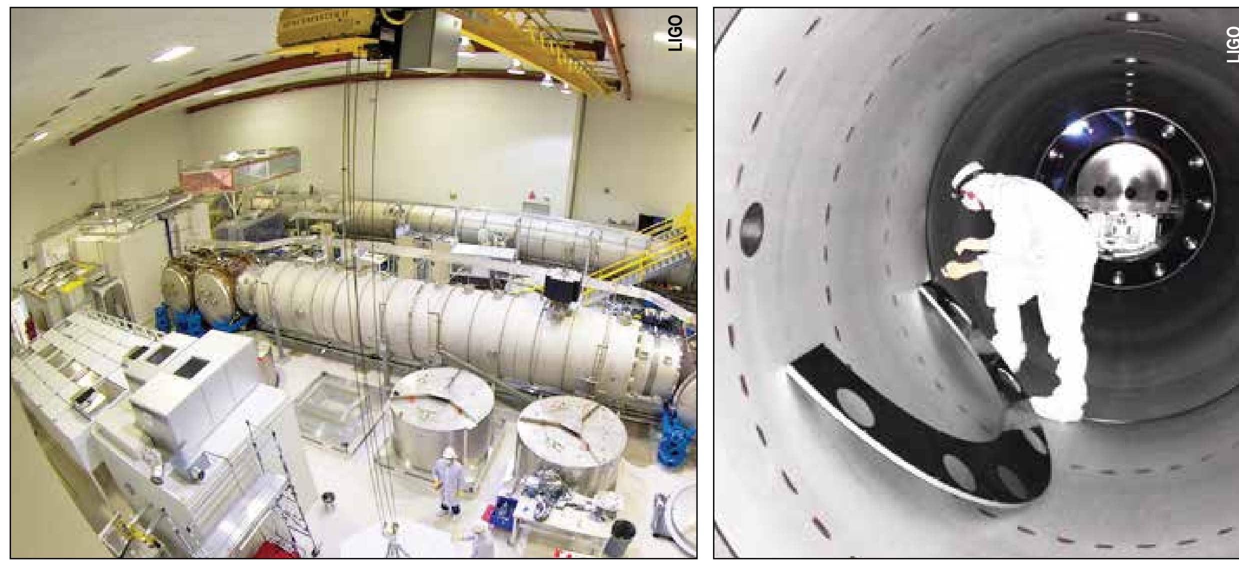
Like Barker, workers who use technical skills in their jobs but who do not have a four-year degree are part of the nation's skilled technical workforce (STW). Although the Board was at LIGO to learn about "the science," we also learned that without the technical workers who support the researchers and the technical operations of the facility, the Nobel-winning science would not be possible. While scientific breakthroughs often conjure the stereotype of the lone genius toiling in the lab, the reality is that discoveries are the product of a scientific team that includes workers at every level, ranging from people with certificates, an apprenticeship credential, associate's, bachelor's, and graduate degrees.

Throughout America, skilled technical workers are an increasingly important segment of the science, technology, education, and mathematics (STEM) workforce. These workers are in traditional "blue-collar" professions such as plumbing and welding, but also increasingly in information technology and health care fields. In 2015, the median annual earnings for skilled technical workers in "science and engineering" ($60,000) or "science and engineering-related" ($45,000) occupations were significantly higher than the median earnings in other occupations ($29,000) [1]. Skilled technical occupations not only offer solid middle-class salaries, but are also predicted to be among the fastest growing over the next decade [2]. Despite these trends, employers consistently report that they have trouble filling these jobs.

In November 2017, the NSB officially established its Task Force on the Skilled Technical Workforce to identify the opportunities and challenges facing students, incumbent workers, businesses, educators, and others involved with the STW and recommend strategies to strengthen it. Building on its 2015 report, *Revisiting the STEM Workforce*, the NSB has promoted policies that support a STEM-capable US. workforce that includes individuals from all demographic groups, at all education levels, and in all geographical locales. In February 2018, the NSB published *Our Nation's Future Competitiveness Relies on Building a STEM-Capable US Workforce*, a policy statement encouraging the coordination of policies and investments aimed at building and strengthening on-ramps into skilled technical careers.

Strengthening the STW is also a priority for policymakers, with efforts underway to expand post-secondary opportunities for both young people and adults. Congress and the Administration have renewed interest in strengthening the skilled technical workforce through apprenticeship, an age-old workplace learning program that requires a substantial investment by the employer. For example, the House Committee on Science, Space, and Technology introduced the "Innovations in Mentoring, Training, and Apprenticeship Act," which emphasizes engagement with industry partners willing to offer applied learning opportunities such as apprenticeships and internships [3]. In July 2018, the Administration formed the President's National Council for the American Worker to develop a national strategy to ensure that America's students and workers are prepared for 21st century jobs, which often require skilled technical training [4].

For its part, the NSB is contributing to these efforts by getting outside Washington, DC, to hear from communities that have a direct stake in the skilled technical workforce.




**Behind the scenes at each of the LIGO interferometers there is a complex infrastructure of vacuum chambers, optics, electronics, and data networks. All of it requires a skilled technical workforce to operate and maintain.**

By holding "listening sessions" with students, educators, industry, and government officials in multiple geographic regions and industry sectors, the NSB hopes to understand the varied challenges the STW faces across the country.

The NSB held its first listening session in Baton Rouge, Louisiana, in a region where the oil and gas industries fuel some 260,000 jobs. Like many community colleges, Baton Rouge Community College, which hosted the session, is an essential education center for students entering the skilled technical workforce. The NSB's second listening session took place at Macomb Community College (MCC) in Warren, Michigan. MCC is in the heart of the rejuvenated automobile industry and home to the Center for Advanced Automotive Technology (CAAT), a NSF-funded Advanced Technological Education center. CAAT's mission is to meet the expanding workforce needs of the automotive industry by increasing the pool of skilled technical workers in advanced automotive technology including automated and connected vehicles, and vehicle electrification.

In total, over 50 participants from multiple sectors including, academia, industry, non-profit, chambers of commerce, and state government participated in these sessions. They shared their perceptions of the challenges facing the STW in their communities. While some significant differences exist between Baton Rouge and Warren, including socio-economic factors, we observed several common themes:

1. **Stigma**: Students and parents continue to believe that a four-year college degree is required for a lucrative, stable, and enjoyable career. One participant said that "A lot of people don't know that a four-year degree is not the only way to an American Dream." There tends to be a view of the career landscape as a dichotomy between jobs requiring a bachelor's degree and jobs that are "no skill." High school guidance counselors can also perpetuate this view by promoting the benefits of a four-year degree while neglecting to highlight educational and career pathways in technical fields that do not require a four-year degree. And lastly, for some technical jobs in the manufacturing fields, people are not aware that they are clean, bright, and highly technical workspaces.
2. **Skills Gap:** Students often lack the appropriate skillset to work in technical careers upon completion of high school and/or training in community college. For example, it is difficult to find qualified teachers who know and understand industry-specific technical skills and as a result, the curriculum may be misaligned. Another factor is that declines in state funding led many public-school systems to cut technical programs.
3. **Human Resources (HR) Practices**: Many companies and government employers require a four-year degree for work that could be done by well-trained skilled technical workers, thereby excluding many qualified candidates. HR policies that focus on credentials instead of skills exacerbate worker shortages and block individual opportunities.
4. **Expense and Lack of Wrap-around Services:** Community college students tend to be older (averaging 28 years old) and have families and jobs. Additionally, many face socioeconomic hardships. For example, some lack transportation to get to school or training programs. Childcare is also a significant issue, both in terms of cost and time.
5. **Gender Diversity**: Technical fields are predominantly male. Women may not be aware of these pathways in part because of the lack of female role models in technical industries.

This past June, NSB held a third listening session, meeting with students and faculty who were participating in NSF's Community College Innovation Challenge in Alexandria, Virginia. This two-stage competition uses STEM to find innovative solutions to real-world problems. The student finalists and their faculty mentors represented community colleges across the country and echoed many of the same themes that came to light in Warren and Baton Rouge. In September, NSB members visited Florence-Darlington Technical College in Florence, South Carolina to learn more about the workforce needs of the advanced manufacturing industry.

The individuals we've met in these listening sessions have moved and inspired us—and the members of the NSB—with their personal stories of overcoming challenges, which are numerous, varied, and complex. Promisingly, there appears to be an energy and willingness to work together to solve these challenges. In the words of one of the listening session participants, "Everyone can help. I don't care who it is that pulls this off, I just want it to get done."

**Disclaimer:** The views expressed here are solely those of the authors and do not in any way represent the views of the American Association for the Advancement of Science (AAAS), the National Science Board (NSB), the National Science Foundation (NSF), or any other entity of the US Government.

*Christina Maranto is an AAAS Science and Technology Policy Fellow hosted by the National Science Board Office. Mateo Munoz is an AAAS Science and Technology Policy Fellow hosted by the National Science Board Office.*

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