APS NEWS

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APS physics

APS Seeks to Improve Student Visa Policy
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IGEN takes the APS Bridge Program to the Next Level

By Leah Poffenberger

APS has joined forces with four other scientific societies—the American Chemical Society, the American Geophysical Union, the American Astronomical Society, and the Materials Research Society—to increase participation of underrepresented students in graduate physical science programs. The five societies make up the Inclusive Graduate Education Network (IGEN) that will be funded with a five-year $10 million grant from the National Science Foundation.

By supporting more underrepresented racial and ethnic minorities in graduate school, IGEN will build on foundations laid by the APS Bridge Program. For the past six years, the APS Bridge Program has been testing and implementing ways to eliminate a participation gap between undergraduate and graduate students in physics from underrepresented groups. The lessons learned through the APS Bridge Program will now be more broadly applied to other science, technology, engineering, and mathematics (STEM) fields through IGEN.

APS Bridge Program student Michelle Lollie at Indiana University in 2016.

"When we started the APS Bridge Program six years ago, we had no idea how much community support would materialize," said Theodore Hodapp, IGEN Project Lead and Director of Project

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PHYSICAL REVIEW D

covering particles, fields, gravitation, and cosmology

Physics at the Shortest and Longest Scales

By Urs Heller and Erick Weinberg

The first issue of *The Physical Review*, with five articles, appeared in July 1893. Over time the journal grew in both size and stature, becoming the world's leading physics journal. In 1970, motivated by the continued growth, the single all-encompassing journal was divided into a family of four journals, *Physical Review A, B, C,* and *D*, with the shared title denoting a pledge to maintain the standards for which *The Physical Review* had become known.

Physical Review D (PRD) was to cover physics at the shortest—subnuclear—and the longest—cosmological—distances and times. The close connections between these two regimes were perhaps not as well appreciated in 1970 as they are today. The journal was divided into two parts. D1, focusing on the more experimental and experimentally-oriented theory papers, appeared on the first of the month, while D15, containing articles on more formal theoretical topics, was published on the fifteenth. Today articles are published online as soon as they are ready, rather than in semi-monthly batches, but the designations D1 and D15 remain.

The early years of PRD coincided with the development and acceptance of the Standard Model of particle physics. Indeed, in its first year one of the journal's most cited articles, the Glashow, Iliopoulos, and Maiani (GIM) paper on the fourth quark and the GIM mechanism appeared. Another top-cited paper, "Confinement of Quarks" by Kenneth Wilson was published four years later.

125 YEARS

In those years the journal was almost entirely devoted to particle physics. In the first two issues of 1970 only two articles, out of 95, were concerned with gravitation, cosmology, or astroparticle physics. By comparison, 40% of the papers published in PRD in 2017 were devoted to these subfields. A notable precursor, Bekenstein's "Black Holes and Entropy," appeared in 1973. Eight years later Guth's paper on the inflationary universe, PRD's all-time most

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Parker Probe En Route to Solar Rendezvous

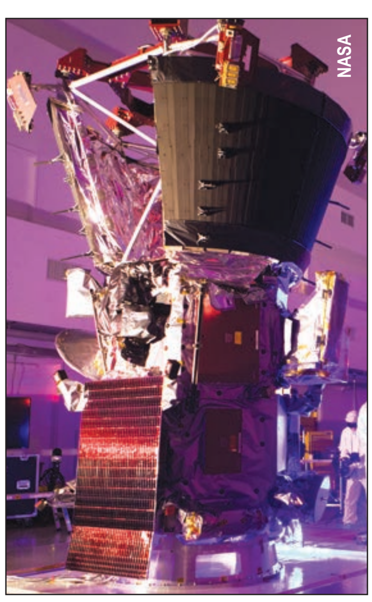
By Amanda Babcock

On August 12, 2018 NASA's Parker Solar Probe blasted off on its seven-year journey to observe the Sun. The spacecraft is named after 2018 APS Medal recipient and APS Fellow Eugene Parker.

Parker's name is familiar to APS members and plasma physicists alike. In addition to receiving this year's APS Medal for Exceptional Research, he received the 2003 APS James Clerk Maxwell Prize for Plasma Physics and the 1989 National Medal of Science. His lifelong work in solar physics, especially his theoretical hypothesis for the superheating of the solar corona, led to his recognition by NASA.

When asked about his reaction to getting a phone call about the honor, the first time a NASA mission has been named after a living person, Parker expressed surprise at the decision. "The call ended, and I sat there staring at the wall, beginning to feel what had transpired," he said.

After a moment, the news began to sink in. "I felt immensely flattered, particularly so after two decades of retirement," Parker said. "The Solar Probe was going to be a big step forward in probing the conditions close to the Sun, and I looked forward to the fun."



The Parker Solar Probe undergoing testing prior to launch

In a paper published in 1958, Parker coined the term "solar wind" to refer to the continuous outward flow of charged particles from the Sun's upper atmosphere (the corona). However, his ideas about the solar wind were initially

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Quantum Information Science in the National Spotlight

By Leah Poffenberger

Quantum information research has become a hot topic in physics circles, but physicists aren't the only ones to see its potential. Recent movements to prioritize research into quantum technologies by international players, like China, Europe, and Canada, has spurred a response from US lawmakers in the form of the National Quantum Initiative Act (NQI).

The House and the Senate have recently introduced bills to create the NQI, a 10-year commitment to advancing quantum information research in the United States. Putting such a long-term program onto the front burner comes with a hefty price tag for developing experimental technology into powerful tools that can impact the economy, industry, and national security.

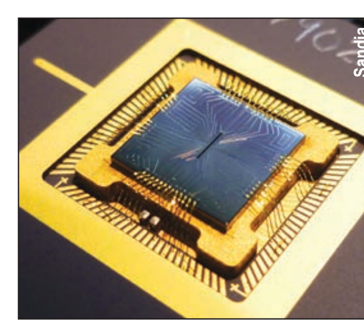
Quantum information research has already become a top priority for government agencies like the US Department of Energy and the National Science Foundation, but the passage of NQI will continue to emphasize the importance of these new technologies. In September, the House of Representatives passed their version of the bill—a version that has been heavily influenced by grassroots efforts by stakeholders from academia and industry.

The initial draft NQI bill established the framework, but without providing any additional funding—all funds would come at the expense of other research programs. Improvements to the bill that restore new funding have since been made, thanks to efforts of the quantum science community through the National Photonics Initiative, the Optical Society, SPIE, and APS.

For its part, the APS approach involved direct member grassroots interaction with Congress. "A lot of our work and a lot of our success comes from working with APS members in order to change this bill," says Francis Slakey, APS Chief Government Affairs Officer. "In this case, it was two APS members who walked into offices in their states and asked direct questions to get the language that we wanted included in the bill."

Several scientific organizations have been urging the US government to embrace quantum technology. But why devote so many resources to a new type of computing instead of using resources to beef up our classical computing capabilities?

"Quantum computing is often misconstrued as being just the next generation of computers that we use, but it's more fundamental than that," says Christopher Monroe, co-founder of IonQ, a quantum computing start-up company. Monroe is also a professor at the University of Maryland, part of a community which he says has more people doing quantum research than anywhere else in the country. "Quantum computers offer the potential for solving problems, that are not only harder than what we can currently do, but problems that could never be solved otherwise."



Ions trapped in devices such as this offer a route to quantum computation.

The kinds of problems that could be solved with quantum information processing tend to deal with a large number of configurations—so large that traditional computers don't have the capacity to process them—like factoring a very large number or searching a huge database. Increased computing power afforded by quantum mechanics comes from quantum bits—the qubits. Regular bits—the fundamental processing units of computers—can only exist in one state at a time, either as a zero or a one, in order to represent numbers. Qubits, on the other hand, can exist as both zero and one at the same time, a condition known as superposition.

"This is what people stay up late at night thinking about: What does it mean to be in two states at the same time?" says Monroe. This question is difficult to answer thanks to another quantum quirk: the system only works as long as

QUANTUM continued on page 6

Small Box, Big Physics: Putting Together PhysicsQuest

By Leah Poffenberger

Every year at the end of August, a small army of high school students descends on the headquarters of Educational Innovations Inc. (EI) in Bethel, Connecticut for a box-packing extravaganza: Over three days, 20,000 cardboard containers are assembled, crammed with experimental materials, labeled, and shipped out to middle schools across the country. Thanks to the expertise of EI, the packing party runs like a well-oiled machine, but coming up with what goes inside the boxes takes some trial and error.

Spectra

Creating innovative physics demonstration kits for under $20 to send to 20,000 physics classrooms is no easy feat. Thankfully, the dynamic duo of EI's Ted Beyer and APS Head of Outreach Rebecca Thompson have the process down to a science.

For 13 years, Thompson and Beyer have been collaborating on PhysicsQuest, the APS program that sends educational materials to middle school classrooms to inspire engagement in physics. Each activity that goes in a PhysicsQuest kit demonstrates a concept found in the accompanying *Spectra* comic books, which are written by Thompson, and make use of fairly easy to find parts. Beyer's specialty is finding the right stuff at the best price.

"There's usually a normal set of classroom activities that you can find—experiments everyone will talk about and everybody will see," says Thompson. "You can't find the activities in PhysicsQuest kits anywhere else—these are all from scratch. It's taking an idea, some experiments people have done before, some classroom activities and totally redoing them in a way that makes them cheaper, or more accessible or way more instructive."

To create these out-of-the-ordinary classroom activities, Thompson takes classroom concepts like diffraction or conductivity and comes up with ideas for experiments mostly using common things like wires or straws. Then it's up to Beyer to find the materials at the best price, propose a better alternative, or sometimes send Thompson back to the drawing board.

"[Thompson] used to call me up and say 'I want, or I need, or

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High school students pack PhysicsQuest kits at Educational Innovations Inc. in Bethel, Connecticut.

This Month in Physics History

October 2006: Definitive Discovery of Element 118 Announced

At the turn of the last century, physicists discovered the process of nuclear transmutation, whereby one chemical element can be converted into another, via nuclear decay. Ernest Rutherford and Frederick Soddy found that the radioactive thorium they kept in the lab spontaneously decayed into radium. Soddy proclaimed they had discovered transmutation. "For Christ's sake, Soddy don't call it transmutation," Rutherford purportedly snapped in reply. "They'll have our heads off as alchemists."

Yuri Oganessian, leader of the team at JINR that made the definitive discovery of element 118, now called "oganesson."

By 1919, Rutherford successfully converted nitrogen into oxygen with this process. And in 1957, physicists figured out that heavier elements were created in the final throes of supernovae. When the age of particle accelerators dawned, physicists realized they could be used to create even heavier elements.

Lawrence Berkeley National Laboratory (LBNL) helped pioneer the field of superheavy elements, creating berkelium, californium, lawrencium, and seaborgium in its cyclotron. By the early 1980s, the Gesellschaft für Schwerionenforschung (GSI) Laboratory in Darmstadt, Germany, was dominating the discoveries, creating bohrium, hassium, and meitnerium, along with the as-yet-unnamed elements 110, 111, and 112. Not to be outdone, Russian scientists at the Joint Institute for Nuclear Research (JINR) in Dubna, headed by Yuri Oganessian, created element 114 in 1998. So LBNL scientists were keen to re-establish their leadership role, and were confident they could find the elusive element 118 with a new gas separator detection device.

In April 1999, LBNL scientists spent five days bombarding a lead target with a beam of krypton nuclei. The debris passed through the separator where detectors could record the energy, position, and timing of each event. All the raw data was processed by LBNL team member Victor Ninov who was originally trained at GSI. He looked for evidence of a decay pattern consistent with krypton and lead fusing briefly to produce a nucleus of element 118. Ninov found not one, but three such events. Two weeks later, after a second run, he found yet another event. The team published their results in *Physical Review Letters*.

The next step was to confirm the discovery by reproducing it in other cyclotrons. GSI scientists tried and failed to do so that summer; scientists at the Riken Institute in Japan were also unable to reproduce the result. When LBNL scientists tried to replicate their own experiment in 2000, they couldn't do it either. An independent review committee was able to rule out the most likely sources of experimental error, and the team spent much of the year upgrading their detectors.

In 2001, they made another run, and once again Ninov claimed to have found evidence of the 118 decay chain, but nobody else on the team could find it in the data. Nor could a second review committee find the pattern in the original raw data from 1999. At that point, LBNL submitted a retraction to *Physical Review Letters*. When the researchers reviewed the analysis software log files for the 2001 data run, initially it seemed to show the decay chain. But a second analysis of events logged just a few hours later in the run showed no such pattern. The earlier record had been changed. Someone had cut and pasted lines from elsewhere in the data and changed a few numbers. The 1999 records also showed similar tampering for one of the three reported events.

LBNL determined that Ninov was the most likely culprit, since he had responsibility for translating the raw data into readable results. And his computer account was used to access the files. Ninov vehemently denied any wrongdoing, but he was fired from the lab. His former colleagues expressed bafflement as to his motives. The review committee also censured the rest of the group for its lack of vigilance.

Nuclear physicists at JINR in Dubna led by Oganessian, along with colleagues from Lawrence Livermore National Laboratory (LLNL) continued the hunt for element 118. After additional experiments in 2002 and 2005, they found three more signature decay patterns. This time no one person was responsible for the data analysis, and the findings passed rigorous scrutiny. Finally, on October 9, 2006, JINR and LLNL officially announced they had definitely discovered the elusive element.

Initially given the placeholder name ununoctium, in November 2016 the International Union of Pure and Applied Chemistry officially named it "oganesson," after Oganessian. "For me it was an honor," Oganessian later commented, in no small part because the suggestion had come from his colleagues at LLNL.

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APS Addresses Decline in International Student Applications to U.S. Physics PhD Programs

By Tawanda W. Johnson

In the wake of a decline in applications from international students to physics PhD programs in the United States, APS leadership recently met with congressional staff on Capitol Hill as part of a larger effort to reverse the trend.

"Physics students want to come to the United States from all over the world because they know their educational and career opportunities here will be extraordinary," said APS President Roger Falcone. "Our country's research, technology, and economy have been enormously strengthened by a positive attitude toward such immigration of students. We should continue to be a welcoming place, and to embrace open and global mobility for people."

Added Francis Slakey, Chief Government Affairs Officer in the APS Office of Government Affairs (APS OGA), "The US is at high risk of no longer attracting the best and brightest minds in physics."

During the 2018 APS March Meeting, a small number of Society members informed APS OGA that their physics departments had experienced a substantial decrease in the number of applications from non-US-based students to their respective PhD physics programs between 2017 and 2018.

To help inform the Society's response, APS OGA worked with department chairs of US physics PhD programs that reported graduating 10 or more students per year to gather data concerning the number of international student applicants. A total of 74 department chairs were contacted, and 49 responded to the inquiry.

The departments that responded to the survey represent 40% of all international physics graduate students enrolled in the US Additionally, 41% of all physics graduate students enrolled in the US were at one of the 49 respondent departments.

According to the data collected in the report, there was an overall decrease of almost 12% in the number of international applicants to the physics PhD programs that responded to the survey.

Although some institutions did not see a decline in their international applications, there were a handful of programs that experienced declines of more than 40%.

Among the questions asked in the study were: "How has the general decline in applications impacted your 2018 cohort?," "Has the overall class size changed?," and "Did you accept more domestic students?"

The replies, which were reported anonymously to protect the integrity of the PhD physics programs, included the following: "We've admitted more domestic students, so as to fill our program. On the other hand, many of the better applicants in the past were international students, so our sense is that the overall quality of the applicants we admitted this year was somewhat lower than in the past."

Respondents were also asked, "Could you comment on what countries had the largest declines in terms of applicants, from 2017 to 2018?" For schools reporting their Chinese applicant numbers, the average decline was 16.4%.

Some department chairs speculated about the possible reasons for the decrease. "There is speculation among the faculty, but it is not necessarily evidence based: That Chinese institutions have 'arrived' in terms of quality, meaning many Chinese students prefer to stay home rather than go to the US for graduate study," replied one department chair.

Another department chair stated, "Anecdotal evidence and rumors suggest that China has been investing heavily in training young scientists, particularly in the area of condensed matter physics, and so many talented students may be choosing to stay in China for their post-graduate studies rather than go abroad…"

To address these concerns, APS OGA is implementing a strategy that entails making the F-1 visa—the standard method international students use to enter the US to study at colleges and universities—"dual intent." Under current law, international students have to prove that they will return to their countries after they have been educated in the United States. That can be an extremely high burden of proof for students who may have to demonstrate that they have a spouse, a child, an ill relative, or property to care for back home.

With an F-1 "dual-intent" visa, students would no longer be required to provide proof that they are only in the United States temporarily and have the ability to declare that they plan to live and work in the United States permanently, giving them a smoother pathway to a science, technology, engineering, and mathematics (STEM) career in America.

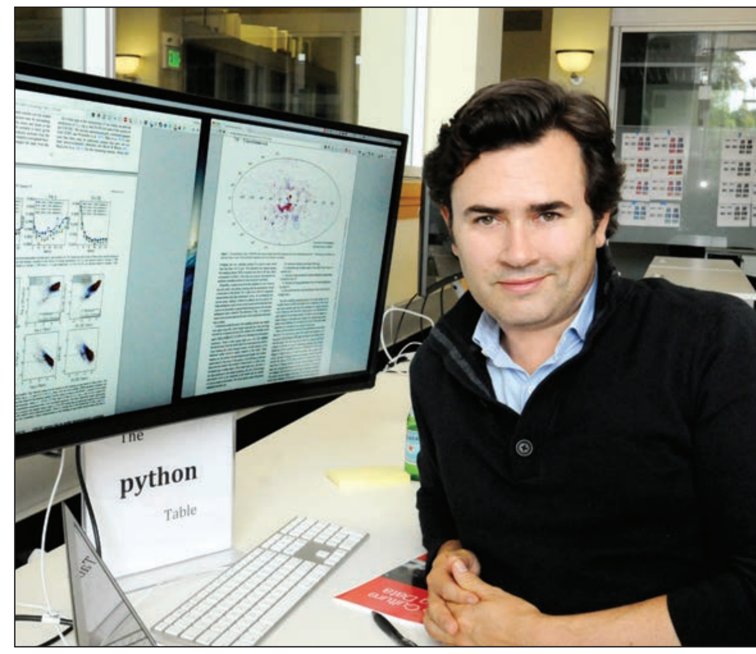
Historically, the United States

DECLINE continued on page 7

Profiles in Versatility

The Industrial Internet of Things is Upon Us

By Alaina G. Levine



Josh Bloom moved from astrophysics to working on artificial intelligence and machine learning.

In manufacturing, oil refining, and other industries around the world, a new approach to solving problems and leveraging data is changing the way we make business decisions. The Industrial Internet of Things (IIoT) combines smart gadgets and data collection on grand scales. You've heard of smart refrigerators, smart cars, and smart homes—now imagine a smart power plant, where hundreds of thousands of sensors take data across the entire system, and software, driven by machine learning (ML) and artificial intelligence (AI), provides intelligent information to workers, allowing them to make the right operating choices.

This is the realm of Josh Bloom, a physics professor at the University of California, Berkeley, who also serves as vice president of data and analytics at GE Digital. The former astrophysicist started his career examining gamma-ray bursts, the brightest explosions in the cosmos. But when he realized that an explosion of astro data was imminent, he gravitated toward data science. The problems he was trying to solve in understanding the origin of the universe had relevance for industry as well.

As a new faculty member in Berkeley's astronomy department in 2005, Bloom started thinking about "the massive data influx expected in the coming decade," he recalls. With advances in observatories, hardware, and computing power, "We knew there was going to be a big data problem in astronomy—there was going to be a bottleneck." That bottleneck would be finding out what lay hidden within the vast data and what researchers could do with the information.

Bloom recognized that his greatest asset was his access to experts at Berkeley. So he began giving talks in departments across campus to cultivate ideas from this interdisciplinary nexus. Conversations led to collaborations, and he began to hire computer scientists and engineers into his group. "At this point there was little to no machine learning in astronomy," he describes. "There was the romantic view of astronomy, that you look through the telescope and decide what to do next. We were one of the first groups to augment or replace the human-driven work flows around the data."

Soon he wanted to build systems that not only collected and analyzed data but also provided insight and suggested actions for smart decision-making. He was surprised to learn that this need was not being fulfilled by existing companies

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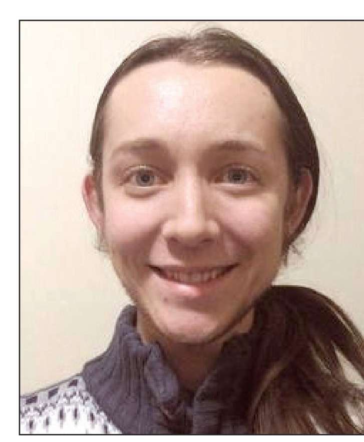
Out in Physics : Gaining Visibility and Acceptance

Erica Snider

Kerstin Nordstrom



Ansel Neunzert

By Amanda Babcock

Scientists around the world participated in the first International LGBT STEM Day on July 5, 2018 to promote the visibility and acceptance of LGBT+ individuals in STEM fields. Acceptance, in turn, directly impacts retention of LGBT+ physics students and professionals of all levels. From the undergraduate level to established physicists, acceptance and retention affect everyone, including Erica Snider, a staff physicist at Fermi National Accelerator Laboratory (Fermilab); Kerstin Nordstrom, an assistant professor of physics at Mount Holyoke College; and Ansel Neunzert, a graduate student in physics at the University of Michigan.

Snider works with Spectrum, a resource group at Fermilab aimed at fostering a welcoming environment for the LGBT+ community. The goal of Spectrum hits close to home with Snider, who has faced her own challenges.

"I've thought about leaving the field at various points, and I certainly did consider the possibility that I might need to leave as a result of coming out as transgender," Snider says. "At the moment that you decide to do this, make the social transition, you have to accept that you could lose everything. That's a possible outcome."

Still, Snider speaks optimistically about her coming out and the reception she got from her colleagues at Fermilab. "When I started that exploration in the workplace, you know, I found the world did not collapse," she says with surprise in her voice. "I enjoy the science, I enjoy the work and I enjoyed the laboratory environment and I like being at Fermilab. So, once I discovered that nobody here seems to care all that much about [my coming out], then it made it much easier to decide [to stay in physics]."

Snider describes the pictures on the walls throughout the lab of scientists conducting experiments at Fermilab. "All of that imagery reflects the culture. Not just the culture that we have, but the culture that we want to have here," she says, reflecting on the diversity of the people in those images. "The type of people who should think of themselves in these roles as scientists and technicians."

Last year, Fermilab debuted a Pride flag in the atrium of its main building alongside the flags representing the many countries and cultures that participate in research at the lab. "I thought it was really important that the laboratory be visibly welcoming to the [LGBT+] community," Snider says of the addition. "You can't tell when you

LGBT continued on page 6

KITS continued from page 2

I have to have [a specific item] made,'" says Beyer. "Now she calls and says 'I need something that has certain parameters'—there's synergy between the two of us because we've worked together for so long."

Beyer recalls Thompson calling him one day asking for individual butter packets to go inside the PhysicsQuest kits for a thermal conductivity experiment. Since butter would melt in the mail, likely ruining the rest of the kit, Beyer looked for a new solution: something easy to pack, inexpensive, and with a low melting point. Inspired by an M&Ms commercial, he decided on Hershey's Kisses—chocolate would be more stable than butter but would still melt. The resulting experiment has the student put the candies on the tops of three different wires—aluminum, copper, and iron—and place the other end of each wire in a cup that would be filled with boiling water. The wires then conducted heat, melting the chocolates to slide down the wire—copper's chocolate slid the most. Iron's didn't move at all.

Sometimes experiments aren't possible because of available resources: An experiment to make optical lenses out of gelatin was scrapped because Jell-o is too expensive and a demo on the tribo-luminescence of quartz was impossible to include since quartz can't be ordered as small portions to fit in a kit. But sometimes the back and forth to find just the right PhysicsQuest materials takes a humorous turn.

"[Thompson] called me up and said 'I have one more thing I want to put into the kit—boiled eggs,'" recalls Beyer. "I expended hours trying to figure out how I could get her hard-boiled eggs—until she called me the next morning to say she was kidding."

The biggest factor that determines whether an activity or a material is usable for the PhysicsQuest kits is cost: Each kit is under $20, usually closer to $15, and half of that is shipping. It becomes a puzzle to determine what will work, and how the kits can be most cost effective.

"We're cutting pennies to make this work," says Beyer. "The spreadsheets I use to calculate how much each kit costs goes four digits beyond the decimal."

Once the materials for the PhysicsQuest kits arrive, the precision continues into the packing and shipping. With more than two decades of experience supplying teachers with materials for classroom demonstrations, EI is the perfect PhysicsQuest partner.

"The effort that goes into making everything work is insane—it's so organized," says Thompson, who visited the EI headquarters in August to get in on the kit-packing action.

"Things don't get mixed up—everybody gets what they ordered and what they ask for and what they need with everything in the boxes—nearly 20,000 kits get where they need to be."

Putting together PhysicsQuest kits is a huge event with many moving parts, but for everyone at EI, it's also something to be excited about.

"We look forward to PhysicsQuest every year—it's hard work, but a lot of fun," says Tami O'Connor, President of EI. "We always have such a sense of accomplishment when it's finished—everyone is just delighted to be a part of PhysicsQuest."

For more about the APS Physics Quest project, visit physicscentral.com/experiment/physicsquest/

The APS Office of Government Affairs

APS Takes Steps to Address its Carbon Footprint

By Tawanda W. Johnson

As a follow-on to its recent assessment of greenhouse gas (GHG) emissions, APS is taking steps to address the impact of the emissions from its largest GHG sources, including emissions from member travel to and from select APS national and annual meetings.

"APS has demonstrated its commitment to addressing climate change through this critically important assessment of the Society's carbon footprint. Moreover, the Society isn't just talking the talk. It's walking the walk by embracing solutions to climate change—one of the most pressing issues of our time," said William Collins, Director for the Climate and Ecosystem Sciences Division at Lawrence Berkeley National Laboratory. Collins also serves as a member of the APS Panel on Public Affairs (POPA).

In 2016, after issuing its Statement on Earth's Changing Climate, APS conducted a GHG inventory of its daily operations and select associated activities. The first portion of the inventory covered two emission categories: Scope 1 (direct emissions from APS-owned sources) and Scope 2 (indirect emissions from purchased energy).

An independent firm audited the results, which were publicly posted online, making APS the first scientific society in the United States to broadly assess and publish its emissions.

The GHG Inventory Advisory Committee, overseen by the POPA, manages the inventory project. Additionally, APS selected Anthesis—a global specialist consultancy skilled in GHG inventory development—to support the committee and assist the Society in determining its inaugural inventory.

APS previously released results from Scopes 1 and 2 last year. Scope 3 results have now been released and include emissions from member travel to and from six of the largest APS national meetings. Emissions from APS meetings are nearly 15 times larger than those of the Society's daily operations. Given the GHG impact of APS's Scope 3 activities, the advisory committee offered a list of recommendations for mitigation. APS is already acting on a number of them.

Although there is no way to make air travel a "green activity," APS has developed an opportunity for its meeting attendees to mitigate their travel emissions. Rather than purchasing carbon offsets, which have often been criticized as being insubstantial, the Society will provide members with an estimate of their carbon footprint and encourage them to donate to an environmental organization of their choice. If they prefer, APS offers members a suggested place for their donations.

In addition, the APS Meetings Department will incorporate language in its request for proposals to future host cities, asking that they provide information related to their environmental and sustainability policies. APS will also provide meeting site selection teams estimates of the GHG emissions for attendee travel to and from the list of proposed meeting locations. These steps will allow the selection of locations that, in addition to providing the necessary lodging, meeting space, and logistical requirements, also enable lower GHG emissions.

"That information will be provided to the site selection teams. Our aim is to help inform them of the potential GHG impact of hosting a meeting at various cities and venues," said Mark Elsesser,

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SIGNAL BOOST

Signal Boost is a monthly email video newsletter alerting APS members to policy issues and identifying opportunities to get involved. Past issues are available at go.aps.org/2nr298D. To receive Signal Boost and learn more about grassroots activities, contact Greg Mack at mack@aps.org.

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

FYI: Science Policy News From AIP

Congress Accelerates Work on Long-Awaited Light and Neutron Source Upgrades

By William Thomas

With spending legislation passed in September, Congress is providing the Department of Energy (DOE) with resources to press ahead quickly on five projects at four major scientific user facilities:

- The Advanced Photon Source Upgrade (APS-U) at Argonne National Laboratory;
- The Advanced Light Source Upgrade (ALS-U) at Lawrence Berkeley National Laboratory;
- The Linear Coherent Light Source II High-Energy Upgrade (LCLS-II-HE) at SLAC National Accelerator Laboratory;
- The Spallation Neutron Source (SNS) Proton Power Upgrade (PPU) at Oak Ridge National Laboratory; and
- A Second Target Station (STS) at SNS.

DOE's light and neutron sources—which also include the National Synchrotron Light Source II (NSLS-II) at Brookhaven National Laboratory and High Flux Isotope Reactor (HFIR) at Oak Ridge—provide unique capabilities for thousands of researchers annually in fields ranging from physics to biomedicine.

The surge in support for facility upgrades is part of a broader, multi-year funding increase for the DOE Office of Science, the nation's largest funder of physical science research.

DOE originally began advancing this latest suite of upgrades between 2009 and 2011, when it provided initial approval for STS, APS-U, the LCLS-II facility, and a facility called the Next Generation Light Source.

However, the department soon put all four projects on ice. Rather than expand SNS, it decided to bring the existing facility up to full capacity. Then, in 2013, an external review concluded DOE's light source plans were insufficiently ambitious and would "leave the US behind the international community." That verdict sent LCLS-II and APS-U back to the drawing board and derailed the Next Generation Light Source altogether.

A revised plan for LCLS-II soon followed and the $1 billion facility is now on track for completion in 2020. In 2016, DOE's planning coalesced around the current five projects, which, combined, are likely to cost over $3 billion.

With bipartisan agreement on the projects' value, Congress is eager to proceed. It accelerated spending on APS-U, ALS-U, and PPU last year and this year they will be almost fully ramped up. Funding for LCLS-II-HE is increasing even as construction continues on the original facility. STS, the most ambitious project of the five, is receiving dedicated project funding for the first time. Congress is also directing DOE to submit a plan for doubling the number of beamlines at NSLS-II.

Earlier this year, DOE Under Secretary for Science Paul Dabbar explained, "The things that were part of our long-term five-year plan for our various labs, those are being brought forward so our lab directors at Stanford and Berkeley are

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Education and Diversity Update

APS Conferences for Undergraduate Women in Physics (CUWiP): Application for Students Closes October 12

The 2019 APS CUWiP will be held at twelve universities across the U.S. and Canada January 18 - 20, 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 3 - October 12 at the CUWiP page.

Deadline to Apply to Host a 2020 APS CUWiP: November 1

The 2020 Conferences for Undergraduate Women in Physics will be held January 17-19, 2020 at multiple sites throughout the United States and Canada. Canadian host applications should be submitted through the same process as U.S. applications. **If you are interested in applying to host a conference, please visit go.aps.org/cuwiphost.**

Get the Facts Out

In conjunction with the 2019 APS March Meeting, PhysTEC will be hosting a Pre-Meeting Workshop on a new initiative called "Get the Facts Out: Changing the Conversation Around STEM Teaching." This project is designed to encourage discussion among students and faculty about teaching as a profession and misperceptions about it. The workshop will be available to those attending the March Meeting and the 2019 PhysTEC Conference. For more information, go to phystec.org.

PhysTEC recently completed a study of "thriving" physics teacher education programs (i.e., programs that frequently graduate five or more physics teachers per year). The goal of the study was to identify common practices and structures of these highly successful programs so that these approaches may be emulated by other physics teacher education programs. To download the report and supporting materials, go to phystec.org/thriving.

APS Releases Updated Statistics on Women, Minorities, and Education

Drawing on national databases, each year the 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 PhDs), women in physics, underrepresented ethnic/racial minorities, and more, visit aps.org/programs/education/statistics. Data are also available to see how every department compares to national averages in terms of producing physics degrees and encouraging diversity among these degrees (aps.org/programs/education/statistics/compare.cfm). Thanks to Bardia Bijani Aval from the College of St. Benedict and St. John's University for his help in assembling the data.

Professional Skills Development Workshop for Women Physicists

With support from the National Science Foundation and the APS Division of Fluid Dynamics (DFD), APS will offer a Professional Skills Development Workshop on November 30 in conjunction with the 2018 Annual DFD Meeting in Atlanta, GA. The workshop is open to female postdocs and early career female physicists and is designed to provide professional training in effective negotiation and communication skills, as well as a special opportunity for networking. Registration will close on October 22. For more information and to register, please visit apsdfd2018.org/events-1/.

Join us in California for the 2018 Bridge Program/NMC Conference!

The 2018 APS Bridge Program & National Mentoring Community Conference will be held on November 16-18, 2018 at Google Headquarters and Stanford University. Workshops and plenaries focus on strengthening mentoring relationships, building firm foundations for successful student experiences, and providing learning and networking opportunities on other topics related to diversity in physics graduate and undergraduate education. Registration is open until October 31, or when maximum capacity is reached. For more information and to register, please visit aps.org/programs/minorities/nmc/conference/.

Millie Dresselhaus Fund for Science and Society

This Fund will support the Dresselhaus Prize, the first APS prize named in honor of a woman, and the Dresselhaus Keynote Lecture, which will provide opportunities and mini-grants to undergraduate women in physics. For more information on how to participate, please contact Irene Lukoff, APS Director of Development at (301) 209-3224 or lukoff@aps.org. Online gifts can be made at go.aps.org/dresselhaus. On the occasion of the fund launch, the following article has been excerpted from Physics Today *(July 1985).*

On Being APS President

By Mildred S. Dresselhaus

It may seem surprising that the most frequent question I was asked during the year I served as president of the American Physical Society was "how it felt" to be president of this distinguished and venerable society. This question is perhaps not so surprising when you consider that the probability for a physicist to experience personally this challenge is only on the order of one chance in a thousand. In this article, I will attempt to give one operational answer to this complex question.

I must admit that I was caught completely by surprise when the chairman of the APS nominating committee called to ask if I would run for vice-president of APS. I could hardly believe that I was a serious candidate.

After consulting my family, my boss, my colleagues, and a few close friends, I concluded that while I didn't have much of a chance to win the election, this would be a fine opportunity to voice some of my priorities for APS, for physics, and for physicists. My boss at MIT assured me that the most valuable contribution that MIT could make to women in science was for me to take this proposition seriously. He did not, however, take my nomination seriously enough to factor the possibility of my election into my work assignments for the coming years.

With these words of encouragement, I accepted the nomination and proceeded to prepare an upbeat, liberal platform aimed at young physicists and industrial physicists. I called for increased participation of the younger, more active physicists in the leadership of APS; I supported increased APS sponsorship of studies on technical issues of national concern; and I said APS should work to increase the scientific literacy of the general public, so that citizens can better make decisions on issues that involve the interface between science and society. My husband

and close friends liked my platform, but thought it was too radical for winning the election. This assessment turned out to be wrong. I honestly believe that I won the election because of my activist platform. … Luckily, the forefathers of APS, in their wisdom, framed the organization's constitution to give the president a two-year apprenticeship prior to inauguration. For me, those two years as vice-president and president-elect were absolutely essential, because there was so much to learn about ongoing APS programs, committee activities and people who carry out the work of the Society. Thus, upon election, I plunged into the work of APS with much enthusi-

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cited paper, appeared.

If one were to pick up a current issue of PRD and compare it with one from the early 1970s, one would notice changes beyond the evolution of the science and the shifting distribution among subfields. Perhaps the most obvious change is in the sheer size of the journal. In 1970, PRD published 912 papers; by 2017 this had increased almost four-fold, to 3470.

Most of this growth has come from outside the US. In 1980, 57% of the papers published in PRD were from the US, while in 2017 78% were from elsewhere. The referee base has also expanded; 73% of the referees consulted in 2017 were outside the US. Almost half of the journal's Editorial Board is based outside the US. PRD, like the entire *Physical Review* collection, has become truly international.

Another change over the past half-century is the increased size of collaborations. The advent of experimental collaborations with authors numbering in the thousands, in high energy physics and now also in gravitational waves, has often been remarked upon. Less noticed has been a trend toward increasing collaboration in theoretical work. In 1970, 45% of PRD papers were by a single author. In 2017 this had fallen to 11%.

The growth of the journal has made it increasingly difficult to keep aware of notable developments outside one's immediate sub-subfield. In an attempt to counter this trend we have begun highlighting articles that the editors find to be particularly important or interesting. Announcements of these Editors Suggestions are posted on the journal's home page, together with a brief summary and a link to the article itself. We have highlighted 250 Suggestions since the first one in 2014.

Of course, it is not as easy to pick up an issue of PRD as it once was, and not simply because the issues have become heavier. The hard-copy journal is becoming a thing of the past. Today, the overwhelming majority of users access the journal online, and the online article, posted as soon as it is ready, is the version of record.

Today much of the physics literature can also be accessed online through the eprint server at arXiv.org. The arXiv began in the high energy physics community, and has been almost universally embraced by those working in this and many other fields. Roughly 98% of the papers in PRD are posted on the arXiv, usually at or before the time of submission to the journal. Thus one of the traditional roles of the journals in these fields, the dissemination of new scientific results, has largely been taken over by the arXiv. However, the journals still have an essential role to play. Peer review acts as a filter, often leading to corrections and improvements in the process.

The transformation of the scientific literature from hard copy to online has led to a movement for open access. Last January APS joined the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP[3]—see *APS News*, December 2017). Under this agreement, the high energy physics articles in PRD are published as open access papers without the authors being required to pay a publication fee.

Much has changed over the almost half-century since PRD began, but the central goal has remained constant. We aim to accept those manuscripts that are scientifically sound and that significantly advance physics. In this effort we will treat all authors fairly and without regard to national boundaries.

Urs Heller is an Editor of PRD and has been with the journal since 2002. He received a diploma in physics at the ETH Zürich and a PhD in theoretical high energy physics at Rutgers University. Lead Editor Erick Weinberg joined PRD in 1996. He received his PhD in physics from Harvard in 1973. After a postdoc at the Institute for Advanced Study, he moved to Columbia University, where he is now a Professor of Physics. He is a former chair of the department and an APS Fellow.

Review of Particle Physics Celebrates its 60th Anniversary Edition in PRD

The 60th anniversary edition of the *Review of Particle Physics* (RPP) is now online in *Physical Review D*. The biennial compilation of particle properties, topical reviews, and physics facts is part text book and part encyclopedia.

For the full story, visit aps.org/publications/apsnews/updates/anniversary60.cfm and go to journals.aps.org/prd/abstract/10.1103/PhysRevD.98.030001 for access to the RPP.

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walk into a place, you can't tell by looking at people, you can't tell by talking to people unless you sort of explicitly bring it up." Though it may seem like a small gesture, even just that visible reminder of inclusivity is enough to alleviate some of the isolation.

Kerstin Nordstrom highlighted the isolation felt by LGBT+ individuals, both in social and working environments. Creating an inclusive environment is important for building a support system for LGBT+ students within the physics department. Nordstrom actively works on creating inclusive environments which can be a challenge for departments not aware of the issues of their LGBT+ students.

People need a safe way to report harassment and other issues, says Nordstrom. Harassment is not exclusive to supervisors and subordinates: it's also a peer-to-peer issue. "Faculty members and other supervisors may not even know that it's happening," says Nordstrom. "But it is and it is creating big climate issues." Still, she advises students to find creative ways to stay engaged and not give up.

"If you're a new grad student, a new post-doc, new faculty member, it's very likely you moved from somewhere else to be at your current position. And that can be extremely isolating," she says, describing a situation common to academia.

Physics itself can be isolating which only compounds the problem for LGBT+ physicists. "Often our work is collaborative, but a lot of real sweat and work is mental. It's in our own heads," Nordstrom says. "We have to write code or analyze data or just run through equations and that's very solitary and a lot of us are very introverted, too."

To fight the isolation, many of Nordstrom's undergraduate students participate in several activities in addition to school, but she cautions them to find one they love and stick to it. "Once you get to grad school, you won't have time to do multiple outside things but that doesn't mean do nothing outside of school," she says. "Find one activity outside of school and commit to it."

Nordstrom's advice comes from personal experience. "I played rugby for the entire time I was in grad school and a post-doc," she says. "That was a huge source of support." The sport helped Nordstrom interact with people outside of physics and gave her a support system free from the stresses of work.

And the stresses can be especially challenging when someone doesn't fit into the binary male/female labeling that society imposes. In the face of this, Ansel Neunzert at the University of Michigan maintains relentless optimism. "I'm trans, I'm non-binary," Neunzert says proudly.

They (Neunzert's preferred pronouns include "they" and "them") came out three years ago as non-binary and speak positively of their experience in graduate school. "Being out in graduate school has for the most part actually gone better than I expected, but it's also definitely been a process of navigating a whole bunch of minor and major decisions," Neunzert says. "I often joke that there isn't really an etiquette that exists for telling someone that you're trans. And so, I try to just look very confident and hope that they follow along."

It's that confidence that Neunzert carries into both the physics classroom and also into advocacy work for the LGBT+ community. Neunzert points to this involvement as what helps to make them comfortable in their career. They were a part of the panel discussion titled "Best Practices for Establishing a Diverse and Inclusive Workplace" at the APS April Meeting earlier this year. "I don't think I could ever be a physicist who just ignores social issues and only does math," Neunzert explains.

At times those social issues have hit close to home. Neunzert describes how it felt to be considered a subject of debate because of their gender. "People will literally get into debates over me and people like me as though we're some sort of hypothetical situation," Neunzert says. "I've sat in rooms where people are debating trans issues as though there aren't any trans people in the room."

Even so Neunzert stays focused on the joy of physics and on continuing to support the LGBT+ community. "I don't take off my gender and leave it at home when I come to work."

LGBT STEM Day website: prideinstem.org/lgbtstemday/

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

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Development at APS. "Propagating this throughout physical science disciplines, and simultaneously confronting how admissions and retention issues are addressed in graduate education was an obvious next step to both expand the impact of this strategy and sustain it for the long run." Catherine Mader, professor of physics at Hope College, will be co-principal investigator and the alliance program director.

IGEN will concentrate on improving mentoring of undergraduates, modifying graduate admissions practices, and recruiting large numbers of students from underrepresented groups who would otherwise not enter graduate studies. For those students who are already in graduate programs, IGEN will improve retention by helping them acquire multiple mentors, ensuring that students benefit from monitoring and intervention early in their academic careers. In addition, IGEN will work to enhance professional development of students to prepare them for the professional world.

"The APS Bridge Program far exceeded its original goals, thanks to the leadership of Ted Hodapp and the support of physics departments across the country," said APS Chief Executive Officer Kate Kirby. "Having seen that the program can be successful in physics, we are confident that the approach can yield similar results across the spectrum of STEM fields, as represented by our partners in IGEN."

While many scientific societies have programs in place to stimulate interest in STEM fields among high school students or undergraduates, many, including the American Chemical Society, have not had a specific program to promote graduate school enrollment among underrepresented minorities.

"We [at ACS] would like to replicate what APS is doing to help underrepresented student groups to make sure they're able to succeed from day one until they graduate," says Joerg Schlatterer, head of the ACS Graduate and Postdoctoral Scholars Office. According to Schlatterer, 17% of chemistry graduates are underrepresented minorities, but in graduate school that number drops to 12%. "We're concerned that talent is being lost by not placing underrepresented minorities in graduate school," he says. "For us, a successful program will look like no difference in these graduation rates."

For more on the APS Bridge Program go to apsbridgeprogram.org.

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it isn't observed.

While the exact details of how qubits behave may be difficult to understand, the usefulness of their bizarre behaviors is apparent: for every qubit that's linked together to form a quantum computer, there's an exponential increase in the number of possible configurations and therefore an increase in parallel computations. The connections between multiple qubits are made without actual, physical wires, thanks to the concept of entanglement, which gives quantum computers their power. The point at which quantum computing can outrun conventional technology is being called "quantum supremacy."

"If you have two qubits there are four possible states, for three there's eight," says Monroe. "If we have 300 qubits—I think we're several years from having control of 300 qubits—that's two to the 300, which is more than the number of particles in our universe."

Harnessing the power of quantum computing could have all kinds of practical uses, which draws the interest of government agencies, like the National Science Foundation, the National Institute of Standards and Technology, and even the National Security Agency. Quantum information processing may be ideally suited for optimization challenges such as the traveling salesman problem: What's the shortest path connecting hundreds of cities on a map?

"This is a classic, really hard math problem—it's a classic logistics problem that companies like Fedex and UPS are very interested in," says Monroe. "For a sufficiently large number of cities, it can't be solved."

The same kinds of computations can also be applied to materials science to model binding energy of molecules by calculating the many possible configurations.

"Quantum computing is a potential way to attack certain problems, but things are in the infant stage," says Monroe. "We don't have the technology to do some of these things yet, but there are paths to getting there."

One of quantum computing's biggest potential uses, and a critical issue for driving government investment in the field, is in codebreaking. This means that quantum research becomes a national security issue.

"A lot of times we start from scratch when persuading people to invest in one area or the other—we hear people ask 'do we really need to be number one in this?'" says Mark Elsesser, Manager of Science Policy at APS. "But when it comes to things that have to do with national security—like quantum computing—in those areas we can't afford not to be number one."

Quantum information science as both part of national security and a future stimulus for the economy has become a priority in the White House, both during the Obama Administration and continuing in the Trump Administration: In June, the Office of Science and Technology Policy created a new subcommittee, led by NIST physicist Jacob Taylor (see *APS News*, February 2018), to coordinate the national agenda on quantum research.

The stimulus for government support of NQI comes from concerns about falling behind other countries in quantum research, especially China, which just devoted $10 billion to build a new quantum computing center. Canada and parts of Europe are in on the race, too, but the hope is that NQI will keep the US ahead by allowing research into different quantum technologies.

"In some places, like parts of Europe for example, they've picked what they think is going to be the winning technology and they're heavily investing in that area," says Elsesser. "The US is still at the point where we can invest in a broad portfolio of technologies because we don't know what the winner is going to be."

Monroe's research and his work at IonQ represent one of the possible quantum technologies: Most of the larger companies on the hunt for quantum supremacy, like IBM and Google, use superconducting wires to make qubits, but Monroe uses individual atoms. The atoms, which are floating in space in a vacuum chamber and held in place with lasers, make great qubits since they're completely identical—there's less room for mistakes with fabrication—and they're much easier to manipulate than traditional qubits made from superconducting materials.

"A superconducting system is like a conventional chip—you have a bunch of things that are wired together and send signals back and forth," says Monroe. "We don't have any wires—we can reconfigure the system in very flexible ways. We don't know exactly what quantum computers will ultimately be useful for, but with a reconfigurable architecture like trapped atomic ions, when someone finds a good use, we will be able to program their application no matter what it is."

In an emerging field like quantum information science that still has many unknowns, both about how the process works and what it can be used for, there's room for even more new ideas.

"We need a marketplace of companies playing with new ideas and designing new systems," says Monroe. "At places like Boeing and Facebook—they should know quantum physics, they will need it for the future, but there's the problem: Industrial engineers are not generally comfortable with quantum physics, and that's a workforce issue."

Part of the NQI legislation aims to address this workforce gap, encouraging bright scientific minds to venture into quantum mechanics—a field that, according to Monroe, isn't just for physicists anymore, as software developers and other "non-quantum people" join in on the research and turn it into useful devices.

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has been able to attract the best and brightest students to its universities and research facilities. And those students have had a positive effect on the US economy. During the 2016-17 academic year, for example, international students and their families at US universities and colleges contributed an estimated $36.9 billion to the US economy. Moreover, American innovation is bolstered by international talent. Of the 87 startup companies valued at least at $1 billion in 2016, more than half were founded by immigrants, with founders of 21 companies having first come to the US as international students.

In recent years, the United States' overseas counterparts have ramped up their research programs, and that, coupled with a desire to raise international enrollment in STEM fields at US universities, is driving the APS strategy. APS OGA is also working with a number of other scientific societies to flesh out the plan for implementing the strategy.

Additionally, APS OGA recently organized meetings on Capitol Hill with 16 physics department chairs who advocated for the importance of attracting international students to physics PhD programs and making the F-1 visa "dual intent."

"There are several reasons that attracting international students to the field of physics is important. First of all, it is good for physics: the more different world experiences we bring in, the more ways we can think about solutions to a problem," said Brett D. DePaola, William and Joan Porter Professor & Head of the Department of Physics at Kansas State University.

DePaola added, "Second, I've found that over the years on average, international students are better prepared for graduate level classroom work than their American counterparts. But our domestic students, on average, are better prepared for laboratory work. Both skill sets are important in developing strong physicists. I've found that by working together, our domestic and international students teach each other, eliminating the knowledge and experience gaps for both groups. Thus, international students are definite assets to the United States graduate education programs in physics."

The author is the APS Press Secretary.

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rejected. Within a few years of that paper's publication, observation from several *Luna* missions, *Venera 1*, and finally *Mariner 2* in 1961 confirmed the presence of the solar wind.

In addition to his work developing the theory behind the solar wind, Parker also sought to explain what causes a dramatic temperature discrepancy that has stumped solar physicists for decades: Why is the Sun's corona so much hotter than its surface?

The photosphere, the visible surface of the Sun, is a balmy 6,000 K, but the corona is significantly hotter, measuring between 1,000,000 to 2,000,000 K. It's a conundrum introduced early in a physics student's career, a fundamental property of the Sun. But what is the cause?

In general, competing theories on the topic tend to fall into three main categories: magnetohydrodynamic oscillations called Alfven waves that can accelerate charged particles; "nanoflares," relatively tiny cousins of solar flares; and the process of magnetic reconnection, where the field lines get tangled and twisted around each other until they snap back to straighter lines. The probe will test the first two of these theories, the second of which was proposed by Parker 30 years after his paper on solar wind was published.

To gain insights into what combination of these mechanisms is powering the solar wind, the spacecraft carries four instrument packages: FIELDS, to capture the intensity and scale of the Sun's electric and magnetic fields; WISPR, a wide-field camera to image material ejected from the Sun; SWEAP, which will collect electrons, protons, and alpha particles; and IS⊙IS to characterize particle energies.

The Parker Solar Probe will be the closest flyby of the Sun of any mission thus far, passing within 6.2 million km of the Sun's surface on its final three orbits. This is a factor of seven closer than the previous record set by *Helios 2* which passed within 43 million km in 1976. As it passes through various solar regions, the probe will be able to collect data and hopefully observe the mechanisms causing the superheating of the Sun's corona.

"Ten years from now we will better understand the activity of the Sun and the associated terrestrial consequences," Parker mused.

In the meantime, the Parker Solar Probe, like its namesake, will continue to study the Sun. The probe will continue a looping orbital path including seven encounters with Venus. In seven years, it will begin its three closest approaches to the sun. Observational data potentially will solve the coronal conundrum and help settle the decades-old debate. And perhaps, as with all science, bring to light new questions about the nature of the Sun.

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

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Manager of Science Policy for the APS Office of Government Affairs (APS OGA).

As part of the Scope 3 assessment, APS is also exploring options to address GHG emissions associated with its investment portfolio. In the meantime, APS continues to focus on Scopes 1 and 2 by investigating the purchase of renewable energy certificates for electricity used by the Society at each of its three locations. APS OGA staffers are also working with building management at the National Press Building and the co-owners of the American Center for Physics to improve the energy efficiencies of the buildings, where possible.

"APS is on the right track with the necessary solutions to address climate change, a critical issue that poses the risk of significant environmental, social and economic disruptions around the globe," said Dan Dahlberg, a professor of physics at the University of Minnesota and vice chair of POPA.

To learn more about APS's GHG inventory and to read the report, go to the GHG Inventory Project page: aps.org/policy/issues/energy/ghg/

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all of a sudden working on things they were hoping to get money for two, three, four, five years down the road."

Meanwhile, the scientific community has its sights set further ahead. This summer, APS released a report recommending the US invest in a new generation of research reactors to help overcome a diminished capacity for neutron scattering experiments. Such a facility would complement HFIR and SNS, but the US has not commissioned a new high-performance research reactor in almost half a century.

Congress is already championing a research reactor, albeit one for nuclear energy R&D. Called the Versatile Fast Test Reactor, the facility would provide a capacity for fast-neutron irradiation experiments that currently exists only in Russia.

The reactor is likely to cost multiple billions of dollars and has not yet undergone a formal review. Some scientists and engineers question its value, but lawmakers from both parties believe it will help keep the US nuclear industry competitive. Accordingly, funding for it is increasing alongside DOE's other major facility projects.

For more on the APS Report "Neutrons for the Nation" visit aps.org/publications/apsnews/updates/neutron-sources.cfm

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

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or start-ups. "I stumbled into the critical aspect of ML in industry," he says. "It wasn't inventing new [algorithms] to do ML, but building a system that can run at scale, that can handle huge amounts of data [in] a privacy-preserving environment."

Collaborations led to creation of a company called Wise.io. Leveraging the team's extensive machine-learning expertise as well as a deep knowledge of customer support processes, its first products captured the decision making of agents on the front lines of customer support. When someone emails a technical support line with a simple query, the software could mimic a live agent to answer basic questions. But if the customer needed a real person due to the complexity of the problem, the software would make that decision and suggest possible resolutions to human representatives. "It freed people to do what they do best—be empathetic and solve the hardest problems for their most important customers," says Bloom. One of their first clients was Groupon.

Wise.io caught the attention of GE Digital, which was looking to expand its reach into data science and ML, especially in heavy industry and industrial infrastructure. In 2016, GE Digital acquired the firm, and Bloom became a GE vice president. Today, his focus at GE is on building ML applications to provide unique value in industry, particularly as it relates to the IIoT.

Bloom's team has been making an impact in the oil and gas sector, where inspection robots are typically deployed inside remote pipelines to help assess pipeline health and identify potential issues. The machine-learning application that Bloom's team developed with GE oil and gas experts allows the company's analysts to home in on problem areas more quickly. "We are not replacing the analysts who have decades of experience looking at these images," he says. "We are trying to find the 'easy' problems to solve to allow the analysts to focus on the grey areas."

Where ML and AI can really make a difference is in large-scale systems such as the IIoT. Smart grids, smart locomotives, and smart factories generate an enormous amount of data, and with an estimated 50 billion connected devices by 2020, Bloom notes. Much of the data coming from the devices are not useful or has, at best, low signal-to-noise. "One of the big challenges is pulling out the right information at the right time that is actionable to users … . This is a problem with human operators—they have too much data to digest." That ocean of IIoT data must be boiled down to something a human can work with.

Physics plays a key role in building and maintaining a successful IIoT. First and foremost, the systems that Bloom models are large-scale and extremely complex, so he is able to borrow from astrophysics to take both a holistic and granular view of the problem at hand. Moreover, the data are collected by physical devices with particular response characteristics. How a sensor in a pipeline will collect data depends on the temperature and pressure changes, vibrations, and other physical stimuli. "We must understand the underlying physics of these objects," he says. "Indeed a physical understanding of a device—through first principles and computer modelling-—provides a natural path to predict faults and detect when something has already gone wrong."

And yet, "We can't put all the relevant physics of these objects into our models because we don't understand all the physics yet or it's simply too expensive to do so," he says. For example, while we know a lot about metallurgy, we might not fully understand the geological forces acting on a pipe underneath the ground. But therein lies the both the conundrum and the supreme opportunity for the IIoT. "This is where the data-driven and physics-driven models operate very powerfully. A physics-based model might get us 90% of the way there to a good prediction and, by layering in sensors, a data-driven machine-learned model might get us the rest of the way."

But Bloom cautions that getting a better answer also requires acceptance. "What's going to happen in the future is a little uncomfortable for some people," he says. "We need our data-driven models to be just as explainable as physical models are—this is a huge challenge and one of the frontiers of machine learning."

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asm and dedication. My life has not been the same since my election to the APS presidential line.

To be sure, serving the society has involved a lot of hard work, but the personal rewards have also been tremendous. First, it has been a marvelous experience to work with so many distinguished physicists and thoughtful people. But more than that, being exposed to such a wide variety of physics has been truly enriching, something like going back to graduate school.

Now that my year as APS president has ended, it is refreshing to look back at the progress that was made. It is, however, difficult to assess at this early time the impact of the initiatives that are taking APS in new directions. Future presidents will support the best programs, and the weaker programs will die. The presidency of APS truly presents a window of opportunity. However, future generations must assess the significance of each president's accomplishments.

The full *Physics Today* article is available at physicstoday.scitation.org/doi/pdf/10.1063/1.880980 courtesy of AIP.

The Back Page

Building a Better World Through Science Diplomacy

By Laura H. Greene

Note: This article is adapted from an address delivered to the APS Leadership Convocation in February 2018

During 2017 my theme as APS President was "Science Diplomacy"—using the words and actions of science to build a better world beyond the realm of any politics; using scientific collaborations among nations to address common problems and to build constructive international partnerships. To repeat: beyond the realm of any politics.

In January 2017, the President of the United States and I each gave our inauguration speeches during the same week and in the same city. On Friday of that week, the Trump administration's executive travel ban was announced during the APS "April in January" meeting in Washington, DC, and I realized that my science diplomacy efforts must now be applied within our own borders. We responded in two important ways. First, we quickly issued a statement (a letter from APS Chief Executive Officer Kate Kirby and me) simply re-affirming our values. We quoted a 2003 APS Council Statement to the effect that pushing the frontiers of science requires the free transmission of ideas and people across borders and boundaries.

Second, I found myself constantly reminding our members, through emails, calls, and face-to-face meetings, that we are staunchly non-political, and I did a pretty good job. We issued several letters and press releases in support of science, including concerns over budget cuts for science. None of this was political—we focused only on the best way to further US science. Our members called on APS in droves to respond and we did so in effective ways. This was only possible because I worked closely with Kate Kirby, James Taylor (APS Deputy Executive Officer and Chief Operating Officer), Amy Flatten (APS Director of International Affairs), and Francis Slakey (APS Chief Government Affairs Officer).

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With our domestic challenges, I had less time for international science diplomacy, but I did help lay foundations and strengthen connections between international societies. Our ties with the Cuban Physical Society (CuPS) began almost three years ago when the US opened up to Cuba, and the APS Panel on Public Affairs (POPA) charged me with reporting on the state of Cuban physics. With help from Myriam Sarachik, a past APS president who lived in Cuba, I had the delightful experience of becoming involved with CuPS and that relationship has grown substantially—Amy, Kate, and I went to their 40th anniversary meeting, which was my third visit.

I have personally worked with many international scientific societies—including those in Canada, Mexico, Brazil, Tunisia, and Ghana—and through the years, I have had the honor of many visits to many countries. My focus has been on developing countries, giving a variety of talks and workshops, and expanding our international alliances. The upcoming APS Strategic Plan includes recommendations from our Task Force on International Engagement and I will continue working with them. I have also taken on new leadership roles at the International Union of Pure and Applied Physics (IUPAP), including becoming Vice President of their Council, with an aim to stimulate and promote international cooperation in physics.

Why work so hard to make the world smaller? I have two answers: diversity and human rights. Let's start with diversity.

I don't bring that up only because I'm a woman physicist with a long and interesting background; I just fundamentally believe that is the right way to go, and I do my best to champion diversity in any way I can. Look at how impressive our APS programs are—from the Bridge Program for underrepresented minorities, to working with LGBT physicists, to what the APS Committee on the Status of Women in Physics has accomplished. I hope to attend the APS Conferences for Undergraduate Women in Physics every year—they are not to be missed!

But if we ignore scientists in developing countries or

the ones who just do not look like us, we are missing out on vast undiscovered talent. And, to attack the problems of the 21st century, we must have diversity of thought and approach. One of my favorite examples is when physicists from the US and the Soviet Union began working together in the 1950s. In my field of quantum matter and superconductivity, we witnessed a complete about-face in theoretical physics: Collaborations led to solving the electron-phonon BCS theory of superconductivity (one of two solved quantum materials problems out of dozens that still exist)—and that was just a group of white guys coming from different countries! In my own research I love to see how students and collaborators from different backgrounds go after problems in diverse ways—it is always enlightening and exciting. And I want to further stress that diversity is more than the way we look, our perspectives, where we are from, or personal challenges, but also our fields of endeavor. To deal with what our planet will be facing in public health, climate change, and global security will require basic science, engineering, humanities, and fine arts.

Most of my work on international science diplomacy has gone smoothly, but we did run into a roadblock. Seven US scientists, including myself, were invited to attend a 2017 international conference on quantum materials that has occurred biannually since 1999, and it was to take place this time in Iran. Only a few days before the conference, we were all denied attending by the US Treasury Department, which claimed we were in violation of the Iranian Transactions and Sanctions Regulations although we were not (see *APS News*, March 2018). Although many in our government value science diplomacy, we have recently seen increased sanctions that will lead to more roadblocks. I will continue to strive, for the good of the US and science to get us back on track.

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Now on to human rights. When I was a graduate student, one of my professors at Cornell, Kurt Gottfried (co-founder of the Union of Concerned Scientists, and winner of the 2017 AAAS Scientific Freedom and Responsibility Award) asked me if I would mentor Elena Sevilla, a physics graduate student who had been in prison in Argentina for two years and could only get out under the "Right of Option." That meant she could only be released if another country accepted her, and the US did so. My response was "hell yes!" We went to the Ithaca airport to pick them up—Elena and her two-year-old son. This case was monitored by APS, the National Academies, and Amnesty International; and that was how I learned how effective Amnesty was at saving lives. That was 41 years ago, this marks my 41st year as a member of Amnesty, and Elena and I are still great friends!

The APS Committee on the International Freedom of Scientists (CIFS) is responsible for monitoring concerns regarding human rights for scientists throughout the world. Over the past few years I have worked with CIFS, AAAS, and the National Academy of Sciences in human rights; and I hope to do more. It is difficult to see your wins and not difficult to see your losses. We think a win was the case of Omid Kokabee, an Iranian graduate student at University of Texas at Austin who, upon returning to his home country to see his family in 2011, was detained because he did not want to do weapons work. Scientific societies monitored this case—and I urge you to see the work CIFS did in this case—(it is posted at aps.org/about/governance/committees/cifs/).

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In 2014, Kokabee received prestigious awards from both APS (the Sakharov Prize) and AAAS (Scientific Freedom). The letters to the Iranian Government could then show that over 100,000 scientists were aware of him. Nothing political—just to point out we were very worried about him (he was in very poor health). He was released in 2016. It was years of work, building up the case and getting the word out.

A current case in Iran is Ahmadreza Djalali, an Iranian medical scientist who was working in Sweden, and was detained upon a visit to Iran. He was charged with being a spy and received a death sentence. Again many societies are monitoring the case and writing letters. In December 2017 the first letter to the Iranian government co-signed by the APS and AAAS presidents was sent. We are monitoring, waiting, and worrying.

Note a theme here—whether science diplomacy or human rights, I only promote them outside of politics. One can be most effective in these areas by being non-partisan. As the 2017 APS President, with my background, I felt I was ready to keep our members, as much as possible, from trying to make APS partisan. It was a challenge!

All of these projects, and more, were only possible because our APS journals are strong and healthy; the revenues from our journals are re-invested back into the Society's activities. As APS proceeds with strategic planning this year, it will be vital to consider the future of the dissemination of scientific information and what scientific information is going to look like. The face of publishing is changing dramatically and at an accelerating pace, open access being one component. It is clear to me that under the leadership of APS Editor in Chief Michael Thoennessen, APS Publisher Matthew Salter, and our team of editors, we are assuring the strength and quality of APS journals.

I want to now turn to you, our leadership and our members. APS needs your help. Now, not all of our members need to be engaged—I was pretty much a full-time lab-rat until I was 40, and that is fine—we need that diverse segment too! But I urge you to encourage your membership units to at least promote young people and underrepresented minorities. We women and minorities do our best, but we need all of you white males to help—you are the majority in our fields. I want each of you to invite worthy women or underrepresented minorities to give talks and nominate them for APS Fellowship or for an APS prize or award. I asked the APS Council to do this—and I'm asking you. If you just put 20 minutes of thought into identifying worthy recipients, I know you will find many. A lot of it is just who you know or think of—so please give it a go. It is really fun and rewarding.

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