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APS physics

Recent Official APS Statements
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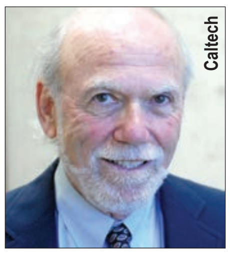
2017 Nobel Prize in Physics

Rainer Weiss



Barry Barish

Kip S. Thorne

New Era In Astronomy see page 3

By David Voss

A little over two years after the first direct detection of gravitational waves by the Laser Interferometer Gravitational-Wave Observatory (LIGO), the Nobel Prize committee has awarded the 2017 physics prize to three leaders of the decades-long project "for decisive contributions to the LIGO detector and the observation of gravitational waves."

Detection of the gravitational-wave signal, resulting from the merger of two black holes, was the culmination of more than four decades of effort by researchers with funding from the U.S. National Science Foundation.

"This is a marvelous prize that recognizes the heroic and successful detection of the undulations of spacetime predicted over a hundred years ago by Albert Einstein," said David Gross, winner of the 2004 Nobel Prize in Physics and Vice President of APS. "By using gravitational-wave detectors, LIGO has created a new window to probe the universe."

One half of the prize goes to Rainer Weiss of the Massachusetts Institute of Technology, while the other half will be shared by Barry C. Barish and Kip S. Thorne of the California Institute of Technology (Caltech). Ronald Drever, also of

NOBEL continued on page 6

Optimism Abounds at Conference on Women in Physics

By Katherine Wright

A discussion about women in physics often includes depressing facts and figures. And certainly, the numbers can sound bleak: In the UK, for example, just 20% of the students taking high-school-level physics are girls, a fraction that hasn't changed in over 30 years; Finland didn't have its first female physics professor until 2000; and worldwide, the fraction of women in physics declines with seniority in every country in which data have been collected.

But pessimism wasn't on the program at the 2017 International Conference on Women in Physics in Birmingham, UK. The triennial conference, which this year brought together nearly 200 women (and a handful of men) from 48 countries, focused largely on the victories women have won with initiatives that break down gender bias and eliminate barriers to success.

"There is so much positivity at this conference," said Jess Wade, a postdoctoral researcher from Imperial College London, who helped organize the meeting. Like many at the conference she found the tales of success inspiring.

One such story came from Anisa Qamar, a professor at the University of Peshawar in Pakistan and also the first woman in her country to have been awarded a Ph.D. in plasma physics. The northern region of Pakistan where Qamar lives and works has been subjected to frequent terrorist attacks by the Taliban, which have destroyed several schools for girls and killed students. "Girls are frightened to get an education because of terrorism," said Qamar. Knowing that two thirds of the women in her country are unable to read or write, Qamar wasn't about to sit back and watch them be paralyzed by fear. So she set out to organize a conference for women to discuss the cultural challenges and issues they face in a male-dominated field and in a dangerous society.

Qamar encountered opposition from both the head of her department, who withheld funding, and from parents, who didn't want

Jocelyn Bell Burnell addressing the 2017 International Women in Physics Conference upon receiving the U.K. Institute of Physics President's Medal.

their girls to attend the meeting. But she prevailed in getting money and support from Pakistan's Higher Education Commission, and in 2016, the conference brought together 150 female physics students. "It is a journey. I don't know where the destination is, but I'm alive and I continue my struggle," said Qamar. She plans to have the next conference in 2020.

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From Cameroon to the APS

By Arsene Tema Biwole

I was born in Bafoussam, Cameroon, on June 15, 1992. Due to my premature birth, I was sick throughout my childhood. My brothers and I only had our poor and single mother to take care of us. I still remember her, struggling hard to feed us daily. Despite the dire conditions in which I was born and raised, I dreamt of one day becoming a physicist. I tried so hard to hold onto that childhood dream, sometimes spending nights studying Newtonian physics close to the cooking fire, due to lack of electricity in the house.

My life took a major turn when I was selected by the Italian Embassy in Cameroon to study at an Italian university. I promised my mother that I would make her proud of me, so I left my family and my home country to follow my passion. In Italy, I studied nuclear engineering at the prestigious Polytechnic University of Turin. Being the only Cameroonian student in Italy engaged in nuclear science placed a huge responsibility upon me: the responsibility to go as far as possible, and prove that

Arsene Tema Biwole

anyone can make his or her dream a reality, regardless of his or her background.

It was in trying to go farther that I flew in April 2017 to the United States of America to do research at General Atomics (GA) for my master's degree thesis, sponsored by the U.S. Department of Energy. I have had the most exciting and satisfying experience of my life, working with the fusion theory group at GA.

I would like to thank all the people who helped me achieve my goals, and especially my supervisor at GA, Sterling Smith, who always encourages and supports

CAMEROON continued on page 7

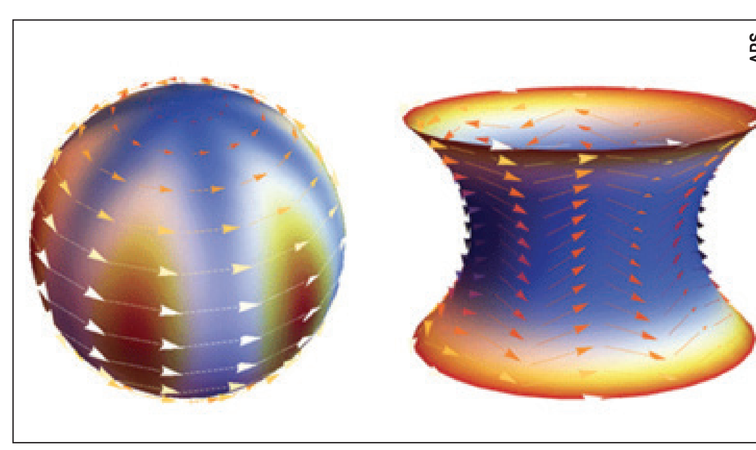
Research News: Editors' Choice

physics.aps.org

A Monthly Recap of Papers Selected by the Physics Editors

A Teary Solution for Electricity Generation

Collecting tears in a bottle might one day have practical benefit for electricity generation, according to researchers who discovered that the antibacterial protein lysozyme—found in tears, egg whites, saliva, and milk—generates an electrical charge when squeezed. This so-called piezoelectric effect occurs in materials whose internal structure lacks a center of symmetry. When squeezed, the ions within this asymmetric structure shift, resulting in a net electric polarization. Several biological substances are known to exhibit piezoelectricity, such as bone, wood, and certain fibrous proteins. However, lysozyme is the first easily crystallized protein for which a piezoelectric effect has been identified. Reporting in *Applied Physics Letters* (DOI: 10.1063/1.4997446), Stapleton et al. created films of lysozyme crystals and applied a downward squeezing force. The induced voltage implied a piezoelectric coefficient as high as 6.5 picocoulombs per newton, which is comparable to natural piezoelectric materials like quartz. Certain synthetic materials used in sensors and actuators have much stronger piezoelectric effects, but they often contain lead or other toxic chemicals. Lysozyme-based materials could offer a biocompatible piezoelectric that could be incorporated into implants or drug-releasing devices to harvest electricity from their surroundings.



Birds, bacteria, and ocean waves might behave like topological insulators.

Topological Behavior in Nature

Two studies indicate that some natural phenomena, such as ocean waves and bacteria, can behave like electrons in exotic materials called topological insulators. In materials with topological invariance, electrons are afforded the "protection" to travel around an insulator's edges, unaffected by scattering and other perturbations. Reporting in *Science* (DOI: 10.1126/science.aan8819), Delplace et al. suggest similar topological behavior for so-called Yanai and Kelvin waves—equatorial ocean waves that play a major role in regulating the climate system. The authors' calculations indicate that these waves can be regarded as unidirectional topological modes enabled by the breaking of time-reversal symmetry caused by Earth's rotation. Topological protection may explain why these waves are not significantly disrupted by storms, wind changes, or passage through islands. In a study appearing in *Physical Review X*, (DOI: 10.1103/PhysRevX.7.031039) Shankar et al. investigated flocks of particles moving on a curved surface—a model that could apply, for instance, to cells roaming the folds of the gut. In such a system, the team similarly finds unidirectional topological modes that could provide channels for transport of biochemical signals in the flock, robust against perturbations and heterogeneities. (See the Synopsis "Even Flocks are Topological" in *Physics*.)

RESEARCH continued on page 4

Spotlight on Development

Your support of physics today will motivate the scientists of tomorrow

As you consider which worthy causes to support this year, we hope you will choose to help expand the reach and impact of APS PhysicsQuest—a program that touched the lives of 400,000 middle school students last year and altogether has reached more than 3.5 million students since its inception in 2005.

- PhysicsQuest teaches fundamental concepts of physics by providing free materials for lab experiments to middle schools.
- PhysicsQuest kits engage students via a physics-themed comic book that features the superhero *Spectra.*
- This past year, 22,000 PhysicsQuest kits were requested, but we could provide only16,500. With your help, we could distribute the rest and many more.
- Gifts of any amount are greatly appreciated.

For more information, contact APS Director of Development Irene Lukoff at 301-209-3224 or lukoff@aps.org

2017 APS Board Statements

APS Statements undergo a meticulous process of draft and review, including receiving comments from members, before being voted on by the Council at one of its semiannual meetings.

Board Statements expedite the APS Statement draft and review process in cases where more rapid action is necessary. If Board Statements are not eventually submitted to Statement review procedures, they are archived after one year and may not be renewed. The 2017 Board Statements are given below.

Unit Statements are drafted by the individual membership bodies and are submitted to the Council via the Panel on Public Affairs. Specific statements of narrower concern may be submitted to the APS Executive Office.

APS Board Statement on H-1B Visas (passed 9/16/2017)

The H-1B temporary work visa program that permits highly skilled foreign-nationals to work in the U.S. has been vital to American interests and should continue. Nevertheless, the APS recognizes a need to reform the H-1B program to stem recent abuse, without affecting the ability of American companies and academia to acquire needed talent. The reform of the H-1B system must ensure access to scientific and technical talent wherever it may be found, while protecting the interests of U.S. citizens.

As for the portion of the H-1B program that exempts institutes of higher education, non-profit organizations and government research organizations from the overall visa cap under specific circumstances, APS is not aware of any abuse of this portion of the H-1B program, and recommends that it remain intact.

APS Board Statement on Racial Violence (passed 4/23/2017)

Physics flourishes best when physicists can work in an environment of safety, justice, and equity. Therefore, all of us must work vigorously against systemic racism and to overcome implicit biases. The Board of the American Physical Society believes that it is timely to reaffirm the importance of building a diverse and inclusive physics community, as expressed in the APS Joint Diversity Statement (Human Rights 08.2). The Board expresses deep concern over incidents of racially biased violence and threats of violence against people of color.

For more on APS Statements, please visit these websites:

aps.org/policy/statements/

aps.org/policy/statements/94_5.cfm

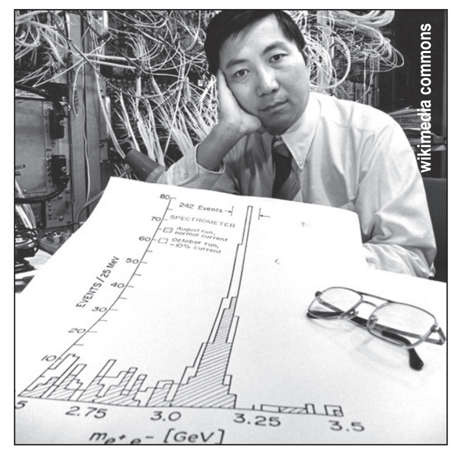
aps.org/about/governance/documents/joint.cfm

This Month in Physics History

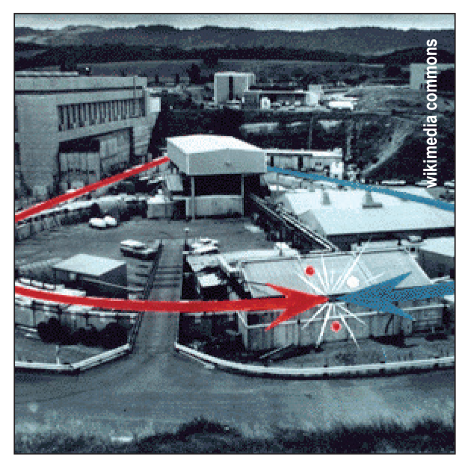
November 1974: Discovery of the Charmed Quark

Quarks are just one branch of the family of particles in the Standard Model. But it was the discovery of the charmed quark in particular—discovered almost simultaneously by two different teams at two different accelerators, using different approaches and led by two very different men—that launched a series of breakthroughs collectively dubbed the "November Revolution."

By the early 1930s, physicists thought they had a complete picture of the constituents of matter: electrons, protons, neutrons, neutrinos, and their corresponding antiparticles. But Nature threw them a curveball in 1936 with the discovery of the muon, a heavier version of the electron. It was so unexpected that I.I. Rabi famously declared, "Who ordered that?" As physicists continued to collide particles at ever higher energies, they discovered more and more particles.



Samuel Ting at Brookhaven National Laboratory



The SPEAR machine at Stanford

It wasn't until 1964 that a theoretical solution emerged. That was the year Murray Gell-Mann and George Zweig proposed that all these new particles were actually made up of different combinations of even smaller, more fundamental particles, dubbed "quarks" after a famous nonsense line in James Joyce's *Finnegan's Wake*. ("Three quarks for Muster Mark!") They speculated about a possible fourth quark, but in 1970, Sheldon Glashow, John Iliopoulos, and Luciano Maiani made a specific prediction for its existence, to explain the absence of an expected particle interaction. This set the stage for the experimental discoveries to come.

At Brookhaven National Laboratory in New York, Samuel Ting was heading up a particle-hunting experiment that involved shooting high-speed protons into a beryllium target to produce showers of new particles, and then using a mix of magnetic fields and detectors to filter out interesting results.

Ting's Chinese parents were visiting Ann Arbor, Michigan when their son was born prematurely, making him a U.S. citizen. They returned to China, but the Japanese invasion interrupted his education. He was largely home schooled until the age of 12, under the watchful eye of his grandmother. At 20, he returned to the U.S. to attend the University of Michigan, completing his Ph.D. in 1962. He became a professor at Columbia University, and then joined the faculty at MIT. His group used the Alternating Gradient Synchrotron (AGS) at Brookhaven for their experiments, since its accelerator could produce higher energies.

Meanwhile, across the country at Stanford University, Burton Richter headed up the team hunting for quarks. Born in 1931 in Queens, New York, Richter began his undergraduate studies at MIT unsure whether he wanted to study physics or chemistry, but soon chose the former. He stayed at MIT for his graduate studies, and eventually ended up in particle physics. After completing his Ph.D., he joined the faculty of Stanford University, where he soon became involved in building an 80-meter diameter accelerator called SPEAR (Stanford Positron Electron Accelerating Ring). Completed in 1973, it was capable of accelerating counter-rotating electron and positron beams up to four billion electron volts.

The accelerator at Brookhaven accelerated protons. But protons are not fundamental particles; electrons are, and Stanford physicists thought they would make for a much better probe. A carousel-like storage ring accelerated a stream of electrons and a stream of positrons in opposite directions and then made them collide to produce showers of new particles from the energy of the collision. The beam was directed to what was basically a scaled-up version of Ernest Rutherford's original scattering experiments, in this case using liquid hydrogen and deuterium as targets.

Over the summer of 1974, both teams independently spotted their prey. Since quarks cannot exist on their own, the discovery came in the form of a meson comprising a charm and anti-charm quark. At SLAC, Richter's team spotted a massive spike (resonance) in the data indicating the presence of a new particle—the charm quark. And it had a much longer lifetime than expected.

Richter and Ting compared notes at a November meeting at SLAC and realized their respective teams had both discovered a fourth flavor of quark. They quickly made a joint announcement, and the two teams published papers a week or so later detailing their respective discoveries. Richter had

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Letters to the editor are welcomed from the membership. Letters must be signed and should include an address and daytime telephone number. APS reserves the right to select and to edit for length and clarity. All correspondence regarding *APS News* should be directed to: Editor, APS News, One Physics Ellipse, College Park, MD 20740-3844, Email: letters@aps.org.

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Education & Diversity Update

Free Professional Skills Seminars for Students

Interested in hosting a communication and negotiation seminar for students next semester? With support from the National Science Foundation, APS has trained 20 women in physics to facilitate professional skills seminars for students and postdocs at your university! Visit **go.aps.org/psdwseminars** to find a facilitator near you.

2018 PhysTEC Conference: Registration is Now Open

The 2018 Physics Teacher Education Coalition (PhysTEC) Conference will take place February 10–11 in College Park, Maryland at the American Center for Physics. The annual conference of PhysTEC is the nation's largest meeting dedicated to the education of future physics teachers, and features panel discussions by national leaders and workshops on best practices, as well as excellent networking opportunities for physics teacher educators. To register please visit: **phystec.org/conferences/2018/**

Register now for the Building a Thriving Undergraduate Physics Program Workshop

The Building a Thriving Undergraduate Physics Program Workshop will be held February 10–11, 2018 in College Park, MD. The goal of the workshop is to assist departments in developing strategies for increasing enrollment of physics majors. Institutions are invited to send teams of two to four faculty members to analyze their department's performance and decide how to take actions that will help them achieve their goals and sustain their progress. Experienced faculty—from departments that have had large increases in their numbers of physics majors—will facilitate workshop activities in small groups and present information on their own experiences through plenaries and case-study talks. The workshop will follow the 2018 PhysTEC Conference. The workshop registration fee is $295, and the PhysTEC Conference fee is discounted for participants attending both the conference and the workshop. To register please visit **phystec.org/conferences/thriving18/**

Travel funding to attend the Next Generation Physics and Everyday Thinking Workshop

In this one-day workshop, learn about the Next Generation Science Standards-based course for prospective elementary teachers using the comprehensive and flexible set of Next Generation Physics and Everyday Thinking (Next Gen PET) materials for students and instructors. Individualized versions of these materials have been prepared for small lab-style (Studio) courses and large (Lecture) courses. A new hybrid implementation that fully supports a general education lecture/lab schedule will also be presented. Travel support is available if you are considering implementing a version of PET at your institution. To register and learn more about the workshop please visit **phystec.org/conferences/pet18/**

CHARMED QUARK continued from page 2

dubbed his the "psi particle, since its decay pattern involved four particles curving in the magnetic field to form something that looked like the Greek letter *psi*. Ting called his the J particle," since that letter resembled the Chinese symbol for his name. They compromised and combined the two, so the charm quark is officially the J/psi particle.

Richter and Ting shared the 1976 Nobel Prize in physics, "for their pioneering work in the discovery of a heavy elementary particle of a new kind." With this discovery, there were now two complete generations of particles: the first—the electron and the up and down quarks; the second—the short-lived muon, charm, and strange quarks.

But nature had a few more surprises in store. Within a few years, SLAC scientists discovered the tau lepton, setting off a search for two more flavors of quark. Fermilab's Tevatron accelerator found the bottom quark by colliding protons with a stationary target at even higher energies, and examining their statistical data for telltale "bumps" indicating the presence of an upsilon (made up of bottom and anti-bottom quarks). They succeeded in 1977. But it would take nearly 20 years for Fermilab's scientists to produce the elusive top quark: that didn't happen until 1995, and it proved much more massive than originally expected—as heavy as a gold nucleus.

As for the charm quark, it continues to surprise scientists. In 2002, Fermilab's SELEX collaboration announced they'd detected a singly charged, doubly charmed particle, made up of a down quark and two charm quarks. The catch: other experiments have since failed to produce any more such particles. And just this year the LHCb detector at the Large Hadron Collider in Switzerland discovered a rare combination of particles: a doubly charged, doubly charmed Xi particle, comprising an up quark and two charm quarks. LHCb's particle also has significantly higher mass than that detected by SELEX. Either one result is wrong—and both analyses were very careful and clean—or it may be that some theoretical tweaking is in order to account for the discrepancy. Who knows what other secrets the charm quark might be hiding?

Profiles in Versatility

Physicists Take Their Skills to the Great Outdoors

By Gabriel Popkin

Topher White adjusts a solar array that powers a cellphone being used as a detector of illegal logging.

If a tree falls in the forest, Topher White will hear it. The one-time physics major has developed a technology to detect chainsaw noise from illegal logging and alert a ranger or law enforcement officer. He now runs a nonprofit, Rainforest Connection, to expand his tree-protecting devices to new places, some of them in the world's most remote and biologically diverse regions.

In 2000, when White headed to Kenyon College, a small liberal-arts school in Ohio, he thought he would major in performing arts. That changed when he discovered the joys of experimental physics in the college's intimate, hands-on lab courses. Rebuilding the campus radio station with scavenged parts also helped instill a healthy hacker spirit.

After graduating, White returned home and cycled through a series of short-term gigs before landing a communications job at the International Tokamak Experimental Reactor (ITER) in France. He found the mission inspiring, but his DIY instincts and desire to address urgent problems such as climate change ran up against the inevitable bureaucracy of a complex multinational project.

Inspiration and restlessness struck when, on a vacation in 2011, White visited a gibbon reserve on the Indonesian island of Sumatra. Just a few minutes' walk from where he was staying, he came across a group of men sawing up a tree; the loggers had apparently evaded several park rangers. White realized that chainsaws produce a fundamental frequency around 110 hertz and higher harmonics that can be distinguished from the forest's background noise—mostly higher-pitched songs of birds and sounds of other animals. He returned home and programmed a cellphone to send an alert when it detected a chainsaw's telltale frequency.

The hardest challenge turned out to be keeping the phones powered up far from electrical outlets—standard solar panels don't work well in dense forest. So White developed a customized solar array optimized to harvest this sporadic light. The solar panel is folded into a backpack, and strapped to a tree where it can power a phone monitoring up to several square kilometers. White took his invention to the reserve in May 2012, and within a few days, the device picked up a nearby signal.

White and the reserve owner hiked over the hill and encoun-

OUTDOORS continued on page 6

Gravitational-Wave Observatories Open New Era in Astronomy

By David Voss

Following closely the announcement of the 2017 Nobel Prize in Physics, the LIGO and Virgo collaborations reported on October 16 in *Physical Review Letters* that they have detected the coalescence of two neutron stars—objects of lower mass and much different in character from the black holes in the previously observed mergers.

Moreover, reports from about 70 ground- and space-based observatories confirm that a variety of electromagnetic signals—from gamma rays to radio waves—was detected as well. Papers on these observations were published in *Astrophysical Journal Letters*, *Nature*, *Nature Astronomy*, and *Science*.

Armed with this range of gravitational-wave and electromagnetic data, the research teams were able to confirm the origin of short gamma-ray bursts, long suspected to be the result of neutron-star mergers. The results also show nucleosynthesis in action, in particular the creation of elements heavier than iron, such as gold and platinum.

The gravitational-wave signal, denoted GW170817, was first observed by LIGO and Virgo on August 17. Researchers concluded that the inspiraling objects were in the range of 1.1 to 1.6 times the mass of the Sun, and thus were unlikely to be black holes. This mass range corresponds to that of neutron stars, typically formed in the aftermath of supernova explosions. The data indicated that the neutron-star merger took place some 130 million light years from Earth.

Black-hole mergers are expected to produce no electromagnetic signals, as photons produced could not escape the gravity of one black hole, let alone two. Neutron-star collisions, however, could yield bright flashes across the electromagnetic spectrum. And indeed, a gamma-ray burst was detected by NASA's Fermi spacecraft and confirmed by the European Space Agency's INTEGRAL space-borne detectors.

The coordinates for the origin of the signal corroborated those

NEW ERA continued on page 7

APS Senior Physicists Gather for Anniversary

By Richard Strombotne

On October 18, the Mid-Atlantic Senior Physicists Group (MASPG) celebrated the 20th anniversary of its founding. As MASPG's founder, I presided over the celebration, which included servings of a sheet cake with lettering: "APS/MASPG 20 years!"

In September 1997, Judy Franz, former Executive Officer of APS, and I moderated a brainstorming session with about 50 physicists that lasted two hours. The session generated a long list of ideas in response to the question of what would an organization of retired (or senior) physicists do? What issues would it consider? After the brainstorming session we enlisted eight or ten of the participants to meet as an informal planning group in October 1997.

Since that initial meeting the Planning Group has arranged talks and tours, and it continues to make plans for the MASPG's future events. It is an informal group that is open to any interested party. In practice, about ten people have consistently participated. It meets on the first Wednesday of the month at 1:00 pm in the fourth floor conference room at the American Center for Physics, College Park, Maryland.

To help celebrate the group's 20th anniversary, on October 18, Jonathan Keohane of Hampden-Sydney College spoke to the MASPG on the physics and history of magnetism. On November 15, Stephen Jefferts (NIST Boulder) will discuss the history of atomic clocks, time and frequency. John Mather (NASA/GSFC) will provide an update on the James Webb Space Telescope project on December 20. The MASPG-sponsored talks are typically held on the third Wednesday of the month (except in July or August) at the American Center for Physics.

Over the past 20 years the MASPG has hosted almost 200 talks on a wide range of topics in physics and related sciences. A few examples of topics and speakers are: "Studying Superfluidity with Ultracold Atoms" by Gretchen Campbell, "Neutrons at N.I.S.T." by Dan Neuman, "Why do Black Holes Shine?" by Christopher Reynolds, "Coevolution of the Geosphere and Biosphere" by Robert Hazen, and "Global Warming 56 Million Years Ago" by Scott Wing. The web site at aps.org/units/maspg has an extensive list of past talks and includes copies of many presentations.

The MASPG has also sponsored tours of science facilities in August. They have included a trip to the National Radio Telescope at Greenbank, WV, a visit to the Radio and Television Museum in Bowie, MD, and a tour of the NIST Center for Neutron Research in Gaithersburg, MD to cite just a few.

APS has supported the MASPG since its founding by providing facilities for meetings and talks, maintaining the website and membership list, and sending announcements of talks and other events. The MASPG is very grateful for this support. To receive announcements of future talks and other events sponsored by the MASPG, you may contact the APS Membership Department at membership@aps.org or 301-209-3280 to add your name to the mailing list.

The author earned his B.A. from Pomona College, followed by an M.A. and Ph.D. from University of California, Berkeley. Following his doctorate he worked at the National Bureau of Standards (as it was named then) in Boulder, Colorado, and then at the U.S. Department of Transportation until his retirement in 1996. He has chaired the MASPG since its founding in 1997.

The Mid Atlantic Senior Physicists Group celebrates its 20th year.

WIP continued from page 1

In the UK, the obstacles to women are less overt but nonetheless present, as evidenced by how few women elect to study physics in high school. Jessica Rowson from the Institute of Physics (IOP) described one successful program that aims to better balance the number of boys and girls who pursue physics. Rowson pointed to interviews with young girls that have shown they are put off from studying physics because it's not a "girly" thing to do or because it's seen as leading to "boy jobs." The IOP program tries to combat such biases by educating students and teachers and encouraging them to change damaging habits. "The problem isn't with physics or girls, it's with schools," said Rowson. "Boys and girls have very different experiences in the classroom."

Rowson explained that boys are more likely to raise their hands and call out answers to questions, and they are quicker to volunteer to take part in a demonstration or to monopolize lab equipment. To keep girls more engaged, the IOP program coaches teachers to, for example, select students at random (instead of asking for volunteers) and to assign equipment to individuals. The program also educates students and teachers about the potential impact of biases and stereotyping in the language they use or the role models they champion. "Gender stereotyping is negative for both sexes," said Rowson.

From 2014 to 2016, IOP piloted the program in six schools across the UK. The headline result was a tripling in the number of girls who opted to take A-level physics, the UK's course for 16- to 18-year-olds. And teachers reported that the girls in their classes had, in general, become more involved and interested in science lessons.

The conference highlighted many other wins for women around the world. In the Netherlands, for example, a program that gives grants exclusively to women for postdoctoral research found that 35 of 39 awardees remain in academia—a much higher-than-average rate. And in Nigeria, a mentorship program that uses social media to link schoolgirls interested in science with established female physicists has helped to break down the perception that science is done by men. This initiative and other programs have led to a slow but steady increase in the number of women studying physics in Nigeria over the last five years.

"It's important to realize that many of the struggles that [women] have are the same, regardless of culture," said Nicola Wilkin, a professor at the University of Birmingham and the conference's main organizer. "By comparing notes we can learn from each other's mistakes and successes."

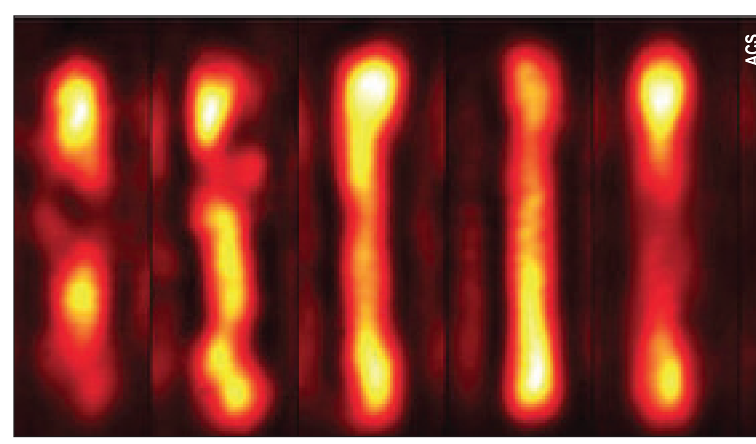
"Society needs physics and above all it needs physicists," said Julia Higgins from Imperial College London, who is one of the UK's most prominent polymer physicists and the next president of the IOP. "We can't afford to leave half of the population out."

The author is an Associate Editor of Physical Review Letters *and a Contributing Editor of* Physics*, from which this article was reprinted.*

RESEARCH continued from page 1

Zero-Index Waveguide

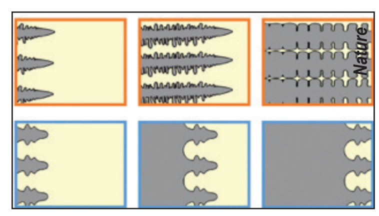
Researchers have now created an optical waveguide with a refractive index of zero, a situation that can lead to exotic types of energy transfer and quantum-optical effects. Conventional bulk materials have a refractive index of greater than one at optical wavelengths, and this is the basis for a vast range of applications in imaging. Nanostructured metamaterials, however, can be made to exhibit zero permeability, zero permittivity, or both, all of which give an effective refractive index of zero. Reshef et al. report in *ACS Photonics* (DOI: 10.1021/acsphotonics.7b00760) the direct observation of zero index in a nanostructured silicon waveguide at a technologically important wavelength (1625 nm). The researchers feed infrared light into both ends of the waveguide to create a standing wave. They then vary the input wavelength until the standing wave diverges and spans the length of the waveguide—the signal of a vanishing index. Under these conditions, optical power can flow at finite group velocity and with lower propagation loss, which could be useful in optical devices.



At zero refractive index, the electric field extends across an entire waveguide (middle).

Metal 3D Printing Gets Out of a Jam with Nanoparticles

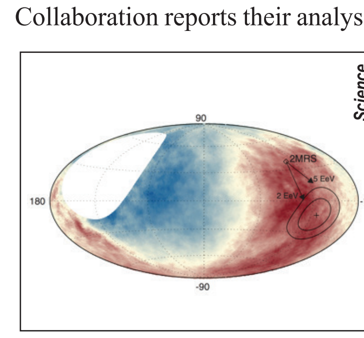
Although better known for making plastic parts, 3D printing can also be used to fabricate metal objects. And now—thanks to a newly developed technique employing nanoparticles—the list of metal alloys compatible with this highly customizable technique has grown dramatically. Metal-based 3D printing, or what's called metal-additive manufacturing, works differently than the more familiar plastic-based 3D printing. Rather than building layer after layer with small beads of melted material, the traditional metal-based technique involves depositing a layer of metal powder and then applying heat locally with a laser or electron beam to essentially weld the desired object from the ground up. Unfortunately, most of the commonly used metal alloys develop cracks during the 3D printing process. Martin et al. have discovered that adding nanoparticles to the powder feedstock can prevent cracking. The nanoparticles act as nucleation seeds that drive a more uniform grain growth. Writing in *Nature* (DOI: 10.1038/nature23894), the team demonstrated the technique with two high-strength aluminum alloys. The resulting components were twice as strong as other components that were 3D-printed without nanoparticles. The authors claim the method should extend to other alloys, such as nickel-based alloys and superalloys.



Better materials through nanotech.

Cosmic Rays from Beyond

A large international team has discovered a significant anisotropy in the arrival directions of ultra-high-energy cosmic rays, confirming that they come from a source outside our Galaxy. First detected in 1912, cosmic rays are atomic nuclei that generate showers of particles as they smash into Earth's atmosphere. Determining the origin of these cosmic visitors is complicated by magnetic field deflections that randomize their paths. But with the latest generation of detectors—such as the Pierre Auger Observatory, with 1600 tanks of ultrapure water that detect Cherenkov light from the particle showers—any slight anisotropy should be observable. In a paper in *Science* (DOI: 10.1126/science.aan4338), the Pierre Auger Collaboration reports their analysis of data taken from 2004 through 2016, covering 85% of the sky. The researchers found that for energies higher than 8 x 10^{18} electronvolts, there is about a 6.5% excess of cosmic-ray particles arriving from a particular direction. That direction is away from the galactic plane, indicating a source outside the Milky Way. Moreover, they report a tentative correlation between the direction of the excess and the location of a group of known galaxies; if the correspondence holds, we might learn even more about these alien particles.



Cosmic-ray hotspot

News from the APS Office of Public Affairs

APS Members Help Sway funding for STEM Education Bill

By Tawanda W. Johnson

After APS members made the case for STEM education funding in the Every Student Succeeds Act (ESSA), a U.S. Senate appropriations subcommittee voted to restore funding to the legislation.

The Trump Administration initially zeroed out funding in the president's fiscal year 2018 budget for ESSA Title II, which states can use to support teacher preparation and quality programs such as PhysTEC and UTeach. The U.S. House followed suit. But the Senate recently did the opposite, agreeing to fund Title II at $2.1 billion, the same as the amount in fiscal year 2017.

The House and Senate must now agree on a final number for fiscal year 2018, which began October 1. Federal programs for the current fiscal year are being funded by a stopgap budgetary measure—known as a continuing resolution—until December 8.

"We are another step closer to seeing funding secured for Title II in ESSA, and we owe this success to the tremendous effort APS members put into this endeavor, which is crucial to training STEM teachers and preparing the next generation of students for the field," said Francis Slakey, Director of APS Office of Public Affairs (OPA).

The effort to persuade Congress to fund ESSA began in May: in an op-ed published in the *St. Louis Dispatch*, APS member Karen King urged Sen. Roy Blunt of Missouri to support the bill. Blunt is chairman of the Senate Appropriations Subcommittee of Labor, Health & Human Services, Education, and Related Agencies. In his role, he oversees messaging for all Senate Republicans; thus, his fellow lawmakers are likely to follow his lead.

King, an assistant professor in the Department of Physics and Astronomy at the University of Missouri, wrote in her op-ed: "President Donald Trump's fiscal year 2018 budget cuts to STEM education would gut the nation's ability to train high-quality science teachers, thereby limiting young Americans' opportunities in STEM careers and putting the nation's global competitiveness at risk."

Blunt quickly responded to her piece, writing in a letter to the paper, "I have serious concerns with some of the cuts included in the president's budget."

Members of the APS Forum on Education amplified the message with an email campaign. Working with APS OPA, King arranged for a meeting with Blunt's staff in Missouri to amplify crucial points in her op-ed. That meeting went well and was followed

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Eric Brewe of Drexel University and APS President Laura Greene visit Capitol Hill to advocate for STEM education.

From Laser Explosions to Feynman Diagrams: Science Comics at Comic-Con

By Eran Moore Rea

APS Head of Outreach Rebecca Thompson participating at the 2017 Comic-Con panel on the advantages of comic books for teaching.

Walk through the exhibit hall at the 2017 Comic-Con International in San Diego, California, and among the 130,000 attendees, you might bump into Wonder Woman, Rick & Morty, or Batman. And along with other small press publishers, you'll find a booth dedicated to the APS comics series *Spectra* and her adventures as a middle-school physics superhero. Written by APS Head of Outreach Rebecca Thompson and illustrated by different artists, *Spectra* first came to Comic-Con in 2010.

This year APS debuted the ninth issue of *Spectra,* titled "Sonic Surprise." But science comics are catching on, and at the 2017 Comic Con, *Spectra* had company.

"I thought I might as well email Brad Pitt."

In 1997, while working on his doctorate in robotics at Stanford, Jorge Cham created the comic *Piled Higher and Deeper* (PhD), a satire on graduate study in physics. Eventually, after a few years as a lecturer and research associate at Caltech, Cham decided to go into comics full-time, creating two feature-length movies and several lecture series.

Then, in 2008, Daniel Whiteson, an experimental particle physicist from the University of California, Irvine, emailed Cham about the possibility of collaborating on science comics for physics outreach.

After Whiteson read a comic by Scott Cloud about the development of Google's Chrome browser, he realized the potential of comics as a medium. "I'm not interested in browser development at all, but with this comic I could understand why they did it," he explained." I was impressed that they could cover a dry dusty topic so well in a comic. So, I thought, if they could do that for browsers, we could definitely do it for something sexy, like the Higgs boson."

After trying his hand at creating comics himself, Whiteson realized he needed to collaborate with an experienced comics artist. "My wife said, why not email Jorge Cham? … I thought I might as well email Brad Pitt and ask him to do a movie about me," Whiteson said. But, "it turns out Jorge does answer his email!"

The two ended up collaborating on two animated videos for the *PhD Comics* website: one about dark matter and another about the discovery of the Higgs boson in 2012.

This spring, Cham and Whiteson co-authored an illustrated book, *We Have No Idea,* focusing on open questions in physics. "Approaching physics from the point of view of what we *don't* know, looking for where exactly is the edge of knowledge, that really helps each chapter move forward," Cham said.

Cham also felt that his 20 years of experience writing *PhD Comics* impacted the way he co-wrote the book. "In our writing, I think there's a certain amount of casualness and irreverence [about science]," Cham said. "I think a lot of science books out there approach the topic with a lot of reverence and 'oh, the cosmos, and oh *matter,* oh the universe' ... as in, this is what we know and you should just appreciate what we know." Whereas Cham sees that "you don't have to approach science so seriously."

As for Whiteson, he connects the efficacy of science comics with the practice of physics itself. "We already use an idea that's like comics in physics, the Feynman diagram," Whiteson said. "Sometimes an explanation with a doodle is much more precise, much more persuasive than just an equation." When he explains concepts to his students, Whiteson said, he can't do it without doodling a little comic to help students visualize what he's saying.

Whiteson emphasized the importance of collaboration with a creative professional.

"Not all scientists are excellent communicators, and many don't have artistic skills like Jorge [has]. So we can really benefit from finding people in the artistic community to collaborate and work with," Whiteson said. "I think there might also be other venues and other creative media that we could tap into, not just comics."

Before his first comic collaboration with Cham (the *Dark Matter* comic/video) went live, Whiteson was very nervous about the potential response from the scientific community.

"Any time you are explaining science to the general public, you're going to have make some simplifications … To my surprise, we got overwhelmingly positive feedback … other physicists were happy to have [their] work described by Jorge … it was like, "we have our moment in the sun!""

Comic books vs. textbooks: how to share physics with kids.

While *PhD Comics* tackles the graduate world, many science comics are targeted at K-12 audiences—and specifically, middle school readers. One Comic-Con panel discussed the advantages of comic books over traditional text-based ways of learning. Panelist Rebecca Thompson from APS narrowed down some of her specific experiences writing the *Spectra* comics.

"In *Spectra* 6, Spectra battles the Quantum Mechanic. So, it was a lot of figuring out what introductory quantum mechanics I wanted to present, how I could present it, and how I was going to do so in a way with the least pushback from other physicists," Thompson said.

"Because that is one of the huge barriers," Thompson said. As a Ph.D. physicist herself, she described how she sometimes needs to train other scientists that, in science communication "There *is* such a thing as *good enough*. If we go back to the dawn of time and get everything exactly right and make sure we're explaining it to the point that [some physicists] want, *nobody's* going to listen."

Thompson explained that sometimes scientific communicators are asked to add more scientific depth to an explanation by adding just one word or one equation to a more

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tered several men with chainsaws nonchalantly taking a smoking break. It turned out they actually knew the reserve owner, and after explaining how they conducted their illicit activity, they promised not to come back.

White had by this time moved back to San Francisco to join a tech startup, but the opportunity to help stop illegal logging, a global scourge that releases billions of tons of carbons annually, proved more enticing. So White quit his job, pulled in $167,000 on the crowdsourcing platform Kickstarter, and launched Rainforest Connection. The nonprofit now has seven full-time employees and an army of volunteers, and operates in Cameroon, Ecuador, Peru, Nicaragua, Romania, and Brazil. In total, Rainforest Connection has 48 devices deployed, monitoring more than 1,500 square kilometers of forest.

White hopes that's just the beginning. Thanks to the rapid global spread of smartphones and cell service to even remote areas, he thinks he's just two-to-three years away from his goal. "The software itself should be the magical part; the hardware I want to be more-or-less throw-away," he says. "I want to make automated conservation as easy as downloading an app."

Wiring the woods for science

Andrew Nottingham's last few years as a postdoc involved wiring up electronics and sensors to generate and collect data. When a shoddy soldering job blew up part of his experiment, he spent nearly a year rebuilding it.

It sounds like life in a typical physics lab, and indeed Nottingham drew heavily on his physics education at Nottingham Trent University (no relation) in the UK. But his "lab" is Barro Colorado Island, a research facility of the Smithsonian Tropical Research Institute in Panama and perhaps the world's best-studied tropical rainforest.

Nottingham wants to know what happens when tropical forest soil is artificially warmed. It's an experiment with big implications. Soils hold vast amounts of carbon, and scientists believe that more and more of this carbon will escape to the atmosphere as the climate warms, further accelerating climate change. But all experiments to date have been done in temperate or boreal regions. A single result from the tropics could go a long way toward making climate models' predictions more precise.

Nottingham's path to soil research pioneer was far from linear. "I had an adolescent, romanticized notion of wanting to know how the world works, and physics always seemed like the purest description of nature," he says. He entered college interested in theoretical questions, but a research project near the end of his undergraduate years showed how applied physical science could help address environmental problems.

Inspired, he enrolled in an environmental science master's program tailored for quantitative scientists. His physics background gave him the tools and the confidence he needed to dive into unfamiliar subjects such as evolution, Nottingham says. "I felt like my background in physics had given me the capacity to go into something blindly and learn about it."

For his Ph.D. work at the University of Cambridge, he studied how bacteria affect carbon movement through tropical forest soils. That led to his current position, split between the Smithsonian and the University of Edinburgh in Scotland, where he focuses on his soil-warming experiment. If tropical soils, which contain around a third of global soil carbon, do the same, it could dramatically accelerate climate change.

Nottingham finally switched on his experiment in November 2016. Since then, much to his relief, he's been able to transition from engineering to research mode, and he hopes to have results within a year. "We have floods of data, it's now a deluge," he says. "Having invested so much time in building this experiment, it's become exciting, seeing returns on my investment."

Making sense of Darwin's entangled bank

The final paragraph of Charles Darwin's *Origin of Species* famously begins: "It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us."

More than 150 years after Darwin published his magnum opus, however, far-reaching quantitative explanations of how ecosystems are structured and species coexist remain elusive. Annette Ostling, a professor in the University of Michigan's Department of Ecology and Evolutionary Biology, hopes to change that.

Ostling grew up enjoying math and physics, but when she showed up at Columbia University as an undergraduate, she thought she wanted to be a doctor. Still, she took calculus-based physics in her first year—a fortuitous decision. "After the first exam, one of my friends in the class turned around and told me, did you notice you're the only woman in the class?'" she recalls. "That was a little motivation to stick with it and choose it as a major."

Ostling then went to the University of Illinois at Urbana-Champaign for a physics master's degree. But it was her Ph.D. work with John Harte, a physicist-turned-ecologist at the University of California, Berkeley that truly inspired her. Working with Harte gave Ostling an opportunity to apply her quantitative skills to data from the natural world. "He was a fabulous advisor," she says. "That was a key thing that made the switch successful into a different field."

Ostling soon discovered that most ecologists take a different scientific approach from that typically used by physicists. Whereas physicists tend to seek general principles, ecologists have largely built their discipline around studies of specific ecosystems and species interactions. Harte is one of the few physicists who has attempted to bridge this gap, using statistical physics and information theory to predict how many competing species can live together in a given environment.

Ostling has taken up a similar challenge, focusing on putting leading ecological theories of biodiversity on a more quantitative footing. One leading ecological theory is known as niche theory—essentially, that species specialize in ways that gives them micro-advantages. More recently, an alternative, neutral theory, has gained in stature; it argues that biodiversity results from random environmental fluctuations that maintain a balance among species in an ecosystem.

Ostling believes that perhaps neutral theory sets the overall ecological stage, and niche theory can explain finer details of species' ability to coexist in particular environments. But whereas physicists can quickly generate massive quantities of data in experiments, ecologists seeking a similar level of statistical certainty often need to painstakingly measure ecosystems for years or decades—which can stretch the patience of funders and thesis committees.

This has brought Ostling to the forest—specifically, the rainforest of Barro Colorado Island, where Nottingham does his soil studies. In a different part of the forest, researchers have measured the diameter and height of every tree in a 50-hectare (almost 125-acre) plot every five years since 1980, creating an exceptionally long and complete dataset. Ostling is now using these data to test predictions, though she notes that her theories are not forest specific, and could apply to other ecosystems.

In this technological, numerical age, physics-trained scientists with an interest in the natural world will find plenty of opportunities in ecology, Ostling says. "I think it is becoming increasingly quantitative, mostly for the good," she says. "There are a lot of things that we don't understand in ecology yet, and mathematical approaches, including some from physics, can be really useful for figuring it out."

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Caltech, expected by many to share the honors, passed away in March 2017; under the terms of the Nobel Foundation, deceased persons cannot receive the prize.

LIGO employs two of the most sensitive instruments ever built: a pair of laser interferometers with four-kilometer-long arms that can detect a change in length about one-ten-thousandth the diameter of a proton. Gravitational waves from distant cataclysmic events propagate as compressions and expansions of spacetime. These waves slightly jiggle the interferometers, one in Hanford, Washington, and the other in Livingston, Louisiana, and LIGO first observed this disturbance on September 14, 2015.

"LIGO is among the grand physics experiments that rely on the struggle and perseverance of thousands of scientists, engineers, technicians, and staff," said APS President Laura Greene. "In a very real way, this prize belongs to the many people who have contributed immeasurable efforts to design, build, and commission one of the wonders of contemporary physics. A project of this scale must begin with extraordinary visionaries like Kip Thorne and Rainer Weiss who, over forty years ago, were bold enough to sketch out interferometers of a magnitude that was almost unbelievable at the time. A great vision, however, requires equally great leadership to achieve. Since 1994, Barry Barish has been instrumental in directing the construction of the LIGO facilities and establishing the LIGO Scientific Collaboration. These three physicists, along with a multitude of collaborators and supporters, have created a truly amazing device that allows us to see the universe in a whole new way."

Since the initial discovery, LIGO has detected three additional events involving black hole mergers. Most recently, the Virgo Collaboration, which participated in analyzing data during the initial discovery, brought online its laser interferometer in Italy. In August 2017, a simultaneous detection of a black-hole merger by Virgo and the two LIGO detectors allowed researchers to narrow the location of the source of those gravitational waves.

"The measurement of gravitational waves represents science at its best," added APS President-Elect Roger Falcone of the University of California, Berkeley. "Compelling theory, explicit predictions, clever experimental techniques, brilliant ideas from individual scientists, thoughtful management, and perseverance by an international team and a government agency dedicated to funding basic science. It's a wonderful and inspiring story."

All three winners are Fellows of APS. Barry Barish served as APS President in 2011.Weiss received the APS Einstein Prize in 2007 and Thorne was awarded the APS Julius Edgar Lilienfeld Prize in 1996.

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by a meeting with OPA staff and Blunt's office in D.C. The effort then expanded to include several meetings on Capitol Hill featuring APS leaders, including Laura Greene, president; Roger Falcone, president-elect; and Eric Brewe, Education Policy Committee chairman.

"I made two visits to Capitol Hill with APS President Laura Greene and Greg Mack [APS government relations specialist] to advocate for both the House and Senate to include funding that can be used for professional development for teachers through programs like PhysTEC, Modeling Workshop Project, and UTeach," said Brewe, a physics education researcher at Drexel University.

He added, "Legislative teams for all of the (congressional) members were receptive to the message of supporting teachers, and many were surprised to find a scientific professional society advocating for this position. From my perspective, it is important for APS members to also meet staffers in person. It felt like the legislative staff cared about the message beyond what you can achieve with a letter or phone call alone."

Mack said the effort to boost funding for Title II in ESSA has been working out well. "This concerted undertaking involving the APS president, president-elect, and Education Policy Committee chair really shows the commitment the Society has for education," he said. He continued, "Our efforts in the Senate have paid off, and our meetings with House offices are crucial as the senators and representatives negotiate what the final funding levels will be. I have to admit, hearing congressional staffers react positively to the APS leadership gives me hope that the House will do the right thing and agree with the Senate."

APS remains concerned about ESSA funding for fiscal year 2019 as well, but hopes the Trump Administration will support STEM efforts. In fact, the President recently signed a memorandum aimed at making STEM education a bigger priority for the country. His directive calls for the Department of Education to annually fund $200 million in grants toward STEM education and training for students in kindergarten through 12th grade.

The author is Press Secretary in the APS Office of Public Affairs.

COMIC CON continued on page 5

basic explanation.

"One of the problems I've run into—and I think a lot of science communicators run into—is that sometimes, adding one word can be *hugely* detrimental … Teaching other scientists that the more important thing is how it's perceived, not how it's said, is very difficult … when you use words like "theory" or "98% agreement," when you start hedging in the way you need to in science, all of the sudden the public's experience is *totally* different than what you're trying to put out there," Thompson said.

When physicists use "theory" or "98% agreement," they are using technical language that reflects instrumental and mathematical limits and categorization. But "theory" and even "percentage agreement" are also non-technical terms used in everyday conversation that can mean something closer to "guess"or even "gossip."

Because *Spectra* comics are specifically written for middle-schoolers, she finds that if she gives a copy of a comic to a scientist's child, "what happens is that this kid will just randomly, very intelligently start explaining how a laser works to their parents," Thompson said. "That's been effective, because when it comes from kids … it's easier to see that this kid has more knowledge [from the *Spectra* comic] than they [had before]," Thompson said.

There's science in the images.

APS isn't the only organization creating science comics for middle-schoolers; as K-12 libraries add more and more graphic novels to their collections, the market for science comics for education has grown.

Science Comics is a series by First Second Books, a graphic novel publisher at Macmillan Inc. The series began in 2016 with three educational/entertainment graphic novels each about 100 pages in length—*Dinosaurs, Coral Reefs,* and *Volcanoes*. In May 2017, *Science Comics* landed on physics and engineering with a novel covering the history of flight, *Flying Machines.*

Author Alison Wilgus worked with a team to writer the book; A film-and-television NYU graduate, Wilgus worked in animation for Cartoon Network and other channels while creating her own web-comics and science fiction.

By Wilgus's count, she ended up explaining in the book at least several concepts to do with physics, including why and how an airplane's wing needs to be curved to provide lift, and how a propeller works.

She says that she did an enormous amount of research for the project, but not having preconceptions was a benefit. "The less I knew about something, the less likely I was to get confused and accidentally incorporate bad information," Wilgus said. She also emphasized the importance of using as simple language as possible. At one point, she said, she had used the word "parabolic" to describe a plane's arc, and she and First Second's fact-checker realized she should just say "curved" because, as Wilgus said, "parabolic describes a very specific thing."

Wilgus said during the panel that people who criticize science comics tend to concentrate on the word bubbles and ignore the illustrations. I think a lot of people who are doing comics criticism are book people," Wilgus said during the panel, "and they just read the word balloons [in science comics] and barely look at the images, but not everybody reads comics that way, especially young people."

"Instead," Wilgus said, "young people look really hard at the images. And, in a lot of science/technology comics especially there's an enormous amount of information, aggressively researched information, in those images … information that would take a long time to try to explain [with just words]. [The images provide] more context for the words on the page and all these things co-operate with each other to provide a fuller picture."

The author is a freelance writer in Minneapolis, Minnesota.

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from the LIGO/Virgo data. Soon, follow-up observations by other telescopes revealed emissions at various wavelengths. These results helped identify the merger as located in galaxy NGC 4993 in the Hydra Constellation.

"This detection opens the window of a long-awaited 'multi-messenger' astronomy," said Caltech's David H. Reitze, executive director of the LIGO Laboratory, in a press statement. "It's the first time that we've observed a cataclysmic astrophysical event in both gravitational waves and electromagnetic waves—our cosmic messengers. Gravitational-wave astronomy offers new opportunities to understand the properties of neutron stars in ways that just can't be achieved with electromagnetic astronomy alone."

Additional information:

The Viewpoint "Neutron Star Merger Seen and Heard" (physics.aps.org/articles/v10/114) contains further information and a link to the paper in *Physical Review Letters*.

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me. My sincere gratitude also goes to a special man Orso Meneghini at GA and his kind wife Luz. He believed in me, and provided everything during my adventure so that I stayed focused on my specific objectives. I would also like to thank my fiancée, Ashley for all of her love and support.

During this journey, I have drawn strength from thinking about my continent of Africa, ravaged by war and poverty, thinking about Cameroon, where the majority of the people cannot have a daily meal. Where single and poor women like my mother are crying and do not see any light at the end of the tunnel. I also draw my strength from my older brother, Ivan, engaged in a war against the Boko Haram terrorist group in the north of Cameroon. I call him every night to make sure he is alive.

Participating in the 59th APS Division of Plasma Physics meeting this year, as the first Cameroonian, still feels surreal to me. I am deeply honored and happy to be the first, and my mission is to make sure I won't be the last.

As a matter of fact, my ultimate goal in life is to return to Cameroon, and teach the younger generations, as a physics professor. Using the knowledge and experience acquired, I would like to bring hope to youth all over the world. It is possible to start from Bafoussam, and be part of APS—one of the biggest physics organizations in the world.

The Back Page

Dr. Zwicker Goes to Trenton

By Andrew Zwicker

A lot can change in a couple of years. Not so long ago, my main concern about politics and public policy was how much R&D money would be in President Obama's budget. This year, I found myself marching in the street dismayed by proposed budgets that would lead to unprecedented cuts of federal funding for science and witnessing incomprehensible attacks from within our government on the scientific process itself.

As I write this, I'm running for re-election to a second term in the New Jersey Legislature, a body to which I am the only physicist ever elected. It has been quite a journey for someone whose "day job" is at the Princeton Plasma Physics Lab, where I started out as a postdoc performing fusion-energy research.

When people hear about my two lives, it strikes them as Jekyll- and Hyde-like. How could someone grounded in fact- and evidence-based research find the world of political spin and issue-avoidance the least bit comfortable? But that's the point. It's not about comfort; it's about bringing a scientific approach to decisions that affect every aspect of our lives.

Carl Sagan once wrote, "In science it often happens that scientists say,'You know tha's a really good argument; my position is mistaken,' and then they would actually change their minds and you never hear that old view from them again. They really do it. It doesn't happen as often as it should, because scientists are human and change is sometimes painful. But it happens every day. I cannot recall the last time something like that happened in politics ..."

"How could someone grounded in fact and evidence-based research find the world of political spin and issue-avoidance the least bit comfortable?"

As scientists we are, by nature and training, perpetually skeptical yet constantly open to new ideas. We are guided by data, by facts, by evidence to make decisions and eventually come to a conclusion that we immediately question. We strive to understand the "big picture," and we understand the limitations of our conclusions and predictions. Imagine how different the political process would be if everyone in office took a data-driven, scientific approach to creating legislation instead of one based on who can make the best argument for a particular version of the "facts."

I live in a state with a rich history of innovation. New Jersey has been home to Thomas Edison and the light bulb, Bell Labs and the transistor; 14 of the 20 largest pharmaceutical companies have significant operations here. We have the highest density of scientists and engineers in the country, one of the finest K-12 public education systems in the country, and great research universities.

But we also have a governor who pulled us out of the Regional Greenhouse Gas Initiative, claiming that the then-ten-state compact's cap-and-trade approach to reducing harmful carbon emissions is "gimmicky" even though it had resulted in nearly $30M towards 12 large-scale energy efficiency and renewable energy projects within NJ.

From my perspective, we have key members of Congress and the Administration with an anti-science attitude, with the result that meeting important scientific challenges has become the spark for political battles, with one group on the side of truth and legitimate inquiry and the other not only living in abject denial, but wanting that studied ignorance to be the basis of crucial policy decisions. There are many deeply troubling examples to choose from, whether it is bringing a snowball onto the floor of the U.S. Senate to "debunk" climate science in 2015 or announcing that climate scientists from the Environmental Protection Agency scheduled to speak at a conference on the "State of Narragansett Bay and Its Watershed" are forbidden from presenting their scientific work.

Many of our political leaders on both sides of the aisle have lost their ability to understand that federal investment in research is a key driver of our "innovation economy" and creates thousands of jobs while keeping the U.S. as a world leader in important discoveries in medicine, renewable energy, advanced manufacturing, and more.

Instead, we are now in a moment of history where we have to stand up and say "I believe in science," even though we all know, as Neil deGrasse Tyson has said, "The good thing about science is that it is true whether or not you believe in it."

What is going on?

Well, I can tell you for sure that the problem *isn't* that there are too many scientists in politics.

One thing to note is the background of our elected leaders. The number of members of Congress who identify their professions as lawyers, business people, or career politicians is at an all-time high. There are a handful of physicians, a few engineers and just one physicist, Rep. Bill Foster of Illinois.

Should we elect only scientists? Of course not. But one way to get beyond today's unproductively stalled state of affairs is to have more scientists and more critical thinkers in all levels of government—and in positions where their actions affect government.

Given that background, in 2014 I decided to do more than just think about these issues or complain about the deterioration of rational decision-making. As it turns out, I not only lived in the district of Rush Holt who, before he became the CEO of the American Association for the Advancement of Science, was the second physicist elected to Congress (Vern Ehlers of Michigan was the first), but I also work at the same lab as he did. I decided to run in the Democratic primary to succeed him, against three people with extensive political experience, even though I have never held public office.

"Congressional seats open up rarely and the opportunity to run for one, regardless of the odds, is even more rare. So it was now or never."

This was not an easy decision. First, there was the consideration that running for political office is a full-time job and I would have to take a leave of absence from work. For many of us, our research is all-consuming and time-sensitive; stepping away is difficult. There was also the personal decision of entering a field that has a rather poor reputation and would involve not only an enormous amount of time, but also significant stress. Did I really want to be scrutinized, judged, and spend day and night campaigning?

After many discussions with my family and scientists who have both held office or run unsuccessfully for office the message was clear—Congressional seats open up rarely, and the opportunity to run for one, regardless of the odds, is even more rare. So it was now or never.

I didn't win, but it was a wonderful experience that led to my candidacy for the New Jersey General Assembly the next year. Running for a legislative seat is about knocking on doors, showing up at Rotary Club meetings, church suppers, 5K charity races, and just about any other place where people gather. It's about shaking hands, letting people look you in the eye, and sharing your thoughts in the few minutes allotted.

In other words, it's a far cry from the lab. And I love it. You might think the more one immerses oneself in politics the more disillusionment would grow. But it was just the opposite. I came into contact with so many people—suburban homeowners and parents, recent immigrants, students going to college at night and working by day—who want to work hard, do what's right, and get their piece of the American Dream in the process. They don't think that should be too much to ask, and neither do I. Hearing their concerns, and trying to figure out ways to make their lives more secure was anything but disillusioning.

I can honestly say the campaign was (mostly) enjoyable, surprisingly stressful, and incredibly rewarding (earning my Ph.D. was easier). I met people I never would have met otherwise and talked about issues that they cared about—taxes, health care, gun control, job creation, the environment, and more. I tried to stay true to the scientific approach at all times. That stood out in the political arena and was greatly appreciated everywhere I spoke, whether it was on a lack of correlation between high-voltage power lines and cancer or the economic studies around raising the minimum wage.

"This is no time for people of science to sit on the sidelines."

For many people, knowing that I was a scientist was sufficient reason to vote for me because having more scientists in politics was that important to them. Even some Republicans and Libertarians supported me, typically because they were in a technical field and saw the advantage of a scientist representing them. And I'm sure there were some people with little interest in science who just felt my approach was sensible and refreshing.

On Election Night in 2015, all of that added up to a 78-vote win out of the more than 34,000 votes cast. You don't need to be a scientist to know that is razor-thin. I became the first Democrat ever elected in New Jersey's 16th Legislative District.

Since then, the pace has only quickened. Juggling my two jobs is no picnic, but I feel like I'm making a difference. I've had legislation passed that will help people, and I have a platform to speak out against science deniers while also showing the value—in my party's caucus and on the floor of the Assembly—of seeking factual responses to pressing problems.

If you have ever thought of running for political office I would urge you to do so. I've talked to scientists all over the country about my experience as an elected official, campaigning on a platform of evidence-based decision-making, and about the stresses on my professional and personal life. I've also given a talk about my experience at universities, conferences, and to other organizations that I call, "The Physics of Politics." But even if running in elections isn't for you, it is important to get involved.

This is no time for people of science to sit on the sidelines. Get to know the people who represent you in government at all levels and let them hear your views. Volunteer to provide information or advice on issues that you know well. Talk to the public about science, enhance science communication and science teaching. Prepare the next generation of scientists.

We live in a time when long-held principles are under relentless attack. People have determined that an anti-science mindset is a path to power and influence. We should not have to relitigate facts, but we don't always get to choose our fights.

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