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November 2015 • Vol. 24, No. 10

Keeping the Science in Science Fiction
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Neutrino Oscillations Nab Nobel Prize

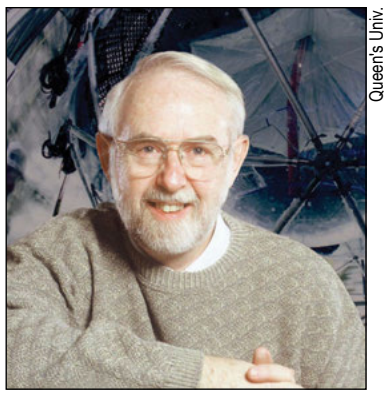
By Emily Conover

The 2015 Nobel Prize in Physics was awarded on October 6 for the discovery of neutrino oscillations, which revealed the unusual behavior of these misfit particles, and indicated that they have mass. The prize honored two scientists who were instrumental in making the discovery: Takaaki Kajita of the University of Tokyo, for his work on the Super-Kamiokande experiment, and Arthur McDonald of Queen's University at Kingston, Canada for his work on the Sudbury Neutrino Observatory (SNO) experiment.

"Hooray for neutrinos — this is the little particle that punches above weight," says Michael Turner of the University of Chicago. "It's truly remarkable how much they've taught us about the universe and elementary particles."

Univ. of Toyko

Takaaki Kajita



Queen's Univ.

Arthur McDonald

Neutrinos are produced in a variety of nuclear reactions and were once thought to be massless. The particles come in three "flavors" — electron, muon, and tau. But we now know that these flavors are not fixed. In a series of large-scale particle physics experiments performed deep underground, scientists showed that neutrinos oscillate from one flavor to another.

"That really turned neutrino physics on its head," says Stephen Parke of Fermilab, because in order for neutrinos to oscillate, they must have mass. A massless particle travels at the speed of light, and therefore can't change, since

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Nuclear Physicists Look to the Future

By Emily Conover

To prepare for the future, nuclear scientists have united behind a plan outlining their priorities for research in the next decade. At a meeting of the Nuclear Science Advisory Committee (NSAC) on October 15, members approved the plan unanimously.

The 150-page plan makes four major recommendations for nuclear research: capitalize on recently completed and ongoing construction projects and upgrades to major facilities; develop a next-generation, U.S.-led neutrino-less double beta decay experiment that could indicate whether neutrinos are their own antiparticles; construct a high-luminosity electron ion collider; and increase funding for small- and mid-scale projects.

The committee hashed out the impact of varying funding scenarios on these projects. These goals would be achievable with yearly budget increases of 1.6% above inflation, the report indicates. But even if funding increases only at the rate of inflation, nuclear physicists say they could still meet their main objectives, although the science reach would be more limited.

The plan also highlights two initiatives that would undergird their recommendations: one to support nuclear theory research, and one to support detector and accelerator R&D.

Finally, the committee emphasized the importance of training students in nuclear science, and recommended boosting programs in that area, including the Research Experiences for Undergraduates program, the National Nuclear Physics Summer School, and fel-

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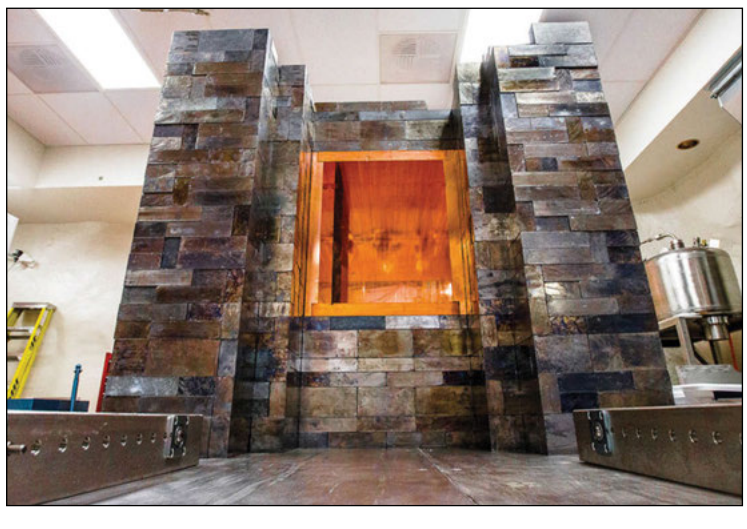

Matthew Kapust/Sanford Underground Research Facility

Researchers will use a detector inside this copper-lead shielded room to look for neutrino-less double beta decay events. The NSAC plan gives this search high priority.

House Science Committee Queries Astrobiology Researchers

By Emily Conover

In an unusually harmonious and enthusiastic meeting of the House Committee on Science, Space, and Technology on Tuesday, September 29, curious representatives peppered four scientists with questions about the search for life on other planets. Fortuitously, the event fell the day after NASA unveiled strong evidence for liquid water on Mars that grabbed headlines and captured the public imagination — apparently including members of the Science Committee: Chairman Lamar Smith said he was "absolutely astounded."

One representative resorted to poetry to express his appreciation for the search for life on other planets — Ed Perlmutter (D-CO) recited a Tennyson quote written on the wall of the meeting room — "For I dipped into the future, far as human eyes could see, saw the vision of the world, and all the wonder that would be." The research, he added, "gives me goosebumps."

Astrobiology — the study of life in our solar system and beyond — unites a variety of fields, including astronomy, physics, biology, and geology. At the hearing, the scientists discussed the possibilities for microbial life on the four solar system bodies considered possible hosts — Mars, Europa, Titan, and Enceladus — as well as current and upcoming exoplanet research, and

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APS PUBLIC OUTREACH

The Physics Bus: Coming to a Town Near You

By Emily Conover

A bus full of physics experiments is cruising through the small towns of Florida this fall, thanks to the hard work of a few dedicated volunteers and the support of an APS Outreach Mini-grant. The grants, awarded earlier this year, funded eleven projects, with up to $10,000 each, to help small groups bring the wonder of physics to the public.

The first Physics Bus rolled out in 2004, in Tucson, Arizona, when Chris DiScenza and colleagues filled a bus with physics demonstrations and created a science center on wheels, which they took to schools, libraries, and museums across Arizona and as far away as Boston and Edmonton. The brightly colored vehicle runs on vegetable oil, making the bus itself a part of the science.

Erik Herman

Demos are a big part of the Physics Bus program.

Over the years, the program spawned other physics buses, expanding to Ithaca and now Gainesville, where DiScenza had moved for a graduate program in coastal engineering at the University of Florida. The Physics Bus teams are all affiliated with The Physics Factory, a nonprofit organization based in Tucson.

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Inside the Beltway

Does Science Bear Any Responsibility for Today's Political Discontent?

By Michael S. Lubell, APS Director of Public Affairs

Not long ago, a friend and former classmate of mine from Yale sent me an email asking whether I had "a sense of how [the 2016 presidential election] will shake out." I told him I would provide an answer in my next *APS News* column. So I'm on the hook.

But before I get to the narrative, here's a bit of a teaser. Our nation's obviously sour mood has a lot to do with the impacts of science and technology.

Now back to my friend, Eric's, email. He preceded his question with several of his own observations: Hillary Clinton is still fighting to put the Benghazi issue behind her; the more Donald Trump says, the less presidential he seems to be; and Bernie Sanders, in Eric's view, has fallen short in demonstrating that he has the experience needed for the presidency, at least in foreign affairs.

He might have noted that neither Trump, who is still leading the pack of GOP establishment canditates, nor Ben Carson, who is jockeying for the number one outside slot, has had a drop of electoral experience. And Sanders, a 73-year-old policy wonk from Vermont who hasn't shed a shred of his Brooklyn accent and calls himself a democratic socialist or just a plain old socialist depending how the mood strikes him, is running even with Clinton in New Hampshire and nipping at her heels in Iowa, according to a spate of recent polls.

It's also Trump, Carson and Sanders, all anti-establishment outsiders, who are drawing the biggest crowds wherever they go. Yes, it's still four months before the first primaries, and voters probably haven't truly focused on the 2016 election. But, in more than 45 years in politics, I have never seen such an astonishing set of public preferences. What is going on?

A new Economic Policy Institute report provides a possible clue. Josh Bivens and Lawrence Mishel, the report's authors, took a hard look at the impact of productivity, defined as economic output per unit input (e.g., labor and capital); on a typical worker's compensation. What they detail is profoundly disturbing.

Bivens and Mishel trace the history of productivity and compensation from 1948 to the present. During the first 25 years, hourly compensation fairly tracked gains in productivity, rising 91.3 percent during that period while productivity, driven in large part by technological advances, rose 96.7 percent. But from 1973 through 2014, while productivity continued to soar, rising another 72.2 percent, compensation grew by a paltry 9.2 percent.

In short, during those four decades, the average worker stopped benefitting from science and technology's largess. But corporations did not: their profits rose dramatically, and their stock prices soared. Between the beginning of 1973 and the end of 2014, for example, the Dow Jones Industrial Average, adjusted for inflation, rose 216 percent.

Although the average worker did not benefit from increased productivity, the average CEO did. With executive compensation ever more tightly tied to stock price performance, CEOs, who in 1960 earned roughly 30 times what their workers did, now take home about 300 times what their employees do.

As Thomas Picketty documents in his 2013 bestselling tome, "Capital in the Twenty-First Century," the rich have been getting richer, while everyone else has seen take-home pay and wealth stagnate or decline. To be sure, scientists are not responsible for that outcome. But the technological advances and innovations their research has generated have been a large part of the productivity-enabling mechanism, as economists Robert Solow, Michael Boskin, Edwin Mansfield and Paul Roemer have each concluded.

Innovation and the productivity gains it spawns need not result in growing income and wealth disparity, as the period 1948 to 1973 amply demonstrates. But avoiding the disparity requires public policies that enable a larger fraction of the population to participate in the benefits that accrue. Clearly, those policies are absent today.

In the last 45 years, many politicians in both parties have accepted the propositions that markets are

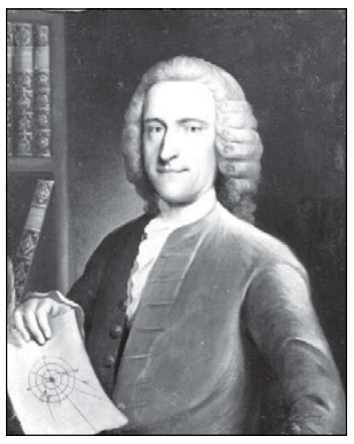
DISCONTENT continued on page 6

This Month in Physics History

November 1696: William Whiston's Explanation for Noah's Flood

History is filled with doomsday prophets predicting the end of the world. One of the more colorful was an 18th-century natural philosopher named William Whiston, who tried to blend science with his decidedly unorthodox and apocalyptic religious views.

Whitson was born in 1667 — one year after Isaac Newton published his landmark treatise, *Principia*. He was the son of a Presbyterian minister named Josiah Whiston, who lived in the town of Norton, England. Educated at home for much of his youth, the boy also helped out by copying manuscripts for his blind father. When Josiah died, young William inherited his library and entered Clare College at Cambridge University with the goal of becoming a minister like his father. He also studied mathematics, as well as the *Principia*. After earning his degrees and being ordained, he initially stayed at Clare College as a math tutor, but ill health forced him to resign that position. In 1694 he moved to Norwich to serve as chaplain to the bishop of that town.



William Whiston

It was during his tenure at Norwich that Whiston penned the treatise *A New Theory of Earth*, applying Newtonian physics to a literal interpretation of scripture. He believed science could be cited in support of certain stories in the Bible. For instance, he concluded that it was Adam and Eve's exile from the Garden of Eden (original sin) that set Earth in rotation, and he linked natural disasters on Earth — most notably, the account of Noah's flood — with astronomical events. In the case of the flood, Whiston fingered a comet as the cause, claiming that comets were also responsible for the formation of the solar system.

Comets were of great scientific interest at the time. The astronomer Edmund Halley had already noted the periodic appearances of comets in the sky, successfully predicting the return in 1759 of the one that now bears his name, although he did not live to see it. Whiston devised an elaborate mathematical proof — accompanied by biblical quotations — to show that a comet passing Earth on November 28, 2349 BC caused rain for 40 days and 40 nights, flooding the planet "to show God's displeasure with the wicked world." These ideas were controversial, but he had allies, among them the philosopher John Locke.

Two years after the publication of *A New Theory of Earth*, Whiston became vicar of a small parish in Suffolk, marrying the daughter of his former childhood headmaster the following year. His father-in-law gave them a farm as a source of income, and in 1701 Whiston briefly became Newton's assistant at Cambridge, but theological differences soon came between them, and they had a bitter falling out. Yet when Newton retired the following year to focus on being president of the Royal Society, Whiston succeeded him in taking the university's Lucasian Chair of Mathematics, although he was never elected to the Society. It is possible that Newton blocked his election. Whiston himself blamed his growing reputation as a "heretick."

Indeed, his unorthodox religious views soon led to his academic downfall. All faculty were required to follow Anglican doctrine. Whiston rejected the Trinity, among other other orthodox beliefs. Although Newton held a few speculative opinions of his own, he kept them private. Whiston was less discreet about broadcasting his opinions and even published a collection of sermons and essays outlining his position in detail.

His Cambridge colleagues were not pleased. When he refused to recant, he was charged with heresy before the heads of all the Cambridge colleges. He lost the Lucasian chair in October 1710 and in addition was dismissed from the university. He even briefly faced the prospect of a trial in London for heresy, but gained a reprieve with the timely demise of Queen Anne.

Left with just the small income from his farm to support his family, Whiston turned to science outreach, lecturing in various coffee houses around London and conducting demonstrations for the public. He also joined forces with a young man named Francis Hauksbee to teach a course on mechanics, optics, hydrostatics, and pneumatics. Eventually their work led to a manual used by lecturers at Oxford University.

He may have lost his Cambridge chair, but in 1714, when Parliament was considering how to encourage its intellectual leaders to tackle the navigational problem of determining longitude at sea, Whiston still had some scientific credibility left. He suggested a financial reward as motivation, and Parliament passed the Longitude Act later that year.

Whiston's motives weren't entirely altruistic: He threw himself into devising his own methods for determining marine longitude, most of which earned the ridicule of his peers. Among his more creative, if impractical, suggestions: firing a shell at a fixed time each day from stations at fixed points all along the Atlantic Ocean. After the flash of the shot, ship captains could then time how long the sound took to reach them, and then calculate their distance.

Over time, Whiston's religious views became even more unorthodox, and his scientific reputation suffered irrevocable damage. He longed for an earlier, presumably purer form of Christianity. In 1715 he founded his own Society for the Promoting of Primitive Christianity, hosting meetings in his home — essentially becoming an 18th century evangelical fundamentalist. He would eventually leave the Anglican Church and become a Baptist. He

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Washington Dispatch

POLICY UPDATE

September 30: Government Shutdown Avoided

Just hours before the government was set to shut down at midnight on September 30, Congress passed a short-term Continuing Resolution (CR) to keep the government funded through December 11, 2015. The House passed the CR by a vote of 277-151 and the Senate by 78-20. Opponents of federal funding of Planned Parenthood cast most of the votes against the bill.

While most CRs maintain flat funding, the current short-term measure includes a 0.02% cut. But unlike the sequester, which mandated across-the-board cuts, under this bill the agencies themselves will be able to determine where best to make cuts.

In December, it is unlikely that Congress will enact appropriations for the balance of the fiscal year. Instead, Congress will probably pass yet another CR, either for another short period or for the entire fiscal year.

Elementary and Secondary Education Act

Both the Senate and House have passed versions of the Elementary and Secondary Education Act, and as this issue of *APS News* went to press, negotiators from both chambers were still working out their differences in conference with the goal of producing a final version that is mutually acceptable. Staff members have indicated that the process is going well.

MEDIA UPDATE

American Research Investment Fund

Former U.S. Rep. Frank R. Wolf (R-10th-Va.) and Norman Augustine, retired chairman of Lockheed Martin Corporation, coauthored an op-ed in *The Hill* newspaper, writing that the best way for the U.S. to compete with China is to start an American Research Investment Fund. (For more on this proposed fund, see "Thinking Big and Outside the Box," *APS News,* July 2015.) Read the op-ed at: http://bit.ly/1K7O9n2

PANEL ON PUBLIC AFFAIRS

After considering membership comments on the revised APS Statement on Civic Engagement and the proposed Statement on Women in Physics, the APS Panel on Public Affairs (POPA) approved sending both to the APS Board of Directors for review. The Board approved each statement, and the APS Council of Representatives will consider both at its upcoming November meeting.

The Council is also scheduled to vote in November on the proposed Statement on Earth's Changing Climate, and also on several current statements up for review by POPA in 2015.

The Physics & the Public Subcommittee continues its work with the American Institute of Physics on a survey focused on overcoming the obstacles of recruiting teachers in the physical sciences. The American Chemical Society and the Computing Research Association are collaborating in the effort. This subcommittee is also developing a proposal for a study on the status of women in physics.

The Energy & Environment Subcommittee is overseeing a November workshop addressing the long-term challenges of helium supply and pricing. The American Chemical Society and the Materials Research Society have agreed to collaborate in the study. This subcommittee is also overseeing the expansion of two pilot programs initiated in 2015: the Liquid Helium Purchasing Program and a science policy internship centered on advancing APS policy goals derived from the 2011 *Energy Critical Elements* report.

A template for study proposals can be found online, along with a suggestion box for future POPA studies, at: aps.org/policy/reports/popa-reports/suggestions/

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still believed in the periodicity of comets, and that a comet had caused Noah's flood. In 1736 he publicly proclaimed that the world would end on October 16 of that year, when another comet would pass by Earth and trigger a massive fire. This sent London citizens into a panic. The Archbishop of Canterbury had to publicly denounce Whiston's prophecy to dispel the hysteria.

The comet came and went, and the world was not destroyed by fire. Whiston was now a laughingstock, and he died a social pariah in 1752 after a short illness. Many comets have passed by Earth since then to no ill effect.

Further Reading

Farrell, Maureen. *William Whiston*. New York: Arno Press, 1981.

Force, James E. *William Whiston: Honest Newtonian*. Cambridge: Cambridge University Press, 2002.

Q&A with TV Science Advisor and Planetary Physicist Kevin Grazier

Dave Fayram

Physicist Kevin Grazier discusses science in cinema and television

Planetary physicist Kevin Grazier hopes to motivate the next generation to go into science — and he's doing it through science fiction. Grazier has worked as a science advisor for sci-fi movies such as *Gravity* and TV series such as *Eureka*, *Defiance*, and *Battlestar Galactica*, the recent re-imagining of the 1970s series. In this role, Grazier works with writers to bring authenticity to the science on the screen.

And Grazier certainly has the science chops for the job: He has a Ph.D. in geophysics and space physics from UCLA, and he worked at NASA's Jet Propulsion Laboratory (JPL) for 15 years before leaving to focus on his work in the entertainment industry. Much of his research at JPL focused on the Cassini probe, which is currently in orbit around Saturn. *APS News* caught up with Grazier at Comic-Con International in San Diego, California, where he moderated a panel discussion about the science of sci-fi. What follows is an edited version of the interview.

How did you transition from science to the entertainment field?

It wasn't really a transition because I'd been doing science advisory things for several years before I left JPL. While I was in graduate school, I was watching *Star Trek Voyager* with a friend of mine. Back then the Star Trek series would take unsolicited manuscripts. My friend and I wrote a script for *Voyager*, and pretty much forgot about it, because we were busy. So, seven months later, I get a call from the executive producer's assistant saying they'd like to have us pitch stories. In doing that, I met two people whom I pitched to: Michael Taylor and Bryan Fuller. When *Galactica* came up I emailed Bryan. I said 'Bryan, I grew up on *Galactica,* so please, please, please, please, please, get me an interview!" And so, he pitched me to [*Galactica* producer] Ron Moore, and because Bryan is well respected it was a five-minute interview, and I was hired. And then it was kind of word of mouth after that.

What are you working on now?

When I left JPL, a little over four and a half years ago, I had

GRAZIER continued on page 6

Zero Gravity: The Lighter Side of Science

Ig Nobels Celebrate Urination and Unboiling an Egg

By Emily Conover

"Listen to me, because this is about physics."

So began the Ig Nobel award ceremonies, the quirky celebration of strange and unusual scientific research, kicked off by physicist Melissa Franklin, of Harvard University.

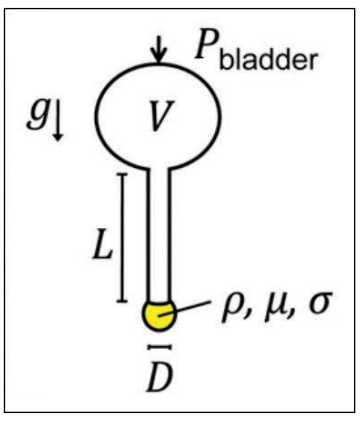
"Well," Franklin continued, "this is actually about airplanes — paper airplanes — but they do obey the laws of physics, or so I say." That was Franklin's way of introducing the grand paper airplane deluge, an Ig Nobel tradition. As Franklin counted down, a rain of paper aircraft filled Harvard's staid Sanders Theatre — the celebration was officially on.

The Ig Nobel Prizes, which celebrate science that "first makes you laugh, and then makes you think," honored ten groups of scientists, for research that included the biological benefits of intense kissing, the most painful body parts to be stung by a bee (reportedly, the nostril, the upper lip, and the penis shaft), and the universality of the word 'huh' across languages. The annual awards are organized by the scientific humor magazine, *Annals of Improbable Research*.

The prize for physics was given for "testing the biological principle that nearly all mammals empty their bladders in about 21 seconds, plus or minus 13 seconds," as reported in a recent paper in *Proceedings of the National Academy of Sciences*, by Patricia Yang and colleagues from the Georgia Institute of Technology.

The researchers, one of whom wore a toilet seat around his neck for the ceremony, wondered how animals with much larger bladders can empty them in the same amount of time as smaller ones, a phenomenon they call "the law of urination." Their light-hearted answer: "All animals have a pee-pee pipe. Because of gravity, the taller the pipe, the faster the pee."

The next time you're waiting for the bathroom, the researchers suggest, give a friendly knock and remind the occupant, "according to the law of urination, you should be done in just 21 seconds."



PNAS

"Assume a spherical bladder..."

The winners of the chemistry prize came on stage with two eggs: one hard-boiled, and one raw. After smashing both eggs with a mallet, the researchers explained that the raw egg has folded proteins, and the boiled one has unfolded proteins. "We invented a way of converting the unfolded protein ... to folded." The prize recognized Callum Ormonde of the University of Western Australia and colleagues for "inventing a chemical recipe to partially un-boil an egg," as reported in a paper in *ChemBioChem*.

As part of the award ceremony, the "24-7 lectures" tasked scientists with explaining a subject twice, first giving a complete technical definition in 24 seconds, followed by a clear summary in 7 words. Nobel laureate in physics, Frank Wilczek, of the Massachusetts Institute of Technology, gave his lecture on "Beauty." His seven-word summary: "We like it when we see it."

Other awards included:

The biology prize for "observing that when you attach a weighted stick to the rear end of a chicken, the chicken then walks in a manner similar to that in which dinosaurs are thought to have walked."

The management prize, for "discovering that many business leaders developed in childhood a fondness for risk-taking, when they experienced natural disasters (such as earthquakes, volcanic eruptions, tsunamis, and wildfires) that — for them — had no dire personal consequences."

The economics prize, awarded to the Bangkok Metropolitan Police, for "offering to pay policemen extra cash if the policemen refuse to take bribes"

The mathematics prize, for "trying to use mathematical techniques to determine whether and how Moulay Ismael the Bloodthirsty, the Sharifian Emperor of Morocco, managed, during the years from 1697 through 1727, to father 888 children."

The diagnostic medicine prize, for "determining that acute appendicitis can be accurately diagnosed by the amount of pain evident when the patient is driven over speed bumps."

For more information about the Ig Nobel Prizes, see: improbable.com/ig/

Letters

Members may submit letters to letters@aps.org. APS reserves the right to select letters and edit for length and clarity.

APS Bridge Program

Kudos to Theodore Hodapp and APS staff for the initial success of the APS Bridge Program, which is significantly increasing the number of underrepresented minority students engaged in Ph.D.-level physics research (*APS News*, July 2015). Readers of *APS News* may be interested to know that the first physics bridge program began back in 2002 at Fisk and Vanderbilt universities. As of spring 2015, the Fisk-Vanderbilt Bridge Program has produced 16 Ph.D. graduates in Physics, Astronomy, and Materials Science, with many more underrepresented minority graduate students in the pipeline. The Fisk-Vanderbilt Bridge Program provided proof of concept that led to the APS Bridge Program.

Richard Wiener
Tucson, AZ

Kepler's Mother and Science Fiction

The article about Kepler's mother in the August/September issue is interesting. But when the writer suggests that Kepler's *Somnium* is "arguably the earliest work of science fiction, given its description of a trip to the moon," I must take the other side of the argument. Lucian of Samosata, who wrote in Greek in the second century AD, is widely considered the earliest science fiction writer. His *Ἀληθῆ διηγήματα* (Verae historiae, or "True Histories") also describes a trip to the moon, among other interesting (and equally implausible) adventures.

Mary K. LeBlanc
Livermore, CA

Shipping Container Security

The method for examining cargo containers for nuclear devices proposed at the April Meeting by Danagoulian and reported in *APS News* (May 2015) is not competitive with the elegant method of muon tomography (C. L. Morris, et al. *Science & Global Security* 16, 37 [2008]) or with the similar method of X-radiography (J. I. Katz, et al. *Science & Global Security* 15, 49 [2007]). Danagoulian's method suffers from two critical drawbacks:

First, the quoted scanning rate of two minutes per container is not compatible with the loading and unloading rate of container cranes, which is about one container per 70 seconds. The resulting port bottlenecks would be unacceptable.

Second, the 15.1 MeV gamma-rays used have a large cross-section for photoneutron emission on most nuclei. Irradiating a container with these gamma rays would produce a neutron flux that would activate cargo and environmental materials by neutron capture, rendering them radioactive.

Jonathan Katz
St. Louis, MO

More on Double-blind Review

I enjoyed reading Shannon Palus' article on double-blind reviews in the July issue of *APS News*. I totally agree with the statement that application across the board is essential for the method's success. However, I believe that the reason for this is simpler than explained in the article. If double-bind review is optional, an author may reason that by requesting this type of review, he/she will be admitting (or be seen as admitting) that they are less sure about the validity of their work than authors who don't mind being identified. Therefore, I believe that studies of the double-blind effectiveness are useless unless they are restricted to journals that apply it across the board.

Besides, I believe that double-blind reviews, if successful, may not do a lot to remove gender bias. (In fact, I would not be surprised to find out that paper refereeing is the area where gender bias manifests itself the least). But it may play a much more positive role in the area of institutional or country bias. There is plenty of at least anecdotal evidence that big-name institutions predispose referees favorably, and if you do a survey of practicing physicists in developing countries, you will be able to collect many refereeing horror stories that those practicing physics in the U.S. or Europe have never heard of.

José Menéndez
Tempe, AZ

Undergrads Share their Research at Optics Meeting

By Emily Conover

Emily Conover

Undergraduate Cedric Wilson chats with conference attendees in front of his poster.

The poster session at the Frontiers in Optics / Laser Science (FiO/LS) meeting buzzed with chatter, animated gestures, and explanations of original optics research. Attendees peppered the presenters with questions, but one came up with particular frequency: "Are you a master's student?" The answer was always negative — they were all undergraduates. The presenters were participants in the meeting's symposium on undergraduate research, yet their work belied their level of education, rivaling that of more advanced students.

FiO/LS, a joint meeting of The Optical Society and the APS Division of Laser Science (DLS), took place in San Jose this October. The Symposium on Undergraduate Research, a tradition at FiO/LS meetings, is hosted by DLS, which provides some funding for students to attend, with additional funding coming from sources like the National Science Foundation (NSF) and the students' home institutions. Since the symposium began in 2001, hundreds of students have taken the opportunity to present their work.

"I love getting to be somewhere where I can just talk about physics and other people are really excited about it too," says Julie Gillis, a senior at Duquesne University. She spent her summer at Fermilab, as part of the Summer Internships in Science and Technology program. She worked on the superconducting electron linear accelerator at the Fermilab Accelerator Science and Technology (FAST) facility, a proving ground for accelerator technology. The FAST accelerator relies on a drive laser system that produces electrons when the laser strikes a photocathode. Gillis optimized one of the amplifiers for the laser system. " I had a fantastic team that I worked with," Gillis says "They wanted me to experience as much as I could."

The driving force behind the session is Harold Metcalf of Stony Brook University, who shepherded the students throughout the day, pushed them to ask questions, and encouraged them to get to know each other and other scientists at the event.

"They learn they're not the

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APS OFFICE OF INTERNATIONAL AFFAIRS

U.S.-Brazil Young Physicists Forum

Opportunity for Early-Career Physicists at the 2016 March Meeting

By Amy K. Flatten, APS Director of International Affairs

I want to inform APS members of an exciting new initiative, led by the APS Office of International Affairs — the U.S.-Brazil Young Physicists Forum (YPF), which will take place the weekend before the 2016 March Meeting, and at the same location (see announcement on p. 7 of this issue).

APS, the São Paulo Research Foundation (FAPESP), and the Brazilian Physical Society (SBF) have been working to bring together young physicists from our two countries. Many U.S. and Brazilian physicists from the United States and Brazil may wish to attend the 2016 APS March Meeting in Baltimore, MD. APS, FAPESP, and SBF will hold a YPF at the site of the March Meeting, on the weekend before the March Meeting begins — March 12-13, 2016. The YPF will combine scientific sessions with career development and networking opportunities for early-career physicists who are employed in a permanent professional position and who completed their Ph.D. within the last 10 years.

The YPF is specifically dedicated to early-career physicists who are working in the U.S. and Brazil in any of the scientific disciplines of the March Meeting, with special focus on networking. The YPF will provide participants with:

- Networking opportunities, scientific presentations, and social events with leading Brazilian and U.S. physicists working in academia and industry.
- Career development sessions on publishing in peer-reviewed journals.
- Panel discussions on university-industry cooperation.
- Scientific parallel sessions and poster sessions with international peers.
- Opportunities for building international and interdisciplinary collaborations.

Space is limited, so I urge early-career physicists to apply soon. The application deadline is November 20; to apply, go to: go.aps.org/ypf-2016.

Each country will send approximately 20 participants, and the selections will be announced in mid-December 2015. Physicists from the U.S. without any experience in Brazil are especially encouraged to apply.

If you plan to attend the APS March Meeting 2016, there should be no additional travel expenses beyond two extra nights at your hotel, and financial support for those expenses is available. See the YPF website and application for full details.

During the meeting, eminent senior physicists will present plenary talks to the early-career physicists, followed by parallel sessions with the participants themselves presenting to each other. Perhaps most exciting, a poster-session/networking-reception will allow early-career physicists to discuss their research with not only their international peers, but also with industry leaders and distinguished VIPs from the FAPESP, APS, and SBF. Throughout the YPF, physicists can discuss their work and connect with potential partners and international colleagues in a smaller, more intimate setting than the larger March Meeting will allow. All participants will be expected to contribute scientifically, either through presenting their research during a parallel session, or presenting a poster during the poster-session/networking-event.

APS President-Elect Laura Greene will present "Publishing in Peer-Reviewed Journals," a talk which she has given to international audiences of scientists around the globe. In addition to the scientific presentations and poster session, two panel discussions focused upon professional development and career-building will be tailored to both U.S. and Brazilian physicists' interests: "University-Industry Collaboration in Research in the U.S. and Brazil" and "Life as a Young Physicist in Brazil and the United States."

The plenary and parallel scientific sessions will provide the YPF participants with an expanded view of physics beyond their own classrooms, laboratories, and nation. The panel discussions and networking opportunities will broaden their perspectives on career opportunities outside of academia, and will allow deeper insights into each country's scientific culture and approaches toward scientific research or partnerships.

Likewise, the relationships formed at this conference have the potential to last throughout the participants' professional lives. As the YPF participants will have already begun attending the annual APS March Meeting, they are likely to maintain connections over the years, as they continue to attend these APS meetings and international conferences in related subfields.

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Education News from APS

Effective Practices Book Released

The Physics Teacher Education Coalition has released a new peer-reviewed book — *Recruiting and Educating Future Physics Teachers: Case Studies and Effective Practices*, edited by Cody Sandifer and Eric Brewe (see *APS News*, October 2015). The book provides a practical guide to innovative, state-of-the-art physics teacher education programs, with a special focus on implementation advice, ongoing challenges, and lessons learned. It is freely available for download at: phystec.org/webdocs/EffectivePracticesBook.cfm

Registration Open for 2016 PhysTEC Conference

The Physics Teacher Education Coalition (PhysTEC) Conference is the nation's largest meeting dedicated to physics teacher education. The 2016 PhysTEC Conference will be held March 11-13 at the Royal Sonesta Harbor Court in Baltimore, immediately preceding the 2016 APS March Meeting. Come hear exciting talks by national and international leaders in physics teacher education, and participate in interactive workshops. Register now at: phystec.org/conferences/2016

Physics Learning Through Best Practices

Periscope is a set of video lessons showing how best practices in teaching can facilitate physics learning in college and university classrooms. The goals of Periscope are to support physics learning assistants, teaching assistants, and faculty. These goals include:

- Learning to notice and interpret classroom events.
- Relating pedagogical knowledge to content knowledge.
- Understanding course transformation.

Periscope is free to qualified educators at physport.org/periscope

Award for Improving Undergraduate Physics Education

The APS Committee on Education (COE) annually presents the COE Award for Improving Undergraduate Physics Education to recognize excellence in undergraduate physics education and to support related best practices**.** This year's selection process was highly competitive, with the 2016 award going to Western Washington University and California State University, Long Beach. More information on this award and a list of past recipients can be found at: aps.org/programs/education/undergrad/faculty/award.cfm

Join the APS National Mentoring Community

The APS National Mentoring Community (NMC) is an effort to increase the number of underrepresented minority students who earn bachelor degrees in physics. The NMC identifies mentors throughout the country who can establish a personal relationship with students and provides these mentors with guidance and support. Please visit aps.org/nmc to join the NMC, and then invite your mentees to join as well.

Einstein's House in Bern: Joint EPS-APS Historic Site

On September 14, 2015, the European Physical Society and the American Physical Society together recognized Albert Einstein's house in Bern, Switzerland, as the first official Joint EPS-APS HIstoric Site. Among those in attendance were Christophe Roussel, president of EPS and Sam Aronson, president of APS.

D. Lee

The house at the Kramgasse 49 in Bern is where Einstein lived during his annus mirabilis. The flat on the second floor, which he had rented from 1903 to 1905, has been restored in the style of that period. His biography and life's work are presented in a small exhibit on the third floor.

D. Lee

From left to right: H.R. Ott, President of the Albert Einstein Society, C. Rossel, President of EPS, Q.M. Tran, President of the Swiss Physical Society (SPS), A. Tschäppät, the Mayor of Bern and S. Aronson, President of APS on the occasion of the inauguration of the Einstein House as first joint EPS-APS Historic Site.

New Editor-in-Chief at *Physics Today*

Physics Today, published by the American Institute of Physics (of which APS is a member society), has a new editor-in-chief (EIC). Charles Day, formerly the magazine's online editor, assumed the top editorial job on November 2, following a 22-year run by previous EIC Stephen Benka. Day will become the seventh EIC at *Physics Today*.

He received his Ph.D. in astronomy from the University of Cambridge in 1988 and joined the magazine as an editor in 1997. Since joining, he has edited many of the magazine's sections as well as regularly writing for his blog, The Dayside.

"Physics Today has the best team of professional editors and staff in the business," said Day in a statement released by AIP. "I'm honored to have been chosen to lead them into the magazine's great future."

Jan Day

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according to special relativity, its clock doesn't tick.

In 1998, the Super-Kamiokande experiment saw a telltale signature of oscillation in muon neutrinos that are produced when cosmic rays interact with Earth's atmosphere. Physicists measured the number of muon neutrinos coming from directly overhead, which passed through the Earth's atmosphere and flew one kilometer underground to reach the detector. They also measured the number that came from below; to reach the detector, those neutrinos traversed a vastly greater distance through Earth. The experiment revealed a deficit of muon neutrinos from below, indicating conclusively that neutrinos changed flavor during their long journey.

When Kajita first presented Super-Kamiokande's results during a talk in 1998, "The entire audience realized that the game had just changed," says Boris Kayser of Fermilab. "Until that point the possibility that neutrinos had nonzero masses was speculation. After that point it was fact." He adds, "I have never heard more enthusiastic, more prolonged applause for a physics talk than for that one."

In 2001, SNO clinched the case for oscillation in electron neutrinos produced by the sun. SNO used several detection methods, including one that measured the total number of neutrinos, and one that measured only electron neutrinos. The scientists saw fewer electron neutrinos than expected, but the total number of neutrinos matched theorists' predictions, indicating that a flavor change was responsible for the electron neutrino shortage.

Previous experiments had shown hints of oscillations, but none that were convincing. "We just didn't have the smoking-gun evidence," says Paul Langacker of the Institute for Advanced Study. But SNO and Super-Kamiokande "cleaned everything up and made it compelling so that every physicist understood that, yes, that's what's going on."

The precursor experiments included Ray Davis' Homestake experiment, which began in the 1960s. Davis' measurements of solar electron neutrinos resulted in the vexing "solar neutrino problem," which took decades to sort out. Davis consistently measured only about a third of the number of neutrinos predicted by theorists, most notably John Bahcall. The SNO result definitively clarified this confusing picture — the predicted numbers of neutrinos were indeed born in the sun, but they oscillated into other flavors, making them unobservable in the detector.

"It was a heroic experimental task to sort everything out," says Langacker.

The prize honors the leaders of Super-Kamiokande and SNO, who worked with their many colleagues to secure the results. On the phone during a press conference announcing the prize, McDonald repeatedly emphasized the contributions of his collaborators, saying, "There's great camaraderie associated with this work."

"These are enormous experiments, and they have now given a Nobel Prize to individuals in these experiments. And that is something that hasn't happened that often before, "says Parke. "I see these two prizes as not only recognizing these two individuals ... but I also see it as a recognition of the two teams."

McDonald, an APS Fellow, previously won the APS Tom W. Bonner Prize in Nuclear Physics in 2003. Kajita received the APS W.K.H. Panofsky Prize in Experimental Particle Physics in 2002.

The discovery that neutrinos oscillate, and hence the implication that they have mass, has led physicists to some intriguing puzzles. In the Standard Model of particle physics, neutrinos are massless. "That tells us that this amazing model we have of how the world works is incomplete and there's more to be discovered," says Turner. APS President Sam Aronson said, in a statment, "The discovery has major bearing on the structure of the universe as well as the physics of the nucleus."

Precise values of the neutrino masses are still unknown, but physicists do know that neutrino masses are oddly tiny — a million times smaller than the electron mass. Some physicists believe there may be different physics underlying the masses of the neutrinos than of other particles. Massive neutrinos could also be a key to understanding the source of the matter-antimatter imbalance in our universe. And there may be other types of lurking, undetected neutrinos, known as "sterile" neutrinos.

"This is not the end; this is really the beginning," says Turner.

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The bus, says DiScenza, serves an important need in north central Florida, the region around Gainesville. "There's a lot of really small towns throughout the area and there's not really enough resources for all the kids in these small towns." This spring, the bus debuted at a local festival, and DiScenza has also visited nearby schools and museums, with plans for more extensive tours in the coming months. A team of volunteers, including physics and engineering students at the University of Florida, has helped get the bus on the road.

Attractions on the bus range from the classic demonstration of a ping-pong ball suspended in the stream of air from a hair dryer, to a tabletop fog tornado, to an electric pencil sharpener that causes a magnet to dance around due to the magnetic fields generated by the motor. "You never would think a kid would get excited about a pencil sharpener," DiScenza says. "The exhibits on the bus demonstrate that there's physics in these everyday items that they never even realized."

The group even has a bicycle that kids can pedal to run a blender. "It's been a huge hit, especially since it's really hot here — kids love making smoothies," DiScenza says.

This is the sixth year that APS has offered Outreach Mini-grants. This year, a National Science Foundation grant has supported an expansion of the program, allowing twice the usual number of mini-grants to be funded.

"The mini-grants are important because they fill a funding gap," says Rebecca Thompson, Head of Public Outreach for APS. They provide funding for pilot projects that need more than a few hundred dollars to get started, but aren't ready for a larger grant. "We can fund kind of crazy stuff and see if it works," she says.

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a whole stack of writing projects. Those range from journal articles to screenplays. I've still got new computational research going on. I've got a sci-fi pilot that I'm shopping, I've got a sitcom I've been shopping, I have a book about how science and scientists are portrayed in the entertainment industry. My coauthor and I are finishing *Hollyweird Science 2*, and we're just about to sign a contract for the third book in the series.

What was your goal in writing *Hollyweird Science*?

A lot of scientists who write about the entertainment industry typically take it from a standpoint of "This is wrong, this is wrong, this is wrong," and rarely is it "This is right, this is right." My coauthor Stephen Cass and I said, "no one wants to read 300 pages of snark." One of the things we want to do is help scientists understand that screenwriters are every bit as professional as you are, they're just differently professional — they have different goals — and when you peek into their world, maybe you'll get a little glimpse as to why the science isn't always perfect, and why sometimes you don't even want it to be perfect, necessarily.

Why would you ever want to get the science wrong?

On *Breaking Bad,* they purposely degraded the accuracy of the science because you really don't want to teach people how to make methamphetamine in your dramatic TV series. So it's a very complex, nuanced issue as far as that goes, and we want to capture that, we want to make people aware of how complex it is.

What do your scientist colleagues think about what you're doing? Do you get positive feedback? Do some people say 'why do you bother with that?'

Yes, all of the above. Scientists are going to come at it from different directions. Some people are very supportive of it. But there's the traditional "If you're doing this you can't be serious about your science" and that's not true either. We used to acknowledge that there's something called a Renaissance person, right? I mean, that's a goal to shoot for. The opportunity to work on these shows and work with these incredibly talented people is of course insanely fun, and it comes with a paycheck. But at the same time you're trying to raise the level of science dialogue. When I worked at JPL, there were so many people who were motivated to go into science because of *Star Trek.*

Were you one of them?

Yeah. So I would love it if some time, years in the future, I was at a convention where someone says, "I was motivated to go into science by *Eureka*."

Have people's attitudes to sci-fi changed? Are we more interested in having accurate science than we used to be?

I think people are far too interested in having accurate science. It used to be that there was an implied bargain between screenwriter and the audience: "Go with me on these one or two really fantastic ideas, and we will be more grounded in the other areas." But people have gotten to where they're nitpicking even these fundamental conceits. I go back to how many people were motivated to go into the space program because of *Star Trek*. It's riddled with things that are never ever going to happen.

How do you achieve the balance between accurate science and a good story?

It's important to get the science as right as possible, but science is in service to the story. Now if you make an error you don't have to make, I have a serious problem with that. But if it serves the story, if it's part of your fundamental conceit, well, yeah, fine. If we're requiring our stories to perfectly adhere to science, we lose the superheroes, we lose *Star Wars*, and we lose *Godzilla*. So there is a balance to be struck, and different films have different bars for that accuracy. I think we used to suspend our belief a little more and I think there's a pendulum that's swung a little too far to the other way. Today, the average person knows what the surface of Mars looks like better than the top scientists in 1963. Let's keep things like that in mind.

What's your favorite thing about your line of work? What drives you to do this?

It's fun when your show gets accolades; it's fun seeing your name scroll across the credits; but really it's just the work — it's fun creating; it's fun when you're posed with a challenge. It's more like the work is rewarding than it is the final product. Though it is kind of cool seeing the show that you worked on and it being really good.

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Consequently, the YPF has the potential to lead to many fruitful interdisciplinary and/or international networks and collaborations.

I ask APS members to share news of the U.S.-Brazil Young Physicists Forum with their colleagues, and to *please encourage early-career physicists to participate*. Please feel free to contact me at flatten@aps.org with any additional questions.

More information regarding application submission, registration, and the program is available at go.aps.org/ypf-2016

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only ones" interested in this type of research, Metcalf said. "All of a sudden they're in a community." The symposium fulfills an important need for opportunities for the young scientists to present their work, Metcalf says. "They're undergrads — they have no other way to get their stuff out there."

Metcalf also founded the Laser Teaching Center at Stony Brook, which provides opportunities for undergraduates to get their first taste of laser research. John Noé, who organized the undergraduate symposium along with Metcalf, serves as the center's executive director. Of his work with students, Metcalf says, "I don't get anything tangible out of it, but there are a lot of intangibles ... I feel that as an educator I should give back"

Rachel Sampson, a senior at Stony Brook, got her start at the Laser Teaching Center, and went on to participate in the NSF's Research Experiences for Undergraduates (REU) program. She spent this summer doing an REU at the University of Arizona.

She worked on creating a diffraction-based optical switch for communications. Data traffic and flow is rapidly changing, Sampson says. "It's important that our technology can keep up with that." Sampson enjoys the chance to interact with scientists attending the FiO/LS meeting, she says, especially the possibility that other scientists may offer her ideas to improve her work, or that she could contribute to theirs. "There's definitely a good sense of collaboration at this meeting," she says.

Faculty mentor Hong Lin, of Bates College, has sent her students to the symposium for ten years. "It provides a very good opportunity for undergrads to share their research experience," she says. "Not only can students talk to their peer students, but also they can talk to professional scientists." Interest in the symposium has grown since Lin began sending her students here, she says. The first symposium had ten presenters, but has grown to host 40 or 50 students. "It grew and grew," says Metcalf, and now it's "an institution."

Many of the students plan to attend graduate school after college. Cedric Wilson, a student at the University of Utah, is applying to graduate programs in atomic, molecular, and optical physics and cold atoms. This summer, he participated in an REU at the University of Rochester, where he worked on modeling and improving an atomic trap for making a Bose–Einstein condensate. "The research was right up my alley," he says. It was harder for him to find opportunities that fit his interests at his home institution, he says.

Ahmad Azim, a senior at the University of Central Florida, is working on construction of an ultrafast laser system. He says the meeting is a great experience for aspiring researchers like him. "I want to go to grad school, get my Ph.D., become a research scientist, and do that for the rest of my life," he says. "There's a lot of great scientists here who inspire me to do that."

At a lunch during the symposium, faculty mentors spoke about their experiences in optics research, advising students on how to get a job in industry, and describing their career arcs. The lunch was followed by two sessions, in which students gave short talks on their research. When one mentor asked the students how many of them had never attended a scientific conference before, hands shot up in the air. "This is their launching into what its like to go to a big meeting," Metcalf says.

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lowships for postdocs.

NSAC advises both the Department of Energy (DOE) and National Science Foundation (NSF) on basic research in the nuclear sciences. It has produced six long-term plans since 1979, with the previous plan in 2007. In April 2014, the agencies charged NSAC with creating a new report.

The current plan builds on the successes of the 2007 guidelines. An upgrade to the Continuous Electron Beam Accelerator Facility at Thomas Jefferson National Accelerator Facility is nearly complete, and the Relativistic Heavy Ion Collider at Brookhaven National Laboratory received an upgrade as well. The Facility for Rare Isotope Beams (FRIB) at Michigan State University, is now under construction. The first recommendation of the report was to take full advantage of these upgraded and upcoming facilities.

Neutrino-less double beta decay experiments, the second recommendation in the report, search for a hypothetical type of radioactive decay in which two electrons are emitted without any accompanying anti-neutrinos. Discovery of such a process would indicate that the neutrino is its own antiparticle. Several current-generation experiments are preparing for the search, and hope to demonstrate technology that could be scaled up to a larger, next-generation experiment of the type endorsed by the report.

The plan's third recommendation — an electron ion collider — would be a high-energy, high-luminosity machine that collides polarized electrons with polarized protons and ions. Construction of the collider would begin following the completion of construction on FRIB, and could be operational around the end of the 2020s. The collider would allow researchers to uncover the source of neutron spin and reach the next frontier of quantum chromodynamics by systematically studying the properties of gluons.

The fourth recommendation, to increase funding for small- and mid-scale projects, follows a period with decreased investment in such efforts, as a result of intense focus on large undertakings like FRIB, said NSAC chair Donald Geesaman, a physicist at Argonne National Laboratory. Now, "we have to have projects at a number of scales," he said in a presentation at the meeting.

The plan passed easily, without any significant critique or questions from the committee or the audience, and the vote was unanimous, an indication of what Geesaman described as broad engagement from the nuclear physics community. Difficult decisions had already been worked out in the committee, said Geesaman, leading to "a lot of consensus" on the most important priorities. To produce the report, NSAC created a dedicated working group that held a series of town meetings and produced white papers. "The key thing, in my mind, is actually going through real budget scenarios," he added.

DOE and NSF officials also approved of the NSAC report. "I think it's an outstanding plan. I think it builds on the past and looks toward a very vigorous future," said Patricia Dehmer, acting director of DOE's Office of Science, in a presentation at the meeting. Fleming Crim, assistant director of NSF's Directorate of Mathematical and Physical Sciences, commended nuclear scientists for coming together to set goals. "Plans like this are successful when they really engage the community," he said.

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self-correcting, and that technological change is a universal good. But with the average family less well off than it was a decade or two ago, those propositions may now be striking a discordant note with the average voter.

Most Americans today have either lost a job or know someone who has lost a job due to technological change. Assembly-line workers have lost out to robots; green-shaded number crunchers have lost out to computers; and tens of thousands of service-sector workers have seen their functions offshored thanks to the telecommunications revolution. Voters want their elected officials to fix what they see as a rigged and broken system, and so far, they're not happy with the performance.

The 2016 election may well be a tipping point where the average voter shouts, as Howard Beal did in Paddy Chayefsky's screenplay "Network," "I'm mad as hell, and I'm not going to take this anymore." And in today's context, that voter will say, "Donald Trump, Ben Carson or Bernie Sanders, any one of them will be better than the establishment figures who have dealt me the losing hand."

The danger for the science community is that disillusioned voters could begin to direct their ire at the progenitors of the technological changes they see as harming them. If they do, the road ahead for American physics could be a rocky one.

On a populist landscape, it is imperative that the science community make the case that research is not simply a benefactor of the rich and entitled. As part of its civic responsibility, the science community must work to promote public policies that bring the benefits of research to everyone. If the community fails in that mission, public support for research will inevitably ebb, to the detriment of American science and to America in general.

ANNOUNCEMENTS

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efforts in the search for extraterrestrial intelligence (SETI).

In her testimony, NASA Chief Scientist Ellen Stofan focused on the search for life — either current or fossilized — on Mars. She highlighted the astrobiology capabilities of the planned Mars 2020 rover, but argued that NASA's plan for a crewed mission to Mars is also essential to finding life, if it's there. "I believe it will take human explorers — geologists and astrobiologists — who can move quickly and make intuitive decisions on their feet," she said.

But how might one detect the fingerprints life may have left on the solar system's four likely suspects? Jonathan Lunine of Cornell University explained, "The evidence will not be entire living organisms. Much more likely is that we will detect signatures that indicate that life is at work or was at work in these environments," Lunine said. "Biology is built from a very limited, selected set of molecules. And so if we can recognize patterns in the makeup of organic molecules and their isotopes, we then have strong evidence of biology at work."

Jacob Bean of the University of Chicago made the case for zeroing in on exoplanets in the search for life. Telescopes are currently scouring the skies for Earth-sized planets in the habitable zones of their stars, and by using spectroscopy to identify components of exoplanet atmospheres, scientists may eventually be able to detect "biosignature gases," like molecular oxygen, that could point to a foreign planet crawling with creatures. Bean highlighted the importance of the Kepler telescope and the upcoming James Webb Space Telescope and Transiting Exoplanet Survey Satellite for these efforts. But in order to study the atmospheres of the most enticing prospects — Earth-like planets around Sun-like stars — an expanded program in exoplanet exploration, including a flagship telescope with next-generation optics, will be needed, he said.

If other intelligent life exists, scientists could detect its technology using radio telescopes like the Arecibo Observatory and the Green Bank Telescope. "These facilities are among the world's best at searching for the faint whispers of distant technologies," said Andrew Siemion, director of the SETI Research Center at the University of California, Berkeley. He cited the Breakthrough Listen initiative — a $100 Million, 10-year effort funded by Russian billionaire Yuri Milner's Breakthrough Prize Foundation — as an exciting prospect in the next decade.

The search for life on other planets, lawmakers noted, can inspire young people to pursue science, and they stressed the importance of outreach. "While it's exciting to search for intelligent life elsewhere in the universe, I hope we don't neglect nurturing the intelligent life we have right here in our country," said Rep. Eddie Bernice Johnson (D-TX).

Stofan was optimistic about the probability of discovering life on another planet; instruments under development could allow scientists to discover some form of life within as little as 10 to 20 years, she said. But Bean was less sanguine, calling the possibility of finding biosignatures from exoplanets in the next decade "unlikely," an answer that seemed to disappoint Chairman Smith.

The experts agreed that astrobiology research should be prioritized, and emphasized the importance of uninterrupted funding if progress is to be made. "I think that life is the most interesting property of the universe," said Siemion. "If we don't understand that, then I think we don't understand perhaps one of the most fundamental properties of the universe that we live in."

The Back Page

Women in Physics: Why so few?

By Theodore Hodapp and Zahra Hazari

Where are the women? Despite decades of slowly increasing participation, women still receive only about 20% of the physics bachelor's degrees in the U.S. (see Fig. 1). Even more alarming is that in the past decade, this percentage has gone down — all this at a time when physics itself is seeing record numbers of undergraduate and graduate degrees. Just to be clear, although the number of women getting bachelor's degrees is actually going up, it just isn't going up at the same rate as it is for men.

As part of our work, we hear anecdotally that the nation needs to increase the number of women getting Ph.D.s, and we encounter stories of women unable to get academic jobs or increasingly leaving these jobs. Aligned with these concerns is the ADVANCE program of the National Science Foundation (NSF) — an effort to improve gender imbalances in academia. Programs like this are important in the continuing effort to attract and retain women in academia, but we think they are not getting at a critical issue that keeps physics and engineering from breaking the 20% barrier. We ask: Are we focusing efforts where we can dramatically impact participation?

Where does the problem lie?

Let's see what the data tell us. Figure 2 shows the percentage of women participating in physics at various stages, from high school to tenured associate professors in U.S. universities. In high school physics, unlike other levels, there is little gender disparity in science class enrollment. At the associate professor level, the data are consistent with the immediately preceding levels. Although this is not conclusive evidence, it suggests that women are *advancing* at similar rates to men in college and beyond (although absolute numbers decline substantially with each step).

While there are fewer women at the full professor level, proportionately speaking, the numbers are still consistent with previous levels since there were far fewer women getting Ph.D.s 20, 30, or 40 years ago — the time period over which one must integrate to evaluate full professor employment now. It is hard to say much about gender balance in private sector employment — there is little data covering this in physics.

Although there are studies showing gender differences occurring as early as elementary school, the last place where women participate in physics at equal numbers and, more importantly, the first time when they are seriously deciding about their future plans is high school. This is where we have the greatest ability to make a change in the demographic. If you want more evidence for this, see references [1] and [2]. High school is where we might have a chance to make a significant impact — while female students are still a captive audience in physics classrooms.

It has been argued that high school is too late — that female students are rounding out their academic credentials for college rather than taking physics because they are interested in the subject. While this may be true for some students, most female physicists report becoming interested in physics careers in high school and not earlier [2]. Furthermore, surveys of more than 900 female undergraduates [3] given to participants at the APS Conferences for Undergraduate Women in Physics showed that female students are attracted to physics careers during high school, at rates more than double those attracted during middle school or college.

In addition, there are other reasons why high school might be an optimal time period for attracting female students to physics careers. First, high school is the first time when physics is clearly delineated as a subject with a dedicated course and teachers who (usually) have a science background. Most elementary and middle school teachers have very little background in physics. High school may offer the first opportunity for students to explore physics at a deeper level with a teacher who can provide support.

Second, there is a large time lag between elementary/middle school and deciding on a college major or a career. If students are excited about physics at a younger age, there are still many years in which they can become discouraged about physics or attracted away by another discipline. Thus, the excitement must persist in high school.

Finally, what about attracting female students at the undergraduate level when students are even closer to a career decision and instructors have even more content expertise? Not only do the data show that women have already made choices, but reality is setting in for them regarding required courses, sequenced majors, and degree completion. Furthermore, attracting women from other STEM disciplines is either impractical (e.g., too late to switch for the 60% female bioscience majors who often reserve physics for their junior year) or detrimental (e.g., would leave other fields like engineering with a greater representation problem). Finally, fewer opportunities to interact with faculty in intro courses and social pressures make it difficult for undergraduate women to change their minds about physics.

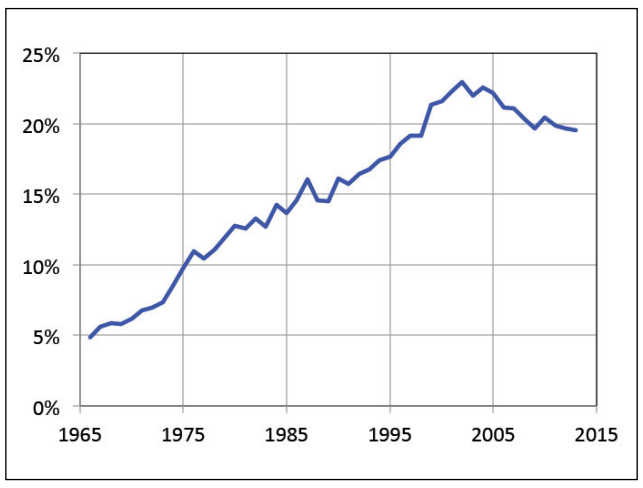

Figure 1. Percentage of bachelor's degrees in physics earned by women. Source: US Department of Education.

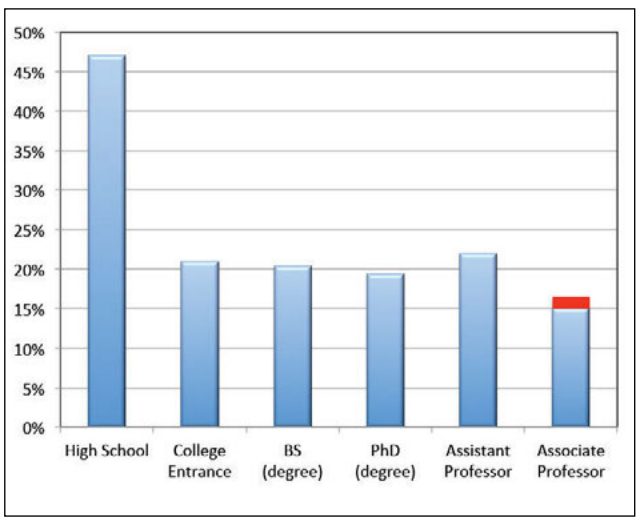

Figure 2. Percentage of women participating in physics at various academic stages. College entrance refers to first-year student's intent to major in the field. The red bar indicates the expected percentage based on assistant professor levels 6 years prior, and is not a statistically significant difference. Sources: American Institute of Physics (high school and professoriate data), Higher Education Resource Institute (college entrance), and U.S. Department of Education (degree data).

So, what can be done at the high school level to effect change and attract women to physics? Evidence-based materials are currently being developed for attracting female students to physics in high school, and existing work [4] already shows promise with three basic strategies: *Recognition, Relevance,* and *Discussion*.

Recognition. Publicly (in the classroom), and privately (to the individual) recognize ability in female students to help them develop a physics "identity" and to encourage persistence. This could include explicitly remarking on good questions or comments from female students, directing other students to them for help, holding high expectations of their abilities, and encouraging them through challenges by expressing belief in their capabilities. A student who is called on or receives a compliment gains recognition that enables her to see herself as a member of the discipline.

Relevance. Engage female students' interests by embedding socially and personally relevant content and contexts. This might include describing how physicists work on solving social problems (e.g., working on cancer research, developing highly efficient photovoltaic cells, studying fluid dynamics that improve drug delivery in microfluidic membranes, or working on climate change issues), and allowing students the freedom to express their interests and discover emotional ties to physics.

Discussion. Through conversations with students, make issues related to women's underrepresentation explicit — issues hidden for many students. This could include class discussions that reveal equity issues such as implicit bias, social pressures to conform to certain gender roles, values that appear missing from the physics discipline such as helping others, or applying stereotyped labels to professions. Students often mistakenly believe that equity has been achieved and are not conscious of these issues. Revealing a need can mobilize students.

So, how do we implement these techniques where they are needed and change the landscape of physics? There are about 27,000 high school teachers of physics in the U.S. Getting each of them to encourage only one more female student each year would profoundly impact physics and engineering. The challenge is how to get that message out, and get it implemented.

This is where the NSF comes back into the picture. Current funding by the Foundation does not emphasize high school to address gender imbalances. Their signature program in gender diversity is ADVANCE, and while these efforts are important, this is not where funding can significantly impact representation for physics and engineering. We recommend an effort within the agency of at least this scope and magnitude aimed at (a) funding research to engage high school physics teachers in this issue, and (b) pilot implementation and assessment of interventions in high school physics classrooms. Moreover, these efforts must reach *all* schools, including rural and inner-city schools, where our most economically disadvantaged students struggle.

What can we do as physics professionals? We must continue discussions and conversations of underrepresentation. Help colleagues (and yourself) become familiar with issues like stereotype threat, implicit bias, and imposter syndrome [5]. Where appropriate, practice the strategies mentioned above with women you interact with to encourage them to consider seeing themselves as physics professionals. If you are a faculty member, find out what your department and institution is doing to recruit, educate, and support high school physics teachers — these individuals interact with hundreds of potential physics majors. We recommend checking out www.phystec.org for information on promoting physics teacher education.

And don't stop doing what you are doing now to promote an inclusive environment for *everyone* to study and practice physics. These include transparent rules, gender representation in the organization's leadership, attention to family-friendly policies, and paying attention to individual's needs at all levels, be they student or scientist. These practices are critical for retaining the small numbers of women we have in our community and propagating a cultural message of inclusivity to the public. Physics may be about conservation laws and equations of motion, but it goes nowhere without physicists. To excel as a discipline, we must excel as a community. Solving this long-standing representation gap is critical to doing better physics.

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APS News welcomes and encourages letters and submissions from APS members responding to these and other issues. Responses may be sent to: letters@aps.org