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Physics Olympiad Results
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2017 APS General Election Results

By David Voss

Voting in the 2017 APS General Election came to a close on July 31, and the results are in: Philip H. Bucksbaum of Stanford University has been elected vice president, Larry Gladney of University of Pennsylvania becomes chair-elect of the APS Nominating Committee, Ahmadou Wagué of Dakar Cheikh Anta Diop University in Senegal will be international councilor, and Vivian F. Incera of the City University of New York/College of Staten Island will become general councilor. Their terms begin January 1, 2018.

Phil Bucksbaum

Larry Gladney

Phil Bucksbaum holds the Marguerite Blake Wilbur Chair in Natural Science at Stanford University, with appointments in Physics and Applied Physics, and in Photon Science at SLAC. His current research is in laser interrogation of atoms and molecules to explore structure and dynamics on the femtosecond scale. Bucksbaum is a Fellow of APS and has been elected to the National Academy of Sciences and the American Academy of Arts and Sciences. Within APS he has been active in the Division of Atomic, Molecular, and Optical Physics and the Division of Laser Science. He has served as a Laser Science Divisional Associate Editor for *Physical Review Letters* (PRL), he was a member of the 2013 PRL Visiting Committee, and he has served on the APS Executive Board. As vice president in 2018 he joins the APS presidential line and will become president-elect in 2019 and president in 2020.

"I'm honored to be elected, and I'm looking forward to the opportunity to serve the members and the Society," said Bucksbaum. "I know we are facing challenges, in the changing landscape for international cooperation, in the future of journal publishing, in the future of federal funding for physics, as well as other areas. There are also tremendous opportunities in physics in the 21st century, and APS has an important role in communicating

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2018 APS Medal for Exceptional Achievement in Research Awarded to Eugene Parker

By David Voss

The APS Council Steering Committee has voted to award the Society's 2018 Medal for Exceptional Achievement in Research to Eugene Parker, professor emeritus at the University of Chicago. Parker, 90, is recognized for his "many fundamental contributions to space physics, plasma physics, solar physics, and astrophysics during the past 60 plus years."

"Eugene N. Parker is the dean of the field of space and astrophysical plasma physics," commented Louis Lanzerotti of the New Jersey Institute of Technology. "Parker's seminal theoretical work beginning in the mid-1950s revolutionized understanding of the solar corona and its production of the interplanetary medium, and the effects of the medium on Earth's space environment."

Parker's theory of the solar wind led to a new understanding of the interplanetary medium. In particular, he predicted that the interplanetary magnetic field would be locked into the coronal plasma and would exhibit a spiral shape as the solar wind carried it into the region known as the heliosphere.

Eugene Parker

"There are very few scientists in the history of science of whom it can be said that they were responsible for the establishment of an entire scientific discipline," said Lennard Fisk of the University of Michigan. "In the late 1950s,

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NSF Grant For Women in Physics

By Rachel Gaal

Regularly drawing 19 million viewers each year, the comedy TV sitcom *The Big Bang Theory* is premiering its 11th season in late September 2017. The male foursome featured in the show—two Caltech physicists, an astrophysicist, and an aerospace engineer—all share the same "geeky intellectual" outlook on life. What about aspiring physicists, however, who don't fit the male nerd image—are they welcome? Thanks to a $3 million grant from the National Science Foundation (NSF), researchers from Florida International University (FIU), Texas A&M University–Commerce, the American Association of Physics Teachers (AAPT), and APS will begin a multi-year project to encourage more women to overcome the negative stereotypes and enter the field of physics.

"[*The Big Bang Theory*] is a funny show, and the 'nerd' stereotypes are funny … but we need to change the 'Big Bang Theory' view of what a physicist or a physics student looks like," Zahra Hazari told *APS News* in an interview. Currently an associate professor of physics at FIU and the lead investigator of this project, her research has centered on reforming the physics learning environment to raise the participation of underrepresented groups who pursue physics, especially women.

Zahra Hazari

"[Shows like these] are hugely detrimental to opening up doors for people who have never considered the field, because they don't look or act the right way," Hazari said. "... you don't have to act that way and be that way to do physics, you can be a caring and nurturing woman. My research is about mythbust-

NSF GRANT continued on page 6

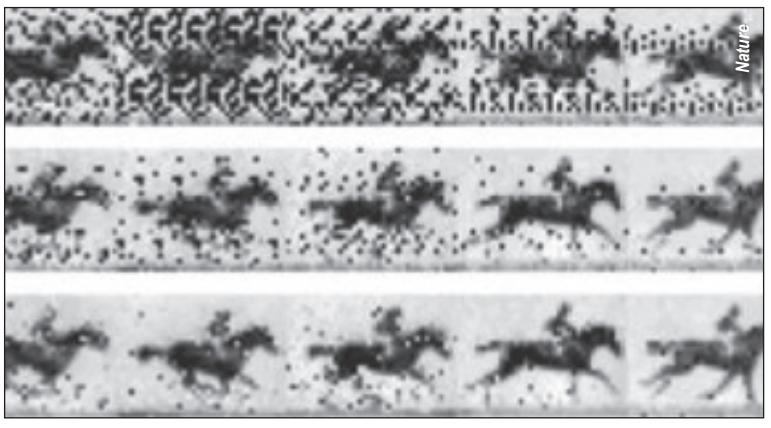
Research News: Editors' Choice

physics.aps.org

A Monthly Recap of Papers Selected by the Physics Editors

Movie Archived on DNA Molecule

A research team has stored a short digital movie inside the DNA of live bacteria. DNA—our genetic information-bearer—is known to have the potential for encoding information at high density. In 2013, scientists managed to encode 739 kilobytes of information into a synthetic strand of DNA, sufficient to store simultaneously all 154 of Shakespeare's sonnets, one image, and a 26-second excerpt of Martin Luther King's "I have a dream" speech. Now, Shipman et al. have further boosted DNA's information carrying capacity, reporting in *Nature* (DOI: 10.1038/nature23017) the first archiving of a movie inside a living cell. The researchers first encoded the black-and-white pixels of the movie's frames into the four "letters" of a DNA strand—the A, G, C, and T nucleobases. Using the new gene-editing technique called CRISPR, they then placed the DNA into an *E. coli* bacterium. The movie's frames could later be retrieved by sequencing the cells' DNA. The stored movie was Eadweard Muybridge's *The Horse in Motion*, a groundbreaking motion picture recorded in 1878 through stroboscopic photography. With the new DNA technique, the authors found they could accurately reconstruct each frame of the movie.



Researchers stored Muybridge's famous galloping horse film in DNA

Twirling Black Holes Caught in the Act

A decade-long study of a distant galaxy has uncovered the first evidence of orbital motion in a pair of supermassive black holes (SMBHs). This type of black hole—often more massive than a million stars—is found at the center of many galaxies, including our own, but only a handful of SMBH pairs have been observed so far. The radio galaxy 0402+379 hosts the closest known SMBH pair, estimated to be 24 light years apart from Earth. Researchers monitored 0402+379 from 2003 to 2015 with the Very Long Baseline Array, which is a system of ten radio telescopes spread across the U.S. An analysis of this data by Bansal et al., presented in the *Astrophysical Journal* (DOI: 10.3847/1538-4357/aa74e1), shows that the black holes are moving relative to each other. From our planet's vantage point, the detected motion is a sluggish 1.6 microarcseconds per year. By making assumptions about the orbit's shape, the researchers estimate that it will take 28,000 years for a full revolution. At this rate, the pair will not be merging

Dance of the massive objects

RESEARCH continued on page 6

Revised 09/25/17

Spotlight on Development

Help Strengthen the Future of the Physics Commmunity by Becoming a Member of the APS Legacy Circle

Dear Valued Member of the Physics Community,

We hope that APS has been instrumental in your career success. Now, we invite you to strengthen the future of the physics community by becoming a member of the APS Legacy Circle.

Some of you will soon be receiving planned giving information that we hope will be useful in guiding your philanthropic decision-making. Estate gifts to support APS programs—that need not cost you in your lifetime—will enable the Society to better serve the professional physics community, help educate the next generation of physicists, and communicate the excitement of physics to the general public for generations to come.

Kindly use the form below to request additional information, and/or share with us your intentions and be counted as a member of the APS Legacy Circle.

Thank you for your consideration.

Sincerely,
Irene I. Lukoff
APS Director of Development

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E-mail: lukoff@aps.org

BEAM Fund Provides Aid to Undergrad Mentees

Undergraduate students have enough to worry about just getting through E&M, thermodynamics, and lab courses; emergencies happen, however, and they can turn life upside down. But now students in the APS National Mentoring Community (NMC) can get emergency financial assistance.

On August 1, the APS BEAM (Bringing Emergency Aid to Mentees) Fund began offering small grants to provide undergraduate mentees with monetary support to help them complete their degrees. And the fund offers rapid response: If approved, students can obtain funds as quickly as two days after they apply.

To be eligible, students must be pursuing an undergraduate degree in physics or a closely related field, and they must be part of the NMC as a mentee (for more on how to participate visit the NMC website at aps.org/nmc). Among the things that can be paid for with the emergency funds are medical expenses, childcare, transportation, and tuition. For complete information on allowable expenses and how to fill out an application,

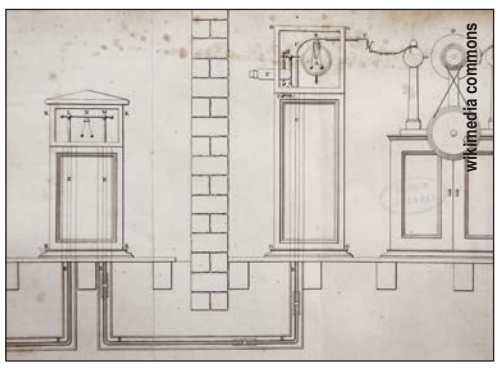
BEAM FUND continued on page 7

This Month in Physics History

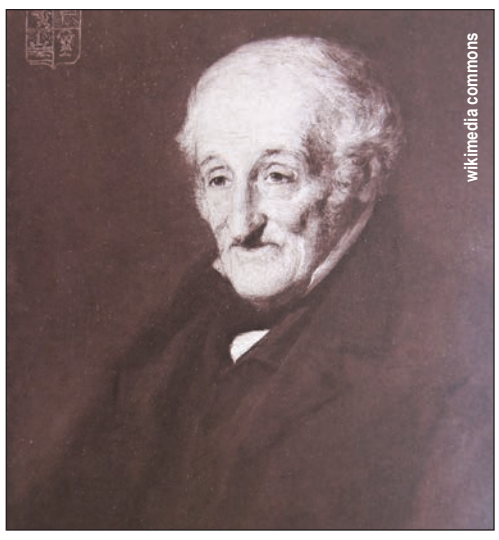
August 5, 1816: Sir Francis Ronalds' Telegraph Design Rejected

The public generally associates Samuel Morse with the invention of the telegraph, which revolutionized long-distance communication. But decades earlier, a London cheese merchant turned amateur scientist and inventor, Sir Francis Ronalds, created his own version of an electric telegraph. Ronalds proclaimed, "Give me materiel enough, and I will electrify the world." But the world wasn't quite ready for his vision; it would be two decades before William Cooke and Charles Wheatstone commercialized the telegraph.

Born in 1788 to London cheesemongers, Ronalds was the second of 11 children. He attended a Unitarian school before taking on an apprenticeship with his father at age 14. When he was just 19, Ronalds took over the family business for several years after his father died. But he also had a strong scientific interest in chemistry and the relatively young field of electricity, carrying out numerous experiments in his own home. He also amassed an impressive personal library of books on electricity, keeping what may have been the first card catalog system to sort them. Eventually he handed off the cheese business to his younger brother so he could pour all his energies into the study of electricity.



Clockwork telegraph



Sir Francis Ronalds

Ronalds published his first papers on the dry pile battery and how it generated electricity in *Philosophical Magazine* in 1814, followed by a description of the first electric clock. He figured out how to record changes in electricity in the atmosphere using an electrograph, and built an "influence machine" capable of generating electricity. He came up with the first description of how induction affects signal transmission in insulated cables, and developed new forms of electrical insulation based on that work.

But his place in history is due to his creation of an electric telegraph at age 28, inspired by his earlier work on electric clocks. In the summer of 1816, Ronalds was living at his mother's house at Hammersmith. He set up a makeshift laboratory above the stable, and commandeered her backyard to design, build, and test his telegraph, "in which [two parallel] wires were enclosed in glass tubes buried in the ground. At each end of the line a clockwork mechanism turned synchronously revolving discs with letters on them. A frictional electricity machine kept the wire continuously charged, while at each end two pith balls hung from the wire on silk threads, and since they were similarly charged from the wire they stayed apart. When someone desired to send a message he earthed the wire at his end at the moment when the dial indicated the desired letter. At the receiving end the pith balls would fall together when earthed and the recipient noted the letter showing on his dial at that moment. The system was slow and depended on the two dials staying in step, but Ronalds demonstrated that it would work over 150 metres of wire." (1)

Not only did he create the device, he had a vision of a wired world where political leaders could converse across long distances, writing, "Let us have electrical conversazione offices, communicating with each other all over the kingdom."

Excited about the potential for his device and praise from a few colleagues, Ronalds offered his design to the British Admiralty. But the timing was bad: a French apparatus called the semaphore had been developed in the 1790s, and the Admiralty had installed a similar setup between London and Portsmouth just the week before. On August 5, 1816, Ronalds' vision was soundly rejected by the Secretary of the Admiralty Sir John Barrow, who showed a remarkable lack of prescience when he declared, "Telegraphs of any kind are wholly unnecessary; and that no other than the one now in use will be adopted."

Ronalds took the rejection of his signature invention in stride, insisting he harbored "not a shadow of resentment," although also expressing hope that eventually someone in a leadership role would recognize the value of an electric telegraph for the future of communication. The field continued to advance for the next two decades, until the subsequent inventions of the battery and the electromagnet. That enabled Cooke and Wheatstone to develop their own rudimentary telegraph in 1837.

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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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News from the APS Office of Public Affairs

APS Members Make Gains with Science Advocacy

By Tawanda W. Johnson

APS members are making big moves in the science policy arena, helping to ensure that the U.S. maintains robust science budgets to keep the nation on a path of jobs and prosperity.

Dominic Calabrese, a physics professor at Sierra College in Rocklin, California, working with the APS Office of Public Affairs (OPA), landed an op-ed in the *Auburn Journal*, urging his representative Tom McClintock (CA-4th) to reject President Trump's proposed cuts to science. McClintock serves on the House Committee on the Budget, and thus plays an integral role in funding decisions.

Dominic Calabrese

Karen King

A highlight of Calabrese's piece: "His [Trump's] proposed 2018 budget would do considerable harm to scientific innovation that has not only positively impacted California's $47 billion agricultural production, but also the millions of farms across the country."

Calabrese said it is crucial that scientists educate members of Congress on the importance of science.

"Very few politicians in Washington, D.C. and the state and local levels have a background in the sciences," he said. "They are making decisions on bills that directly affect the livelihood of many educators and professionals in the scientific community, and I felt I had to voice my concerns regarding science funding."

Calabrese added, "My involvement (in science advocacy) has given me the chance to make a difference in the lives of the members of the science community. It has also allowed me to be heard by my congressional representative. Lastly, I hope my involvement has increased our congressional district's awareness of the significance of federal science funding."

Calabrese took his advocacy a step further by meeting with McClintock's staff in his local office, along with Greg Mack, APS government policy specialist, to underscore key points in his op-ed. McClintock's staffers—both locally and in Washington, D.C., have responded in a favorable manner toward the importance of funding science.

"McClintock was on our advocacy target list, but he was a challenge," said Francis Slakey, OPA interim director. "He represents a rural district with no significant

ADVOCACY continued on page 6

Change is in the Air

By Fred Schlachter

As I sat in my car in total frustration at the horrific traffic jam on my way to a battery conference, my mind wandered to a fantasy from my youth: flying cars. The Dick Tracy two-way wristwatch-radio became reality with the first Apple Watch. Why not flying cars?

There have been many attempts. One 1947 flying car looked like a Cessna glued to a Ford Pinto: the Convair Model 118. There is little interest at the moment in a car that flies, and, as long as it uses lift, it would require an airport runway. But while I was en route from Berkeley to San Jose to attend "Beyond Lithium Ion (BLI) X" at IBM Research-Almaden, the thought of leaping over the traffic stuck on I-880 reinforced my dream of flying right over the traffic jam.

When I finally got to BLI-X, I found the mood more upbeat and optimistic than in recent years, as progress will likely result in batteries that have a higher energy-storage density, are less expensive and possibly safer, and will likely allow new applications. I was particularly intrigued by the prospect of a new battery chemistry: lithium/sulfur. But my mind kept returning to the traffic jam I had negotiated and musing about flying over it.

Helicopters are far too expensive and noisy to be a viable option for most of us. Flying cars might be a pipe dream, but vertical-take-off-and-landing (VTOL) planes could be an alternative. A VTOL craft could take off and land at a small local "vertiport." Making the plane electric and powered by batteries will eliminate carbon-dioxide production if electricity from a green grid is used. Of course, the problem of going to and from the vertiport remains.

The *uber*-disruptive company Uber says it has a solution. It has proposed a summon-on-demand service using battery-powered VTOL air taxis, which it intends to deploy as soon as 2020. The company is optimistic, even though several critical components are missing or still in early stages of development.

A key component is a suitable battery. Batteries that can power such a plane and be quickly recharged do not exist due to insufficient specific energy (energy per unit weight), low charging rate, poor cycle life, and cost. A German company—Lilium—along with other companies are working on a demonstration electric VTOL plane, but it is a long way from certification and production.

When do I get my flying car?

There are a host of other obstacles that must be overcome: Pilots must be trained, and even without pilots, government approved autonomous flight-control software will eventually be necessary; infrastructure needs for takeoff/landing/recharging/air-traffic control must be met; battery safety in aircraft (certain phones are not allowed on commercial flights today due to the risk of battery fires) must be addressed; and a clear business model must be developed. Convincing customers to board a plane with huge batteries could be a problem. Noise at urban vertiports will likely meet with opposition. And costs could be in the stratosphere.

The low energy-storage density of batteries and thus their weight is an issue; however, electric motors are greatly more efficient than internal-combustion or jet engines, and they are more quiet as well. This efficiency is used to good effect in the present generation of electric cars.

NASA is exploring electric planes. Engineers point out that electric motors are much smaller and lighter than jet engines, allowing them to be integrated into the fuselage rather than having them hang under a wing. The result would be improved propulsion-airframe integration and operational efficiency. Unfortunately, present batteries do not store enough energy to power an electric plane over a useful distance. NASA is developing the X-57, a plane with 14 electric motors turning propellers and set into a uniquely-designed wing.

A battery-powered VTOL plane illustrates some of the challenges that product designers face in the 21st century. Better, cheaper energy storage is required to make many such products feasible. It is important for expanding the use of wind and solar energy sources, which are of little use when clouds block the sun or the wind is not blowing.

Energy storage from wind and solar may not require batteries, since portability is not necessary. Energy can be stored in thermal, kinetic, and potential forms. The most important criteria for utility-scale energy storage are long life, low cost, long-term reliability, and scalability. Advanced batteries may be useful but not always the best option for utility-scale energy storage.

The optimistic mood at BLI-X was due in large measure to two recent developments.

(1) All-solid-state batteries, where the conventional flammable liquid organic electrolytes are replaced with solid materials, will reduce or eliminate the fire hazard for batteries. Ceramics and glasses are contenders, although more development is necessary.

(2) Batteries with a lithium (Li)-metal anode and a cathode containing primarily sulfur (S)

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RONALDS continued from page 2

(Some sources say Wheatstone had seen Ronalds' telegraph as a boy.) Within two years, their system was being used to send messages between local railway stations, as much as 29 kilometers apart. British police relied on the telegraph in 1845 to help capture fugitive murderer John Tawell.

Their approach was ultimately superseded by the telegraph system created by an American portrait artist turned inventor named Samuel Finley Breese Morse. Morse also invented his own system of dots and dashes, which could be combined to represent letters of the alphabet, called Morse Code. He convinced Congress to construct an experimental telegraph line from Washington, D.C. to Baltimore. And on May 24, 1844, he sent the message "What hath God wrought?" from the old Supreme Court chamber in Washington to his partner, Alfred Vail, in Baltimore. By 1869, the East and West coasts were connected by telegraph.

As for Ronalds, he didn't publish a paper again in *Philosophical Magazine* for the next 32 years, but he was far from idle. He turned his focus to mechanical and civil engineering, traveling extensively and developing new surveying tools as well as drawing instruments to help artists achieve better perspective in their sketches. He wound up with a strong side business in manufacturing portable tripod stands to support drawing boards for artists working in the field.

He also pursued meteorological interests, developing scientific instruments to study electricity and geomagnetism in the atmosphere. In 1842, he established the Kew Observatory, which became one of the leading meteorological and geomagnetic facilities in the world, rivaling the famous Greenwich Observatory.

Ronalds did live to see his vision come to fruition. And not everyone forgot his contributions: The fledgling Society of Telegraph Engineers (which inherited his formidable library) dubbed him the "father of telegraphy" and declared he "must always stand as the first of English Telegraph Engineering." He was knighted for his efforts in 1870. He died at home near Hastings on August 28, 1873, aged 85.

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3. Ronalds, Beverley F. Sir Francis Ronalds: Father of the Electric Telegraph. London: Imperial College Press. 2016.

Careers Report

"Startup Stories" Encourage Physics Innovation and Entrepreneurship

By Mary Ann Mort

For my final project in an electronics and instrumentation course last year, I created a device that varied the colors on a strip of LEDs according to audio frequencies. My goal was to cut down on the effort that goes into pre-programming light shows for music concerts by letting the frequency filters do the work. But once my product was finished, I had no idea what to do next or how to put it on the market. As the next semester started, my enthusiasm for the project died.

If I had an opportunity to take a class for physics students on marketing, patents, and how to navigate the business world, I might have pursued ways to design and produce more devices like the one from my final project. And what if there were a new kind of class, lab, or part of an existing class that covers how to take innovative ideas from prototype to product? Every semester, physics students are tinkering away and making gadgets and gizmos to help make their lives more convenient—so why not find ways to bring these ideas to market?

In an effort to give students these real-world skills, APS is promoting physics innovation and entrepreneurship (PIE) education for physics undergraduates through the NSF-funded PIPELINE project. This project brings together the efforts of six universities to develop and implement new approaches to teaching PIE. Alongside the physics curriculum, these courses aim to help physics students commercialize new technologies that they create, as well as develop leadership, communication, and multi-disciplinary team skills. These skills will not only serve the meager five percent of physics bachelors destined to be permanent physics faculty, but also those with careers as entrepreneurs and intrapreneurs in the private sector where team management, leadership, and project management skills are so essential for success.

Mary Ann Mort

APS also has a new online feature called "Startup Stories." These are profiles highlighting young physics entrepreneurs who have

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APS Leadership and Staff Featured in *Physics World*

Physics World, the member magazine of the UK Institute of Physics, focuses on physics in the United States in the latest of their "Special Report" series. Among the articles is a round-table discussion with 2017 APS President Laura Greene, 2017 APS President-Elect Roger Falcone, and Francis Slakey, interim director of the APS Office of Public Affairs. Also included is news coverage of physics in the U.S., commentary by U.S. Congressman Bill Foster, a Q&A with former director of the Office of Science and Technology Policy John Holdren, Robert Crease on the DOE laboratories, and more.

The digital version is free-to-read and available at physicsworld.com

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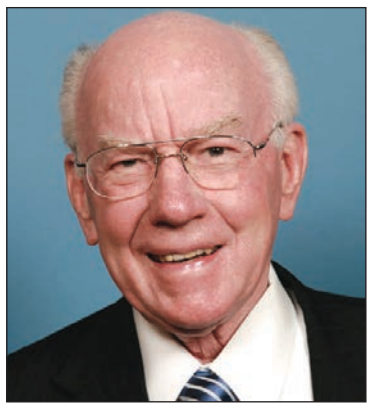
Vernon J. Ehlers 1934-2017

By David Voss



Vernon Ehlers

Former Republican U.S. Congressman Vernon Ehlers, 83, died at his home in Grand Rapids, Michigan, on August 15. Ehlers was a nuclear physicist who won election to the U.S. House of Representatives in 1993, and served until his retirement in 2011, representing the 3rd Congresssional District of Michigan. He was the first of a small, select club of three physicists, including former Rep. Rush Holt (D-NJ) and current Rep. Bill Foster (D-IL). He was a strong supporter of scientific research, science education, and a defender of the National Science Foundation.

"Vern was a serious scientist of some accomplishment," observed Rush Holt, Chief Executive Officer of the American Association for the Advancement of Science, about his former congressional colleague. "But he understood very early on that involvement in politics and public matters was not incompatible with serious physics research and teaching. Vern realized that there were opportunities and obligations to be involved in public affairs."

Holt noted that such a stance took some nerve. "Back when he was advising [former Congressman and U.S. President] Gerald Ford, it was not something a young physicist would normally do. It took the recognition that this was something a scientist could and should do."

"Vern Ehlers was a friend and a mentor to me when I entered Congress as the 3rd member of

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IPhO 2017 Unites Physics Brainiacs in Indonesia

By Rachel Gaal

2017 U.S. Olympiad team (L-R): Jimmy Qin, Sanjay Raman, Michele Song, Shreyas Balaji, Kye Shi

After qualifying exams, countless practice problems, and group preparation sessions, the U.S. physics team set off for Yogyakarta, Indonesia in late July to compete at the 48th annual International Physics Olympiad (IPhO). The seven-day trip, from July 16-24, brought together over 300 high school students from 88 countries to put their physics skills to the test. This year, the U.S. team placed 8th overall in medal count—winning three gold and two silver medals.

"We tied for eighth place in the medal count … about the same as last year's [competition]," Paul Stanley of Beloit College told *APS News*. As one of three team leaders for the U.S. Physics team, Stanley is no stranger to the stiff competition of IPhO. "Our medals were better [this year]; they were better for everyone. [But] the exams were challenging … lots of number crunching for the experiment[s], and some pretty heavy theory for the theoretical exam[s]."

All competitors were given two experimental and three theoretical questions that ranged from estimating the speed of galaxy clusters with dark matter, to solving for thermodynamic variables in earthquake and volcanic eruptions. Allotted a mere five hours for the experimental portion of their exam, students were required to tinker with lasers to find the refractive index and diffusion rates of a saltwater solution. Indonesia is also prone to volcanic activity and tsunamis associated with large-scale earthquakes—a perfect opportunity for students to calculate and explore the properties of a new seismic-detecting technology, called the parallel dipole line (PDL) magnetic trap.

To relieve some of the test-taking jitters, the participants of IPhO were taken to Borobudur Temple, Yogyakarta palace, and Tembi Village. Students made special dyed clothes, known as batik, and were able to play a part in making traditional music.

As a welcoming gesture to the IPhO group, past-president of Indonesia and aeronautic engineer B.J. Habibie created a special video message for this year's competitors. Habibie, known as "Mr. Crack," was the first scientist to help fix a problem with failure in aircraft structures known as random crack propagation. His video was presented at the opening ceremony, which offered both students and team leaders bits of inspiration for their difficult competition ahead.

"Everything we have accomplished is inherited by the younger generation … they must be educated and provided the access to more appropriate methods of education. Only then can they be better than those who came before them," Habibie asserted. "There are two types of physicists [in the world]. One will become like me, and the other will become like Einstein. I hope that participating in this physics olympiad will help guide [these students] to choose where to go when [they] finish [their] education."

The 2017 U.S. Physics Traveling Team includes Shreyas

IPHO continuedon page 5

PARKER continued from page 1

as a young untenured professor at the University of Chicago, Gene Parker wrote his seminal paper on the acceleration of the solar wind, predicting that it would be a supersonic flow. This work was ridiculed by more senior, well-established astrophysicists." Parker's prediction was confirmed by the Mariner 2 spacecraft in 1962 and by the Voyager missions.

"Gene Parker has a wonderful and exceptional record of seminal contributions … over the many years of his distinguished career," said Roger Falcone, chair of the 2018 APS Medal selection committee. "It is remarkable to see so many effects that bear his name."

"Focusing on our nearest star, Gene has taken on the incredibly difficult task of elucidating many of its complexities and has provided the world with new and better understanding of the sun," said APS Chief Executive Officer Kate Kirby.

Eugene Parker received his B.S. degree from Michigan State University in 1948 and his Ph.D. from the California Institute of Technology in 1951. After an assistant professorship at the University of Utah, he joined the faculty of the University of Chicago in 1957. Since then, he has published key papers in solar magnetohydrodynamics, cosmic ray physics, and space plasma physics.

The APS Medal for Exceptional Achievement in Research was initiated in 2016. The first medal was awarded Edward Witten of the Institute for Advanced Study and the 2017 medal was awarded to Daniel Kleppner of the Massachusetts Institute of Technology. The medal includes a prize of $50,000, a certificate citing the contribution made by the recipient, an allowance for travel to the APS Medal Ceremony in Washington D.C. on February 1, 2018 and an invited talk at an APS meeting.

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the joy and excitement of science to the public and to government."

Larry Gladney is the Associate Dean for the Natural Sciences in the School of Arts and Sciences and Edmund J. & Louise W. Kahn Professor for Faculty Excellence in the Department of Physics and Astronomy at the University of Pennsylvania. His research interests are in astro-particle physics and cosmology and in experimental particle physics for which he received the APS Edward A. Bouchet Award in 1997. He currently serves on the Program Advisory Committee for the Advanced Laser Interferometer Gravitational-Wave Observatory. Gladney is also incoming chair of the APS Forum on Outreach and Engaging the Public. He will serve as 2018 chair-elect of the APS Nominating Committee and then as chair in 2019. The committee is responsible for putting forward candidates for positions in the elected leadership of APS.

Ahmadou Wagué is Professor of Physics at the Dakar Cheikh Anta Diop University, in Senegal West Africa, where he has been involved in teaching general physics, quantum mechanics, optics, atomic physics, and laser spectroscopy. Wagué is a member of the Senegalese National Academy of Science and Technology where he is in charge of the Committee on Science Education and Relation with Young Scholars. He was

Ahmadou Wagué

Vivian Incera

elected Vice President of the African Physical Society when it was launched in January 2010, and is currently a coordinator of the International Steering Committee of the new African Optics and Photonics Society. He organized a national campaign called "Light to the People" in bringing Solar Lamps into schools in many remote villages without electricity in Senegal. Wagué is a founding member of the African Laser Centre in Johannesburg, where he works to develop laser facilities in South Africa, Senegal, Ghana, Cameroon, Kenya, Namibia, Tunisia, Algeria, Morocco, Ethiopia, and Egypt, among others.

Vivian Incera is Professor of Physics and the Dean of Science and Technology at the City University of New York/College of Staten Island. She is a high-energy theorist, although her research interests frequently cross the formal boundaries of other areas. Over her academic career, she has made important contributions to the understanding of the properties of strongly interacting matter under extreme conditions. As the new Dean of Science at the College of Staten Island, she has already spearheaded several initiatives to increase student success, foster faculty research, and promote the representation and success of women in the STEM fields. Incera has served on the APS Committee on Minorities and as the Elected Chair of the Texas Section of the APS. She was the Dr. C. Sharp Cook Chair in Physics at the University of Texas at El Paso and received a national award for Leadership in College-level Promotion of Education.

See aps.org/about/governance/election/index.cfm for more information.

Education & Diversity Update

APS Releases Updated Statistics on Women, Minorities, and Education

Drawing on national databases, each year APS collects and produces a number of graphics and data files that document the participation of various groups in physics. To see the latest numbers and historical trends on physics majors (bachelor's, master's, and Ph.D.'s), women in physics, underrepresented minorities, and more, visit aps.org/programs/education/statistics. Thanks to Sam Montgomery from the New Mexico Institute of Mining and Technology for his help in assembling the data.

NMC Travel Awards for 2017 Día de la Física Deadline: September 21

The APS National Mentoring Community (NMC) is partnering with the National Society of Hispanic Physicists to co-sponsor their Día de la Física at the University of Utah on October 21, 2017 in Salt Lake City. This meeting, which occurs during the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) conference, offers programming specific to physicists and physics students. Travel awards are available for NMC participants. For more information, visit go.aps.org/nmc-2017. Not an NMC member? Join at aps.org/nmc.

APS Conferences for Undergraduate Women in Physics Application for Students Opens September 1

The 2018 APS CUWiP will be held at twelve universities across the U.S. and Canada January 12–14, and provide great opportunities for women in physics to network, as well as learn from scientific presentations, panel discussions, graduate school fairs, and career expos! Applications are open September 1 – October 13 at aps.org/cuwip.

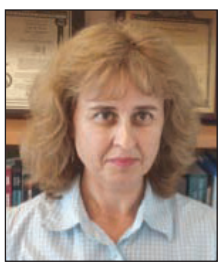
Interested in hosting a APS CUWiP at your university in 2019?

APS CUWiPs are three-day regional conferences at multiple sites across the U.S. and Canada, and are designed to increase the recruitment and retention of undergraduate women in physics. If you are interested in applying to be a host site for our 2019 conferences, please visit go.aps.org/cuwiphost and submit an application form by November 1. Email women@aps.org for more information.

Free Professional Skills Seminars for Students

With support from the National Science Foundation, APS has trained another cohort of women in physics to facilitate professional skills seminars for students and postdocs at your university! Professional Skills Development Seminars are designed to reach women in physics, and will teach students communication and negotiation skills. Visit go.aps.org/psdwseminars to find a facilitator near you!

Woman Physicist of the Month



Lilia Woods

Dr. Lilia Woods obtained a Ph.D. in condensed matter physics from the University of Tennessee under the guidance of Prof. Gerald D. Mahan. She was a postdoctoral researcher at the Oak Ridge National Laboratory/University of Tennessee, which was followed by a National Research Council Director's-funded postdoc position at the U.S. Naval Research Laboratory. Dr. Woods then joined the department of physics at the University of South Florida, where she is currently a professor. Her group of graduate students and postdocs works on a variety of cutting-edge problems reaching across condensed matter physics, materials science, and devices. She works with faculty and graduate students to develop presentations, in-class demonstrations, lab visits, and experiments so high school students can actively participate and prepare for successful undergraduate studies in physics.

Nominate the next Woman Physicist of the Month by emailing the nominee's name, institution, email, and CV, as well as one to three paragraphs about the nominee and why she is worthy of recognition to women@aps.org.

Science Research in Gaza in Palestine

By Sultana N. Nahar

Faculty and student winners of prizes (with certificates) with the IUG President Professor Awadallah (in the middle) at the 2017 annual recognition program for education and research in STEM subjects founded by Sultana Nahar.

Meeting Zher Samak, a post-graduate student from Gaza in Palestine pursuing her Ph.D. in the physics department of Cairo University in Egypt, taught me a lot about higher education in Gaza. Like most others, I was aware of their elementary and high schools but not their universities. Zher graduated from the Islamic University of Gaza (IUG) with a bachelor's and a master's degree in physics. Gaza has several universities, such as Al Azhar, Al Aqsa, Islamic, and Palestine Technical College, but the Islamic University of Gaza is the only research university there that offers a master's degree in physics. The faculty members in other departments and in other universities include students in their research programs, but not at the graduate degree level yet.

Zher saved money as a school-teacher to pursue her Ph.D. degree in physics in Cairo University, where I taught a lecture course on atomic astrophysics and plasma opacity. Her own savings was not enough and hence her parents also contributed. She came to me asking whether she could join the course after her research advisor Professor Sherbini informed her about it. I welcomed her.

A tall, strong young woman in a black abaya whose way of speaking showed determination and persistence in pursuing the degree, Zher stood out as different from other students with happy faces. She lived alone far from campus and used to take the bus everyday carrying a heavy old laptop. Her laptop was the only computer unable to connect to wi-fi internet during the computational workshop on R-matrix and atomic structure codes that I was conducting. She took the final exam with a cold and a fever but did well. I offered her $300 toward purchasing a new computer, but she refused politely saying that she needed only prayer for her success. She accepted it only when I explained that it was for her sincerity and performance in the course. Through Zher I came to know more about IUG and made contact with it. I helped members in the physics department to become members of APS at no cost.

On March 14–15, 2017, IUG held its sixth International Conference on Science Development, and I was invited to be the keynote presenter in the inauguration session. Unfortunately I was not able to attend the Conference, but instead I sent my slides on "Atomic processes: From Universe to Cancer Treatment" with my Skype contact information to answer questions after the presentation. But due to a power outage in Gaza, Skype did not work, so a professor answered the questions. Participants came from the universities in Gaza, and from neighboring Arab countries of Jordan, Kuwait, Qatar, and the city of Bethlehem, and I joined remotely from the U.S. The research areas covered were in chemistry, environmental engineering, earth sciences, water and renewable/green energy, marine sciences, life and health sciences, and biotechnology, mathematics, and physics. The presentations covered interesting and modern topics titled such as "Zinc and Magnesium Levels in Osteoporosis Patients from Northern Gaza Strip" and "Dispersion Characteristics of Graphene Surface Plasmon four-layer Waveguide."

I established a recognition program in STEM (science, technology, engineering, mathematics) areas in IUG in 2015 to motivate and promote education and research in basic and applied sciences. The program gives 14 prizes, 7 to faculty members for high quality research publications and best teaching skill and 7 to students for the best academic performances in the departments of physics, biology, chemistry, mathematics, and six departments of engineering. They were distributed for the first time in April 2017 at the end of IUG's 2nd observation of the research week where various research activities were demonstrated. The winners of the prizes were also revealing. Of the faculty prizes, five went to male faculty members and one to a female faculty member who was from engineering. However, six of the seven student prizes went to female students. It was impressive to see the sincerity and devotion of the women, and I hope that such practices will also be adopted by the men.

The author is a research professor in the Department of Astronomy at The Ohio State University, Columbus, Ohio. She is a Fellow of the APS and known as the Iron Lady for extensive work on iron ions under the Opacity Project and the Iron Project. She received her Ph.D. in physics from Wayne State University, Detroit, Michigan in 1987. With A.K. Pradhan she co-authored the textbook Atomic Astrophysics and Spectroscopy *(Cambridge 2011), and maintains her online database NORAD-Atomic-Data. She has been promoting STEM education and research in developing countries since 1995.*

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Balaji from John Foster Dulles High School in Sugar Land, TX; Jimmy Qin of Seminole High School in Sanford, FL; Sanjay Raman of Lakeside School in Seattle, WA; Kye Shi of Monte Vista Christian School in Watsonville, CA; and Michelle Song of Mission San Jose High School in Fremont, CA. The American Association of Physics Teachers (aapt.org) has more information on qualifying exams to join the U.S. Physics Olympiad team.

The 48th IPhO 2017 was organized by the Directorate General of Primary and Secondary Education in the Ministry of Education and Culture (MoEC) of the Republic of Indonesia.

To learn more about this year's IPhO and to see the official results, visit ipho2017.id

STARTUP continued from page 3

used their physics knowledge to start their own innovative businesses. As an APS Careers intern through the Society of Physics Students, personally interviewing and writing up the stories of these fascinating entrepreneurs was inspirational because I heard about their success in overcoming obstacles. These profiles get students like me excited about solving global problems by using our physics training in innovative ways. The Startup Stories are available on the PIPELINE homepage at aps.org/programs/education/innovation/index.cfm

And the Startup Stories aren't just for students. While the profiles give entrepreneurial tips to students as they complete their undergraduate degrees, the advice also applies to physics faculty who train future generations of physicists. The individual pathways to success are different for each entrepreneur, but the idea of attracting investors by effectively communicating the goals is universal.

These Startup Stories are a part of a larger effort by APS to promote PIE. There is also a monthly newsletter on the latest developments in PIE Education (sign up at aps.org/programs/education/innovation/pipeline/), and a student-oriented webinar on entrepreneurship coming up this fall. PIPELINE members also presented several talks at the 2017 American Association of Physics Teachers Summer Meeting in Cincinnati.

As a physics student who has daydreamed of starting my own business, I will be interested to find out how the curriculum evolves through the PIPELINE project. A class that covers the process of creating a business, which mirrors research in many ways, could strengthen the contributions of physicists. Physicists already have technical problem-solving skills, and teaching them to apply that pragmatic mindset to other aspects of life offers the possibility of improving life for all of us.

The author is a graduating senior in Applied Physics at Sacramento State. She just finished a summer internship at APS through the Society of Physics Students. You can learn more about her internship by reading her blog at spsnational.org/programs/internships/2017/mary-ann-mort.

NSF GRANT continued from page 1

ing, and to [eliminate bias against] women's participation in physics."

Although the show hasn't made major controversy, popular culture might be taking a toll on those who pursue physical science careers. Even though as many women take high school physics as men, women make up only 20 percent of the undergraduates in physics. And according to Hazari, the imbalance has historically been an issue in certain disciplines of engineering and physics; biology has a slight overrepresentation of women, and chemistry is at or around parity, she said.

"Women tend not to choose physical science careers because they don't see them as impactful .... on average, [they] tend to be interested in careers that can make a change in society, that can better our future in society, so they don't see physics as a pathway for that," Hazari explained. "We are going to show how people with physics degrees go on to work on cancer research, they work on things that can make a huge difference in the world."

While efforts are on the rise to retain female physics undergraduates—including the APS Conferences for Undergraduate Women in Physics (CUWiP)—Hazari wants to tackle the preceding step of recruitment with her upcoming research.

"We … understand the issues for women and what the critical timeframes are for intervention, but we haven't wrapped it into practice yet," Hazari said. "[My team and I] want to use [academic research] to change the face of physics, the education system, and to increase pathways and empower women in physics, rather than have all of this valuable research sit in a journal."

With the four years of NSF funding, Hazari plans to carefully field-test her program with small numbers of teachers for two years. "What we are really trying to hammer home is 'how do we make these interventions usable for physics teachers, and how do we reach them?' Whether you are in a rural area, or the inner city, these are materials that [we want] them to use," Hazari explained. "It's a very difficult task, but we [have] help from teachers that come from those demographic regions." If all goes as planned, there will be a nationwide rollout by 2019 with a targeted goal of reaching 16,000 educators.

"[16,000 teachers] is a daunting number," Hazari admitted. But her strategies to reach teachers far and wide includes help from APS and AAPT, who have a vast network of physics educators. "We [hope to] train regional teacher leaders who will go out and run workshops in their region, and include webinars for additional teachers throughout the country," Hazari said. "I know [our plan] is very risky, but the bigger risk is not trying anything. It's always better to try something."

ADVOCACY continued from page 3

research footprint—he's an influential member of Congress, but from his point of view, he had no reason to care about science." That's no longer the case, added Slakey. "Dominic changed that."

Calabrese's advice to APS members who want to become involved in advocacy: "If there is an issue you really feel passionate about, you should try to get involved. You can contact the APS Office of Public Affairs [opa@aps.org] to get started. Nobody else is better equipped to express their concerns about science policy than a person trained in the sciences."

Karen King, an assistant teaching professor in the Department of Physics and Astronomy at the University of Missouri, said she became involved in advocacy because she holds "a deep conviction that all students deserve a high-quality education that includes rigorous courses with critical-thinking skills."

"Whether a child dreams of being a doctor, engineer, or an astrophysicist, she should have access to challenging courses and support of teachers to reach her aspirations," King explained.

Working with the APS Office of Public Affairs, she wrote an op-ed that appeared in *St. Louis Dispatch*. It urged U.S. Sen. Roy Blunt to support STEM education by fully funding Titles II and IV in the Every Student Succeeds Act, which were targeted for cuts in the White House budget proposal. Surprisingly, Blunt responded a week later in a letter in *Dispatch*. He wrote, "I have serious concerns with some of the cuts included in the president's budget."

Blunt is vice chair of the Republican Conference, putting him in charge of messaging for all Senate Republicans. "So when he publicly challenged Trump's budget proposal in response to Karen's op-ed," Slakey explained, "it enabled other Republican senators to do the same."

King was elated with Blunt's response, but she explained that she did not get involved with advocacy for personal gain.

"Advocacy is not about personal rewards; I got involved because it feels like the right thing to do. A positive response from policymakers is encouraging, but it is also critical to maintain sustained effort, even in the face of discouraging results."

Her tips for those who want to get involved in advocacy:

"I encourage [students] to get involved at multiple levels of government, including presenting undergraduate research at our state capitol or applying for federal summer internships. The APS Advocacy Dashboard (aps.org/policy/issues/) is a good resource for further actions that citizens can take. Finally, I think much can be gained, especially locally, by focusing on building relationships—getting to know local teachers, administrators, and folks in our own city government."

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

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made an improvement in society. Hard numbers and documentation of the impacts of any budget cuts are also important inputs to both the Office of Management and Budget and the Hill, and best developed in conjunction with the APS Office of Public Affairs, Panel on Public Affairs, and Physics Policy Committee. Since congressional staffers turn over regularly these arguments need to be made constantly and consistently on the Hill and in your district.

Obviously there are many national priorities. A balance needs to be struck between the support of science and the next generation of scientists on the one hand and meeting important near-term goals of the nation on the other, with the caveat that it can take years for fundamental science to make a huge difference and that it is not known at the time that a particular piece of research will be a home run. But if you don't swing, no home runs will ever be hit. In the meantime other nations are eagerly at bat.

The House and Senate marks from the appropriations committees introduced to the floor just before the August recess have restored some but not all of the major cuts, and have some substantial disagreements.

It is highly likely that the appropriations committees will propose a Continuing Resolution (CR) for FY18 of the non-defense budgets, keeping the government running temporarily at the same levels as FY17, given the little time left before October to negotiate the proposed changes. An important point to make to your congressional representatives and their staff is that a full-year CR for FY18 enacted at the administration's FY17 levels, rather than a stopgap CR of a few months followed by an attempt to enact an FY18 budget, will allow a more measured process for management of the scientific community. A full-year's CR in FY18 would also allow the administration more time to focus on its FY19 budget formulation, which is starting now.

I'll end with an extremely important point: Although I have been talking about physical science, we need to come together as the whole science community to argue that a broad spectrum of government-supported R&D is important, rather than pointing fingers at other disciplines and saying we should be funding this and not that.

Although federal R&D funding is only 3% of the annual budget, it is a critically important investment in the future of our nation.

The author is Benjamin Peirce Professor of Technology and Public Policy in the John A. Paulson School of Engineering and Applied Sciences and Professor of Physics, Harvard University. She served as the Director of the Department of Energy's Office of Science from 2015 until 2017, overseeing $5.5 billion in research funding as well as the management of 10 national laboratories. She was dean of the School of Engineering and Applied Sciences at Harvard from 2009 until 2014, and principal associate director for science and technology from 2007 to 2009 and deputy director for science and technology from 2004 to 2007 at Lawrence Livermore National Laboratory. From 1978 to 2004, Murray held a number of positions at Bell Laboratories (Lucent Technologies). She served as APS president in 2009, and is a member of the National Academy of Sciences and National Academy of Engineering as well as a Fellow of the American Academy of Arts and Sciences.

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anytime soon, but astronomers continue to hunt for evidence of SMBH mergers, which are predicted to be powerful sources of gravitational waves.

Proton is Lighter than Expected

A new measurement of the mass of the proton is the most precise to date and at the same time significantly disagrees with the previous consensus value. Heiße et al. report the result, which they obtained by comparing the motion of a single proton in a magnetic field to that of a carbon ion, in *Physical Review Letters* (DOI: 10.1103/PhysRevLett.119.033001). The researchers stored a proton in a Penning trap, a special configuration of electric and magnetic fields, and measured its cyclotron frequency, which is proportional to the ratio of charge to mass. They compared this to the cyclotron frequency of a 12C6+ reference ion to derive the proton mass with a precision of 32 parts per trillion, and were confronted with a surprise: the proton mass value differs by three standard deviations from the CODATA value (an international compilation of physical data). The value of the proton mass is a key parameter in many aspects of chemistry and physics. The authors next plan to improve the experimental precision by reducing field inhomogeneities in the Penning trap—the main source of systematic error. For more, see the Synopsis in *Physics, "*Proton Loses Weight."

Nanotubes Generate "Truly" Random Bits

Cell phones, computers, and even watches are capable of keeping you online 24/7. To protect privacy, information is encrypted with the help of true random number generators (TRNG), which create a random series of 0s and 1s that encode your data. But as technology becomes sleeker, smaller, and more powerful, it is more difficult to fit TRNGs into microcircuits. Researchers have now found that combining carbon nanotubes with static random access memory cells can create true random bit streams. As Hersham et al. report in *NanoLetters* (DOI: 10.1021/acs.nanolett.7b02118), they exploited the natural thermal fluctuations that occur in carbon nanotubes to digitize high and low voltages into bits (high voltage = 1, low voltage = 0). Their circuit passed a series of rigorous checks, including a National Institute of Standards and Technology test suite. The team's work could pave a path for the development of low-cost and widely applicable security devices for next-generation electronics.

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may become feasible. A Li/S battery would have an energy density twice today's Li-ion batteries with potentially increased safety when a solid electrolyte is employed, and reduced material cost. Lithium metal reacts violently with water, which should be possible only in the event of serious physical damage; or fire could occur if a cell shorts due to growth of a dendrite.

Li/S batteries still have some challenges in cycle life and high-rate manufacturing but look very promising. If these challenges can be overcome, Li/S would be the first significant new battery chemistry since the invention of the Li-ion battery nearly thirty years ago.

There is an example of a Li/S battery in use for flight: Sion Power makes a Li/S battery for UAVs (Unmanned Aerial Vehicles). But it is a long way from a UAV to transporting humans.

The two advances listed above could considerably increase the range and lower the cost of electric cars, make batteries more safe, and maybe even make electric VTOL planes a reality, but perhaps not soon. Our battery future is looking brighter than it has in recent times.

I am still dreaming about being able to fly over those awful freeway jams.

The author is a physicist retired from Lawrence Berkeley National Laboratory, a Fellow of the American Physical Society, and an occasional policy analyst and consultant to APS. He is especially interested in the future of renewable-energy storage and the application of electricity to our transportation future. He is also a Commissioner on the Energy Commission of the city of Berkeley, CA: one of his present issues is replacing natural gas with electricity for residential space and water heating. Fred continues his study of the Thai language in his spare time.

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the bipartisan Ph.D. Physicists' Caucus," said Foster. "At the time I was elected, Vern had already spent more than a decade trying to bring logic and rational analysis to the deeply irrational business we were in. He understood both the need to insist on valid scientific analysis of technological issues like Ballistic Missile Defense and the separate need to apply one's deeply held beliefs towards issues like environmental protection. Vern's career will serve forever as a model to anyone thinking of using their technical knowledge to make Congress and our world a better place."

Born in Minnesota in 1934, Ehlers received his bachelor's and Ph.D. degrees in physics from the University of California at Berkeley. He carried out research at the Lawrence Berkeley National Laboratory and then joined the faculty of Calvin College in Grand Rapids. He entered the Michigan state House of Representatives in 1983. In 1993, he entered the U.S. House of Representatives after winning a special election to replace Rep. Paul Henry, who died in office.

Michael Turner, director of the Kavli Institute for Cosmological Physics at the University of Chicago and former APS President, served with Ehlers on the APS Physics Policy Committee. "Vern was the first Ph.D. physicist in Congress and he did us proud," said Turner. "As they say, you only get one chance to make first impressions, and Vern made a good first impression for the physicists who would follow. He was bipartisan, low-key and wise."

"His colleagues knew he had a science background, but he wasn't pushy or preachy about it," added Turner. "Instead, he was very approachable and a good communicator. He was generous with his time and over the years provided much wise counsel to the APS. When he stepped down from Congress, he bemoaned the growing polarization. He served at a time when science was bipartisan and we benefitted from the support of both parties."

BEAM FUND continued from page 2

see the BEAM website at aps.org/programs/minorities/nmc/nmc-beam.cfm.

The BEAM fund was made possible in part with a grant from the Kenton and Amy Brown Fund of the Winston-Salem Foundation. Such generosity is only one of many ways to support APS programs. If you too would like to make a difference in the lives of others, please contact APS Director of Development Irene Lukoff (lukoff@aps.org).

The Back Page

The Federal Budget, Part One: Physical Science Research and Development Funding for Fiscal Year 2018—a Call to Action

By Cherry Murray

Note: this article is based on a presentation given to the 2017 APS April Meeting in Washington, D.C. in January 2017, with an added mid-August update.

When I gave a presentation at the 2017 APS "April" Meeting last January, I had just completed my appointment as the Director of Science at the U.S. Department of Energy (DOE), which as the *APS News* readership knows is the largest funder of physical science research in the federal government.

I hadn't actually paid a lot of attention to the entire federal budget until I became a federal employee, and then I found it to be quite sobering.

In this Back Page article spread across two issues of *APS News,* I will first, in this Part One, cover some historical trends in U.S. research and development (R&D) funding, contrasted with that of some other nations, and then provide an update on the administration's proposed budget for the next fiscal year (FY18) and a call to the physics community to respond.

In Part Two, in the October issue, I will give a short tutorial on the federal budget as a whole and where R&D fits into it, and I hope to have an update on the congressional budget marks for FY18.

The process and timeline by which the U.S. federal budget is built

The U.S. federal government is normally working on three annual budgets simultaneously. The budget for FY17, from October 1, 2016 to September 30, 2017, is being executed by agencies now. Let's call that budget the FY budget.

At the same time, the FY+1 budget is under consideration by Congress; that budget is (normally) submitted to congress by the president during the first week in February of FY, i.e., four months after the start of FY and eight months prior to the start of FY+1. Congress must assess this budget, usually through hearings and testimony, and enact 12 separate appropriations for the FY+1 budget.

Because of the turnover in the presidential administration last January, submission to Congress of the president's FY18 proposed budget was delayed until late May, and congressional budget hearings are just now being held for FY18 as I write this in late June.

Concurrent with congressional consideration of the FY+1 budget, the administration is formulating the FY+2 budget, a process led by the Office of Management and Budget (OMB) and negotiated separately with each agency; the formulation process can take as long as one year prior to the submission to Congress.

Trends in Federal Spending on Research and Development

Why do governments fund research and development? It is not because, as we all know, science is beautiful.

In 1945, after the major R&D effort that arguably won the war, Vannevar Bush, the first science advisor to the president, in his report *Science: The Great Frontier* made the case for federal government support of research. His argument was that industry does applied research and development, while the federal government must invest in basic research broadly underpinning both national security and the economy.

The U.S. funds federal R&D to ensure national security, innovation, and economic competitiveness—and over the years, improvements in health and food supply and improvements in the environment have been added as well. But the first three are by far the major reasons.

Federal investment in R&D since the 1950s has been a major contributor to the U.S. military and economic global position; but sustaining that global position is no longer a given.

A U.S. National Academies committee on which I served in 2007 (and which issued the *Rising Above the Gathering Storm* report) pointed out that federal R&D, especially in fundamental research, underpins technology and economic development in the U.S. Economists have shown that 85% of our economic growth is due to investment in R&D. Our committee and many others have worried about how the U.S. is losing its international lead in science and technology, how quickly that can happen, and how hard it would be to regain.

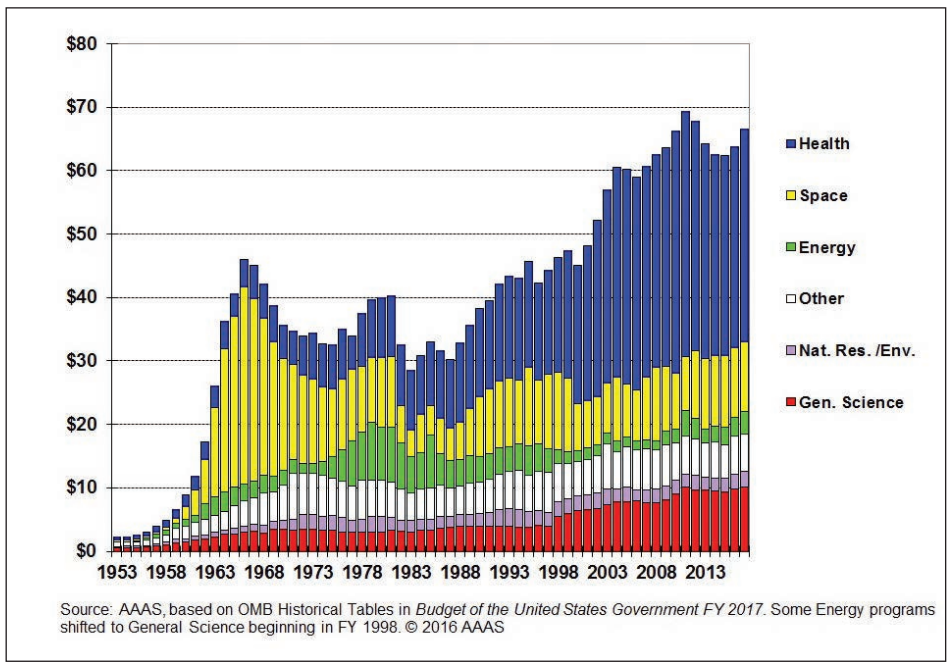

Figure 1. Trends in federal non-defense spending on R&D in constant 2014 dollars

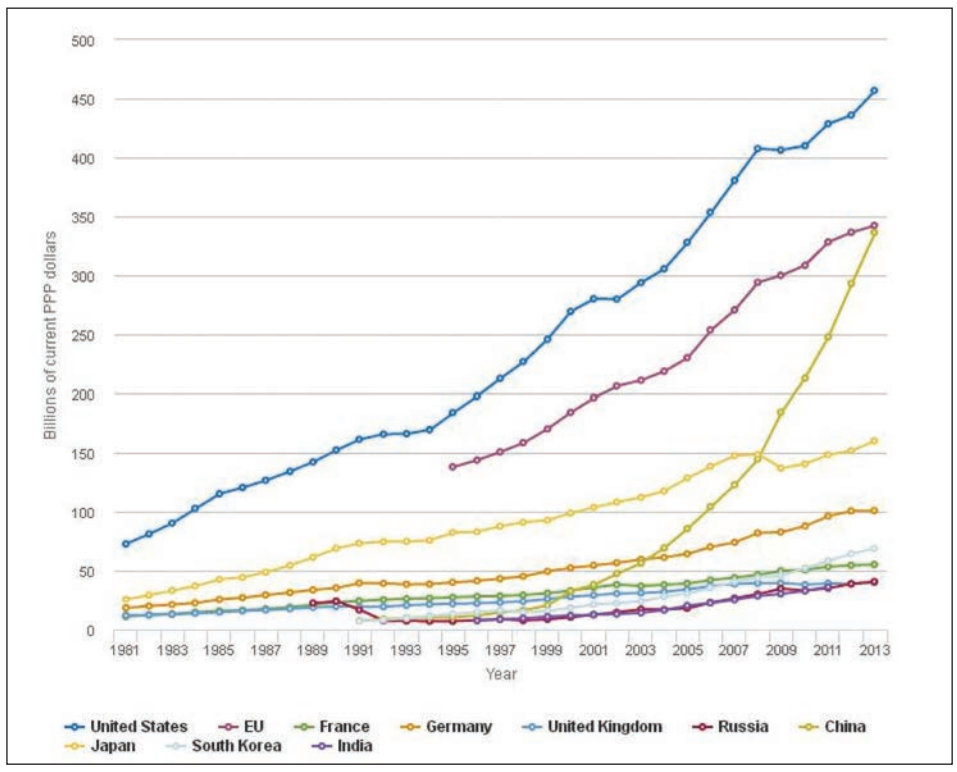

Figure 2. Trends in national and European Union R&D spending in current purchasing power parity dollars Source: U.S. National Science Board

Relevant to physical science research is the "discretionary" spending part of the federal budget, a yearly budget process for about a third of the entire budget of $3.7 trillion through the appropriations committees of Congress. This comprises about half defense and half nondefense spending. And the R&D part of each of those is about 10%, together a very small slice of the total federal budget—roughly 3%.

Despite the importance of federal investment, and its relatively small percentage of the entire federal budget, the federal spending on R&D, as a percentage of gross domestic product (GDP), is going down. In fact, it is pretty much following the decreases in all discretionary budgets over the last thirty years: R&D went from 1.2% of GDP in the late 1970s to just under 0.8% in 2016.

The half of federal spending on R&D for defense is mostly for major systems development. Very little is for basic research—the basic research portion of defense R&D has been decreasing over the last 50 years. And non-defense R&D continues to go down as a percentage of GDP, despite all of the sound arguments to the contrary.

There have been large fluctuations in the funding of types of non-defense federal R&D as shown in Figure 1: first starting in 1957, as a response to Sputnik, the Apollo program provided major funding for NASA. And then there was a blip in energy research during the oil embargo starting in 1973. After that, there was the space station, a slight uptick in NASA in the mid 1980s, and a major increase in life-sciences and medical spending due to the war on cancer and doubling of the National Institutes of Health budget starting in the early 1990's.

International trends in domestic R&D spending (industry and government spending) over time are both interesting and alarming as shown in Figure 2. In the U.S. and the European Union, R&D spending has been climbing nicely, but you can see the amazing skyrocket of the domestic R&D spending of China over the last 20 years. China has made it part of its 15-year plans to aggressively catch up. They have a plan to grow R&D in a comprehensive multi-year strategic program, with plans for a national lab and academic system to rival those of the U.S. and Europe.

Science is international, and the only way to lead in science is to stay ahead of the competition. The global competition here is for the best and brightest minds, which will be drawn to the nations with the greatest ecosystem for scientific R&D and industrial innovation. It is of strategic importance to the national security of the U.S. that cutting-edge biology, materials research, and the fastest indigenous computers are now in China, and that both China and Europe are heavily investing in advances in quantum science and technologies, brain science and artificial intelligence, new energy technologies, and synthetic biology—areas on the cusp of major advances in science and industry.

Funding for Physical Sciences R&D in the FY18 Federal Budget

The administration's proposed FY18 budget drastically slashes non-defense discretionary spending and R&D. Wild swings in R&D budgets are especially poor ways to manage a scientific workforce, and there is considerable pushback from Congress on this.

The administration's FY18 proposed budget cuts to R&D spending in the physical sciences terminate the Advanced Research Projects Agency - Energy, and range from 11% to the National Science Foundation to 16% for DOE Office of Science and 30 to 70% for applied energy programs at DOE. In addition there are proposed drastic reductions in the earth observation and environmental R&D programs across all government agencies.

These cuts if enacted in the DOE R&D budget would immediately trigger layoffs of roughly 25% of staff at the ten DOE Office of Science national laboratories, and reduce operations at the scientific user facilities by 11% to 40%, which would lose the ability to accommodate about 20% of the current user base, three quarters of which comes from academia. The DOE cuts, if enacted, would reduce the physics research funding directly going to universities by 20%, on top of reductions from other agencies. The drastic reductions in applied energy program R&D would cause the U.S. to lose its lead in technology development and economic competitiveness in the major global energy transformation happening in the next decades.

In addition, the reduction in science and energy funding at the DOE National Nuclear Security Administration defense labs would result in layoffs and be devastating to their ability to recruit and retain the best science and engineering staff, essential for their national security mission.

A Call to Action for the Physics Community

So what can the physics community do?

You can propose to your congressional representatives that the support of research in general, and in particular fundamental research, is an important investment in national security and the economy. This is best done through face-to-face discussions and by telling real stories of how your research or other research in their district has

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