2017 Nobel Prize in Physics

By Katherine Weight

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 40 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 Jesu 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 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 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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Research News: Editors’ Choice

A Monthly Recap of Papers Selected by the Physics Editors

November 2017 • Vol. 26, No. 10

Recent Official APS Statements

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From Cameroon to the APS

By Arsene Tema Biviole

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 dream 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 Politecnico 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 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 supervi- sor at GA, Sterling Smith, who always encourages and supports CAMEROON continued on page 7

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 in 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.

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 materi- als 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. aam8819), 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 unidirec- tional 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 appear- ing 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 unidirec- tional 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.)

RESERCH 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 funds the education 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 Spectro.

This past year, 22,000 PhysicsQuest kits were requested, but we could provide only 16,500. 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 semianual meetings.

Board members evaluate the APS Board statement draft and review process in cases where more rapid action is needed. 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.

Board statements are drafted by the American Physical Society, 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 in a manner that will not affect the ability of American companies and academics to acquire the 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 institutions of higher education, non-profit organizations and government research institutions from the overall visa cap under specific circumstances, APS is not aware of any actions in 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 #8.2). 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/docu ments/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—distinguished exceptionally 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 "charm revolution." In the early 1970s, physicists thought they had a complete picture of the contents of the nucleus: 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.

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 members 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 suggested that there was a 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 minutely examine the resulting particles. Ting’s Chinese parents were visiting Ann Arbor, Michigan when their son was born prematurely, never expecting a boy. 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 high-energy protons. 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 to ensure 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 to four billion electron volts. The accelerator at Brookhaven accelerated protons. But protons are not the only fundamental particles; electrons and, are 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, akin to the collision of the proton.

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—and the charm quark was born. And it had a much longer lifetime than expected.

Richter and Ting compared notes at a November meeting at SLAC that supercharged the excitement. The 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 CHARMED QUARK continued on page 3

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This Month in Physics History

November 1974: Discovery of the Charmed Quark

SAMUEL TING AT BROOKHAVEN NATIONAL LABORATORY

Samuel Ting at Brookhaven National Laboratory. He discovered the charmed quark in 1974. Ting joined the faculty of Stanford University, where he soon became engaged 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 to four billion electron volts. The accelerator at Brookhaven accelerated protons. But protons are not the only fundamental particles; electrons and, are 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, akin to the collision of the proton.

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Profile in Versatility

Physicists Take Their Skills to the Great Outdoors

By Gabriel Poppin

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 turtle 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 finding a communications job at MIT Lincoln Laboratory. He got interested in Experimental Receiver (ITER) and 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 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 ordered 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 confirmed it.

Gravitational-Wave Observatories Open New Era in Astronomy

By David Voas

Following closely the announce-ment 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 than the black holes in the previously observed mergers.

Moreover, reports from about 70 ground- and space-based obser-vatories have detected electromagnetic signals—from gamma rays to radio waves—as detected as well. Papers on these observations were published in Astrophyysical 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 nuclear synthesis in action, in particular the creation of elements heavier than iron, such as gold and platinum.

The gravitational-wave signal, detected 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 sig-nals, 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 electro-magnetic spectrum. And indeed, a gamma-ray burst was detected by NASA’s Fermi spacecraft and confirmed by the European Space Agency’s INTEGRAL spaceborne detectors.

The coordinates for the origin of the signal corroborated those shown in the aftermath of supernova explosions. The data indicated that the neutron-star merger took place some 130 million light years from Earth.

OutDOORS continued on page 6

NEW ERA continued on page 7

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 and the American Institute of Physics, 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. Experi-ence with developmental efforts and 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 registra-tion deadline is December 15, 2017. More information is available if you are considering implementing a version of PET at your institution. To register and learn more about the workshop please visit phys.tec.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 and secondary teachers using the Next Generation Science Framework 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 phys.tec.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 the his the 3 psi, since that letter resembled the Chinese symbol for his name. They compromised and combined the two, so the charm quark is officially the 3 psi particle. Richter and Ting shared the 1976 Nobel Prize in physics, “for their pioneering work in the discov-ery of a heavy elementary particle of a new kind.” With this discov-ery, there were now two whole 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 sur-prises in store. Within a few years, SLAC scientists discovered the tau lepton, settling on a search for two more flavors of quark. Fermilab’s Tevatron discovered the bottom quark by colliding protons with a stationary target at even higher energies, and examining their statis-tical data for telltale “bumps” indicat-ing 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 con-tinues to surprise scientists. In 2002, Fermilab’s SELEX collabo-ra-tion 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 detect-or 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 par-ticle also has significantly higher mass than that detected by SELEX around the bot-tom quark. 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?
APS Senior Physicists Gather for Anniversary

By Richard Stormbone

On October 18, the Mid-Atlantic Senior Physicists Group (MASP) celebrated the 20th anniversary of its founding. As MASP’s founder, I presided over the celebration, which included servings of a sheet cake with lettering: “APS/MASP 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 MASP’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 one the first Wednesday of the month at 1:00 p.m. 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 MASP 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 MASP-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 MASP 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 Ultrasonic 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 website at aps.org/units/masp has an extensive list of past talks and includes copies of many presentations. The MASP has also sponsored tours of science facilities in August. They have included a trip to the National Radio Telescope at Greenbank, W.Va., 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 MASP 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 MASP is very grateful for this support. To receive announcements of future talks and other events sponsored by the MASP, 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 MASP since its founding in 1997.

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:

“Within the last ten years, I have seen a huge number of women and girls pursue physics. Rowson pointed to initiatives like the Women in Physics conference, which have shown they are put off from studying physics because it’s not a ‘girly’ thing to do or because it seems 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.

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 present a project. 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 designing an object from the ground up. “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 doctoral research found that 35 of 39 awardees remain in academia—a much higher-than-average rate. 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 Tony Pickard, President of the Royal Society of Edinburgh. "We need to ensure that 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 at Physics, from which this article was reprinted.

Zero-Index Waveguide

Researchers have now created a waveguide that is consistent 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. (DOI: 10.1021/acsphotonics.7b00760) demonstrate the direct observation of zero index in a nanostructured silicon waveguide, which is at an important wavelength (1625 nm). The researchers feed infrared light into both ends of the waveguide to create a standing wave. They 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 negligible loss, which could be useful in optical devices.

Metal 3D Printing Gets Out of a Jam with Nanoparticles

Although best 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 high-precision technology 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 material together. 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/nature23984), 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.

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 shower particles as they smash into Earth’s atmosphere.

The origin of the different cosmic visitor is complicated by magnetic field depletions 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.aace1388), 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^{19} electronvolts, there is about a 6.5% excess of cosmic-ray particles coming from a particular direction. That direction is away from the galactic plane, indicating a source outside the Milky Way. They propose 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.

RESEARCH continued from page 1

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

The Mid Atlantic Senior Physicists Group celebrates its 20th year.
News from the APS Office of Public Affairs

APS Members Help Sway funding for STEM Education Bill

By Tawanda W. Johnson

An APS member made the case for STEM education funding in the Every Student Succeeds Act (ESSA), a U.S. Senate appropriation 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 in the 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 messages 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 competitive advantage 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 by a meeting with Senator Roy Blunt’s staff.

By Eran Moore Reeves

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

Have No Idea, focusing on open questions in physics. “Approaching physics from the point of view of what we don’t know, looking for what is on the edge of knowledge, that really helps each chapter move forward,” Chang said.

Chang also felt that his 20 years of experience writing PhD Comics impacted the way he wrote the book. “In our writing, I think there’s a certain amount of casualness and irreverence [about science],” Chang 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 it, this is what we know and you should just appreciate what we know.”

Whereas Chang 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 powerful 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 Chang (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 to make some simplifications… To my surprise, we got overwhelmingly positive feedback… other physicists were happy to [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 textbook-based ways of learning. Panelist Rebecca Thompson from APS narrated down some of her specific experiences writing the Spectra comics.

“In Spectra, 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 much more like the classroom than 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 in, 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

By Ern Moore Reeves

Feynman Diagrams: Science Comics at Comic-Con

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. Writing for 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.}

“Sonic Surprise”...
tered several men with chainsaws nonchalantly taking a smoking break. It turned out they actually knew the reserve owner, and after examining their chainsaws, they claimed 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 stop illegal logging, a global scourge, was too irresistible. Emissions from deforestation of tropical forests annually proved more enticing. So White quit his job, pulled in $167,000 on the crowd-sourcing 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 46 receivers in the UK but 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 we could be just a small way away from his goal. “The software itself should be the magical part; this is a model that you can’t lose—throw-away, he says. “It’s easy 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 wir- ing up electronics and sensors to gauge weather in the tropics. So when a shoddy soldering job blew up part of his experiment, he spent nearly a year rebuilding it.

The sounds like life in a typical physics lab, and indeed Nottingham drew heavily on his physics educa- tion at Nottingham Trent University (originally called Notts) 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 forest.

Nottingham wants to know what happens when tropical forest soil is artificially warmed. “It’s an experi- ment 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 cli- mate change. But all experiments to date have been done in temperate or boreal regions. A single result from this study, Nottingham said, could be a long- way toward making climate mod- els’ predictions more precise.

Nottingham’sbout with chainsaws nonchalantly taking a smoking break. It turned out they actually knew the reserve owner, and after examining their chainsaws, they claimed their illicit activity, they promised not to come back.

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everyday from been asps.org/meetings/april information, "That' and aggressively schoolers, speakers—follow-up—"guess"or are instrumental in language. “It' s said, and Wilgus described a very specific thing.” Wilgus said during the panel that people who criticize science 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 just 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].” Wilgus provided more context for the words on the page and all these things coordinate with each other to provide a fuller picture.” The author is a freelance writer in Minneapolis, Minnesota.

NEW ERA continued from page 3

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’ astrophysics,” said Caltech’s

David H. Reitze, executive director of the LIGO Laboratory, in a press statement. “It is 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.

CAMEROON continued from page 1

me. My sincere gratitude also goes to a special man Orso Meneghini at GA and his kind wife Luez. He believed in me, and provided everything during my adventure so that I stayed focused on my specific objectives. I would like to thank my fiancée, Ashley for all of my 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—a one of the biggest physics organizations in the world.
**The Back Page**

*Dr. Zwick: Going to Trenton*

By Andrew Zwick

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 think 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? To the contrary. 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 controversy is said to be a sign that the real problem has not been found and not that your 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 a bit painful. But it happens every day. I cannot recall the last time something like that happened in politics...

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 physician, Rep. Bill Foster of Illinois.

Should we elect only scientists? Of course not. But one way to get beyond today’s unprouducively 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 worked 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 allowed.

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 were impressed and said, 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 within the scientific community 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 my 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 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 negotiate facts, but we don’t always get to choose our fights.

Andrew Zwick is the head of Communication and Public Outreach at the Princeton Plasma Physics Laboratory, and a member of the New Jersey General Assembly representing the 16th Legislative District. He is a Fellow of the APS, Past-Chair of the Forum on Physics and Society (FPS), editor of the FPS newsletter “Physics and Society,” and Past-Chair of the APS Atlantic Section. The views expressed here are strictly his own.