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APS physics

Physicists Improving Lives
Pages 3 & 5

MEMBER NEWS

Newly-Elected IUPAP Officers Meet in Trieste, Italy

By Aihua Xie and Kennedy Reed

The 2015 Executive Council and Commission Chairs (C&CC) Meeting of the International Union of Pure and Applied Physics (IUPAP) was held April 24-26 at the International Center for Theoretical Physics in Trieste, Italy.

IUPAP promotes international cooperation in physics and sponsors four types of international and regional conferences. These include (1) general conferences, (2) topical conferences, (3) special conferences, and (4) workshops in developing countries. In addition, IUPAP Commissions sponsor IUPAP Young Scientist Prizes to recognize outstanding early-career physicists, and also sponsor other awards to recognize excellence in the subfields of physics represented by the Commissions.

From left to right: Beverly Berger, Aihua Xie, Kennedy Reed and Heidi Schellman near the International Center of Theoretical Physics (ICTP).

Four APS members attended the IUPAP C&CC meeting: Kennedy Reed, Lawrence Livermore National Laboratory, the IUPAP President-designate; Heidi Schellman, Oregon State University, Vice Chair of the IUPAP Commission on Particles

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APS Election Results

As this issue of *APS News* goes to press, votes in the APS general election are still being counted. Members are voting for Vice President, Chair-Elect of the APS Nominating Committee, and International and General Counselors. For the first time, members are also electing an APS Treasurer, a position on the Board of Directors created as part of recent changes in APS governance. All those elected will take office on January 1, 2016, when the current Vice President becomes APS President-Elect, and the President-Elect becomes President.

Voting ended on June 30, 2015 and the results can be found at **www.aps.org/about/governance/election/**

Inside the Beltway

Thinking Big and Outside the Box

by Michael S. Lubell, APS Director of Public Affairs

The science advocacy industry that APS helped start in Washington 20 years ago is no longer delivering the high returns it once did. Rising above the noise of hyperpartisanship, political sniping, and electoral campaigns that never end has become a daunting task, even for the best messengers delivering the best messages. Couple that challenge with science's almost total reliance on a dwindling discretionary slice of the federal spending pie — projected to shrink to 25 percent of total spending by 2040, from 62 percent in 1970 and 36 percent today — and you have gloom if not doom in your future.

We have come to a critical juncture: Either we develop new arguments and new strategies to persuade Congress and the White House that current budget policies will knock the United States off its high perch on the innovation pyramid, or we look beyond the annual appropriations process to fund long-term research. If you spend just a few days suffering in the fetid political climate in Washington as I do, you will quickly concede that we need a dramatically new approach to funding research.

We must become innovators ourselves. And we must think big. An American Research Investment Fund, run as a private-public partnership, could be the answer. Here is how it might happen, how it might work, and how it might be just what scientists, politicos, wonks, and business leaders are looking for.

First a few facts: Today, the federal government spends about $50 billion per year on basic research, accounting for 55 percent of the U.S total expenditure. Academic and other nonprofit institutions, combined with state and local governments, account for slightly less than 25 percent, while industry contributes about 20 percent.

It wasn't always that way. Half a century ago industry was a major player in the research game. Think of Bell Labs, Xerox, IBM, GE, GTE, GM, Kodak — the list is long. But with each passing decade, one American industrial giant after another bailed out of long-term research, basic or applied.

It's not that they believed they no longer needed the benefits of research. They well knew, and they still know, that research is fundamental to the future of any high-tech enterprise. So, why did they abandon their commitment to their powerhouse in-house laboratories?

Thomas Friedman has written extensively about one of the motivations: the IT revolution that has driven globalization. Two of his bestsellers, "The World Is Flat," first published in 2005, and "Hot, Flat, and Crowded," published in 2008, are must-reads for anyone looking for a window onto the 21st century high-tech landscape. In such a brave new world, it is simply easier for American companies to find and buy the rights to new discoveries wherever they are made.

But there is another motivation for American companies to shed their research laboratories, eviscerate their research budgets, and disband their research teams. Changes in how corporate executives receive their compensation and how Wall Street conducts its business have removed almost all the incentives for long-term industrial commitments.

In 1960, stockholders held an average stock for eight years. Today, with the reduced costs of electronic trading and the proliferation of hedge funds, the average holding time is a mere four months. Today, in response to stockholder demands, companies compensate executives mainly with bonuses based on stock performance, and with options that allow them to buy their company's stock at a future date at a fixed "strike" price, often only a year or two after they receive the options. The more the share price rises, the more the option is worth.

The result of such incentives is that American corporations use fully 80 percent of their annual profits to buy back their stock with the explicit goal of boosting the price of a share. For a Fortune 500 CEO with an average tenure of only 4.6 years, spending money on research that doesn't contribute to the bottom

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U.S. CONGRESS

Senate Bill Provides 5-year Roadmap for Energy Research Funding

By Tawanda W. Johnson, APS Office of Public Affairs

APS has given its support to the newly-introduced Senate bill "Energy Title of the America COMPETES (Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act) Reauthorization Act of 2015" (S. 1398). Co-sponsored by U.S. Sens. Lamar Alexander (R-Tenn.) and Chris Coons (D-Del.), and five other senators, S. 1398 would put energy research on a path of sustained, reliable funding under a bipartisan, partial reauthorization of the America COMPETES Act.

"The Senate bill is notable for making science a priority, even in times of constrained budgets," said Michael S. Lubell, APS director of public affairs.

The legislation would bolster energy research programs in the Department of Energy's Office of Science (DOE-SC) and the Advanced Research Projects

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PHYSICS OLYMPIAD

United States Traveling Team Selected

David Voss

In a ceremony on May 27, 2015 at the American Center for Physics in College Park, Maryland, the American Association of Physics Teachers (AAPT) announced the group of five U.S. high school students who will travel to Mumbai, India, in July to participate in the 46th International Physics Olympiad.

Started in 1967, the Olympiad is an international competition among high school students from more

OLYMPIAD continued on page 6

David Voss

The 2015 U.S. Physics Olympiad traveling team (l to r): Saranesh Prembabu, Adam Busis, Jason Lu, Kevin Li, and Zachary Bogorad.

Revised 7/7/15

Members in the Media

"The prize has been sitting on a shelf somewhere for the last 20 years. … I made a decision to sell it. It seems like a logical thing to do."

Leon Lederman*, retired from Fermilab, after putting his Nobel Prize medal up for auction,* The Washington Post*, May 27, 2015.*

"Doing things the same way is not going to lead us to the breakthroughs we need."

Catherine Foley*, Commonwealth Science and Industrial Research Organisation, Canberra, on the need for diverse teams to produce great innovation and better involvement of talented females,* The Sydney Morning Herald*, May 29, 2015.*

"I quit doing physics and got an apartment in Hollywood and started writing and got a really crappy job for a really crappy show, but I lived off writing for that show for a while, and it got better and I got an agent and a better show and just climbed my way up."

Leonard Mlodinow*, California Institute of Technology, on becoming a screenwriter for "Star Trek: The Next Generation,"* businessinsider.com*, June 4, 2015.*

"This is truly a great honor. I just turned 80 and this is a wonderful, if unexpected, birthday present."

Claudio Pellegrini*, University of California, Los Angeles, on receiving the Enrico Fermi Award from the U.S. government,* gazzettadelsud.it*, June 11, 2015.*

"The physics has been very carefully reviewed by experts and found to be accurate. The publication will encourage physics teachers to show the film in their classes to get across ideas about general relativity."

David Jackson*, Dickinson College, on research papers that resulted from black hole calculations done for the movie "Interstellar,"* geeksnack.com*, June 23, 2015.*

"The sensors that guard DOD's unclassified networks detected Russian hackers accessing one of our networks … [but a] crack team of incident responders quickly kicked them off the network."

Ashton Carter*, U.S. Secretary of Defense, on recent network break-ins,* The New York Times*, April 23, 2015.*

"People point that out to me and say, 'You know, Newton was religious.' The point is — well, first of all, in that time the church was the National Science Foundation. It was the only place to get an education; it was the only place to fund research. But that's fine. It is okay to have a relationship, but you grow up. Parents are useful for children, but the whole point is children grow up and move beyond their parents — we certainly hope that's the case."

Lawrence Krauss*, Arizona State University, on whether the Bible should be included among books essential to sustain or rebuild civilization,* salon.com*, May 29, 2015.*

"That means that the total energy involved had to be at least 6.4 x 10^{16} joules = about 18 billion kilowatt hours, and that's only one part of a big storm system. This is why engineering the weather is a nonstarter!"

Douglas Natelson*, Rice University, on the energy in a thunderstorm that passed the city of Houston,* houstonchronicle.com*, May 26, 2015.*

"I don't think that because I have a Ph.D., I'm in some upper echelon of society. I actually have a major problem with the elitism and the classism that goes on in academia. I think everyone has something to contribute. Everyone is precious in their own way. But I think it's obvious that, structurally, American society has a persistent problem with recognizing not just Black people, but Black people as human beings who are just as deserving of the opportunity to think about big picture questions."

Chanda Prescod-Weinstein*, Massachusetts Institute of Technology, in an interview on being the 63rd Black woman in American history to obtain a Ph.D. in a physics-related field,* huffingtonpost.com*, June 24, 2015.*

"There are lots of people with resolutions to the paradox. Whether it's the way physics actually works in our universe remains to be seen."

Donald Marolf*, University of California Santa Barbara, on recent proposals to view black holes as 'fuzzballs' to get around the 'information paradox'," quantamagazine.org, June 23, 2015.*

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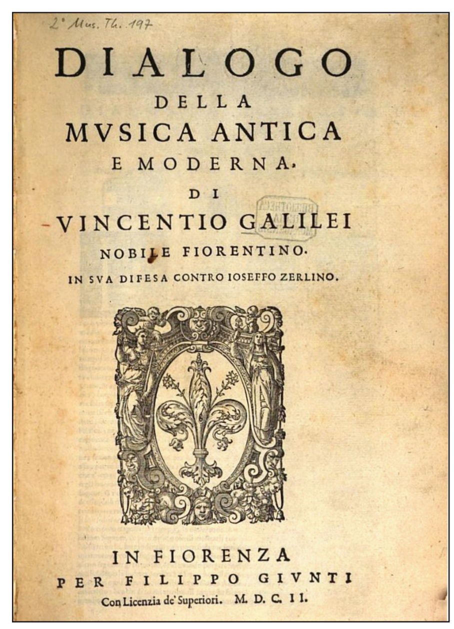
This Month in Physics History

July 2, 1591: Death of Vincenzo Galilei

Music, math, and science have long enjoyed a symbiotic relationship, which led to the Renaissance notion that the motion of celestial bodies gave rise to the "music of the spheres." Galileo Galilei's scientific accomplishments may well have been influenced by his love of music, instilled in him by his father, Vincenzo, a musician and composer who brought an experimental sensibility to his study of music theory.

Very little is known about Vincenzo's early life. Most accounts peg his birth around 1520, in a small Tuscan village, Santa Maria a Monte, near modern-day Florence. He showed a marked talent for music – the lute in particular – at a very young age and became an accomplished and well-regarded musician. At some point, prior to 1562, he moved to Pisa, and married the daughter of a Pisan noble family, Giulia Ammannati. His first child, the future astronomer Galileo, was born in 1564, followed by six siblings.



DIALOGO
DELLA
MVSICA ANTICA
E MODERNA.
DI
VINCENTIO GALILEI
NOBILE FIORENTINO.
IN SVA DIFESA CONTRO IOSEFFO ZERLINO.
IN FIORENZA
PER FILIPPO GIVNTI
Con Licenza de' Superiori. M. D. C. I I.

books.google.com

Cover page of "Dialogo della Musica Antica e Moderna.

Vincenzo's musical talent attracted the attention of a wealthy Florentine patron, Giovanni de Bardi, who established a regular salon for intellectual discussions at his palace, dubbed the "Camerata de Bardi." The subjects included music theory, then considered part of the mathematical sciences, along with arithmetic, geometry, and astronomy. The Camerata's interest in new musical directions would eventually lead to the early development of opera.

Music theory during this period relied on theorems drawn from geometry. This was at odds with a separate school of thought based on the work of the ancient Greek music theorist Aristoxenus, who insisted math had little to do with music, and one should rely on one's senses to decide what music was most aesthetically pleasing. At the center of the conflict was a debate over the best mathematical ratios of the lengths of strings producing "consonances," those sounds (like the octave) deemed most pleasing to the ear.

Since Vincenzo, despite his proficiency on the lute, had little theoretical training, Bardi sent him to Padua to study with one of the leading music theorists of the day, Gioseffo Zarlino. Zarlino embraced the Pythagorean tradition of diatonic tuning, and taught Vincenzo accordingly. But when the lutenist returned to Florence, he found a second teacher, a philologist named Girolamo Mei.

Mei introduced Vincenzo to the work of Aristoxenus, pointing out that the "equal temperament" approach adopted by practicing musicians to tune their instruments wasn't consistent with the Pythagorean doctrine favored by theorists, which specified precise ratios for the intervals. Mei encouraged Vincenzo to test this for himself, tuning two different lutes, one to the requirements of equal temperament, and the other per the dictates of the theoreticians. Vincenzo did so, which convinced him that Mei was right.

The prevailing assumption at the time was that, just as the ratio of *lengths* of two identical strings with the same tension and mass per unit length, tuned an octave apart, would be 2:1, the ratio of the *tensions* of two identical strings of equal length, tuned an octave apart, would be 2:1 as well. Vincenzo decided to test this assumption with a simple experiment involving hanging weights from strings. He found that, in fact, the ratio of tensions was 4:1. This provided convincing evidence that, indeed, consonant sounds were not determined solely by abstract mathematical ratios.

Vincenzo was arguably one of the first to adopt an empirical approach to what is now modern acoustics research. His pursuit of these new ideas, so counter to those of his first mentor, led to a bitter falling out with Zarlino, particularly with the publication in 1581 of Vincenzo's most influential book, *Dialogo della musica antica et della moderna*, which explicitly attacked Zarlino's ideas.

The late science historian Stillman Drake argued persuasively that the elder Galilei conducted these experiments in 1588, at a time when his eldest son was living at home and tutoring local students in mathematics. He believes it likely that Galileo may have helped his father with the experiments, and hence Vincenzo influenced his son to pursue pragmatic experimentation in his science as a means of testing hypotheses. He certainly taught Galileo to play the lute, and Drake also suggested that Galileo's love of music may have led to the astronomer's formulation of the law of falling bodies.

Drake's evidence stems from a page in Galileo's laboratory notebooks detailing his experiments rolling balls of various masses down inclined planes. Some historical accounts report he measured the speed at which the balls rolled by timing his own pulse. But it is possible, according to Drake, that the idea to add moveable frets to his inclined plane as a ruler — thereby breaking up the balls' continuous motion into discrete intervals of time — may have been inspired by the fret intervals on his lute's

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Diversity Corner

Become a Mentor in the APS National Mentoring Community

In an effort to increase the number of underrepresented minority (URM) undergraduates obtaining physics degrees, APS and the APS Committee on Minorities have launched the National Mentoring Community (NMC), an initiative to provide mentoring to URM physics undergrads. We encourage committed faculty mentors to register for free as NMC mentors and to nominate their URM undergraduate physics mentees to membership in the NMC (as their mentees). For more information and to register as a mentor, visit www.nationalmentoringcommunity.org

Save the Date! October 9 - 11, 2015

Registered NMC mentors and mentees are eligible for discounted registration and travel funding to our inaugural NMC Conference (October 9 - 11, 2015), held jointly with the APS Bridge Program Conference (October 10 - 11, 2015) at Florida International University in Miami, FL. For more information and to register for the conference, visit www.apsbridgeprogram.org/conferences/2015/

Women in Physics Email Group

The Committee on the Status of Women in Physics welcomes you to join WIPHYS, its electronic mailing list. WIPHYS is sent weekly and includes funding, job, and professional development opportunities for women. WIPHYS started officially in January 1993, and now has over 1000 subscribers. Join here: www.aps.org/programs/women/email-lists/wiphys.cfm

Network with other physicists on LinkedIn

Join the LinkedIn groups for Minorities in Physics (http://go.aps.org/minoritiesinphysics) and Women in Physics (http://go.aps.org/womeninphysics). Start networking today!

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fingerboards. The balls would bump up as they rolled over the frets, and click audibly when they hit the surface again, lending sound as well as sight to Galileo's observations.

Vincenzo was first and foremost a musician and a composer, despite his scientific dabblings. In his lifetime, he composed two books of madrigals, along with music for both voice and lute, much of which anticipated early Baroque music and very little of which survived. His co-invention of a musical style called monody is often cited as leading to the use of recitative in opera, and he also wrote a two-part treatise on counterpoint, which he finished in 1589. He died on July 2, 1591 in his beloved Florence.

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1. Crease, Robert. *The Prism and the Pendulum: The Ten Most Beautiful Experiments in Science*. New York: Random House, 2004.
2. Drake, Stillman. "The role of music in Galileo's experiments," *Scientific American*, June 1975.
3. Pachetti, Marina Baldissera. "Turning music into sound: Vincenzo Galilei's contributions to the history of acoustics," *The Journal of the Acoustical Society of America* 135(4): (2014).

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"The hybrid monster in the movie is no Godzilla, but an intentionally designed beast from hell. As often happens in sci-fi, the story turns cautionary tale. How far are we prepared to push our technologies without, at the same time, weighing their moral consequences?"

Marcelo Gleiser*, Dartmouth College, on the recently released movie "Jurassic World,"* npr.org, *June 23, 2015.*

"We want to reboot physics — globally."

Neil Turok*, Perimeter Institute, Toronto, on the Institute's Convergence conference, designed to keep physics from stalling in the aftermath of experimental discovery of the Higgs boson,* The Globe and Mail*, June 23, 2015.*

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Agency for Energy (ARPA-E). Moreover, the bill would nearly triple funding for DOE-SC's Early Career and Distinguished Scientist Awards, which help scientists begin their research careers and be recognized for outstanding work in their fields, respectively.

The Alexander-Coons bill is a partial reauthorization of the 2007 and 2010 versions of the America COMPETES bill, bipartisan legislation that called for the doubling of research funding supported by the National Science Foundation, the National Institute of Standards and Technology, and DOE.

On the other side of the Capitol, the U.S. House of Representatives recently passed a full COMPETES reauthorization that failed to get any support from scientific organizations. This bill strips funding from research in energy efficiency (including work supported by ARPA-E), as well as in biological, environmental, and geological sciences, and social, behavioral, and economic sciences.

Many scientific groups, including APS, sent letters to U.S. House Science Chairman Lamar Smith (R-Texas) and Ranking Member Eddie Bernice Johnson (D-Texas), expressing their disapproval of the House bill supported by Smith and opposed by Johnson. It is unclear whether the House and Senate will be able to reconcile the two versions of the COMPETES Act.

The University of Michigan Honors APS Vice President Homer Neal

In April 2014, colleagues and friends from around the world gathered at the University of Michigan (UM) in Ann Arbor for a symposium to honor Homer Neal. Neal was elected in 2013 to the APS presidential line and will take office as APS president in 2016.

The first three sessions of the symposium focused on Neal's experiments at Brookhaven, Argonne, SLAC, Fermilab, and CERN. The fourth session focused on his contributions to the U.S. government as a member of the National Science Board, and to the Smithsonian Institution as a regent. The symposium presentations are available at lecb.physics.lsa.umich.edu/CWIS/SPT--BrowseResources.php?ParentId=707

Photo by Okunawa and S. Lemons

Homer Neal (right) with Alan Krisch, UM physics professor emeritus, after presentation of a sculpture by Jens Zorn showing collisions of protons at the D0 and ATLAS experiments at CERN.

Note: Adapted with permission from the January/February 2015 issue of the *CERN Courier* (cerncourier.com/cws/download/Jan-Feb15).

Profiles in Versatility (Part 1)

Improving Lives with Physics

By Gabriel Popkin

In spring 2006, Susan Amrose was almost ready to leave physics. She had come to the University of California, Berkeley in 2000 to get a Ph.D. in astrophysics, but more and more she felt her career was not helping people in the way she wanted. That changed when she walked into Ashok Gadgil's Design for Sustainable Communities course.

Shyamasree Das Gupta

Susan Amrose and Ashok Gadgil in June 2015 inspect the ECAR reactor, a component of the 10,000-liter-per-day water treatment system being tested at Dhapdhapi High School in West Bengal State, India.

Gadgil — a professor of civil and environmental engineering at Berkeley — had 25 to 30 students work in teams to design and build products to solve real public health or environmental problems in the developing world. Gadgil is a physicist by training; he is also deputy director of the Energy Technologies Area at the Lawrence Berkeley National Laboratory, up the hill from the university. He's spent a career solving problems in some of the world's poorest places. He created the design course to give students an opportunity to use their physics and engineering knowledge to improve lives and living conditions.

That opportunity was just what Amrose had been looking for. "I wanted to do rigorous science and engineering, and I wanted to use that immediately to actually create social impacts," she said. Amrose joined Gadgil's lab, earned her Ph.D. in physics, and is now a project scientist at Berkeley, focusing on developing technologies and moving them to market.

Photo courtesy of Susan Amrose

Susan Amrose gets users' impressions of an early version of the Berkeley-Darfur stove.

Since 2010, she has taught the course that initially inspired her. Together, Gadgil, Amrose, and other colleagues have developed technology that has improved the lives of millions of people.

"He's very inspiring," Amrose says. "There are a huge number of students, especially women, in engineering … [who are] looking for some way to apply it more immediately to some of the social problems that are happening now. They flock to Ashok's lab."

An opportunity not lost

Born in 1950 in Mumbai, Gadgil has always loved the self-correcting nature of science, he says, and was especially drawn to physics because it could explain so many phenomena with relatively few rules.

After earning his bachelor's degree from the University of Mumbai and his master's from the Indian Institute of Technology, both in physics, he headed to U.C. Berkeley for a Ph.D. Gadgil worked on general relativity problems, but he began to feel something was missing. "All along it bothered me at some level that the place I came from, India, [might not] make it in terms of transitioning to a reasonably modern standard of living," he says. "It seemed that it would be a lost opportunity to not try to see what I could do."

Fortunately for Gadgil, Berkeley was home to Arthur Rosenfeld, a former particle physicist who went on to develop some of the first computer models for energy use in buildings. His work led to tremendous energy efficiency improvements in buildings in the U.S. and elsewhere. Seeking a way to use his physics background to have such direct social impacts, Gadgil joined Rosenfeld's research group.

After getting his Ph.D. in physics, Gadgil moved immediately to Lawrence Berkeley Lab, where he has worked ever since. He applied his computational fluid dynamics background to indoor air quality problems, like how to manage radon and other toxic gases that can seep into houses. He developed leasing arrangements that made compact -fluorescent light bulbs affordable in the developing world. He also began working on issues related to drinking water. In the 1990s he developed a battery-powered technology to cheaply disinfect drinking water using ultraviolet radiation. The

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Letters

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

Politicizing Ukraine

In the April 2015 issue of *APS News*, George Gamota wrote a letter to support scientists in Ukraine. I completely support this. However I would like to express complete disagreement with the highly politicized form of his comment. In my opinion, *APS News* is the wrong place to express politicized statements and therefore I will point out only two of the most obvious factual errors.

The sentence "Soon the peaceful protests turned ugly and violent when the president's Special Forces 'Berkut' contingent kidnapped, tortured, and killed over 100 innocent bystanders during the Kyiv 'Euro-Maidan' protests" directly blames Berkut as a major force that resulted in many more than hundreds of deaths. This never was proved. On June 11, 2015, U.S. Ambassador to the United Nations Samantha Power expressed dissatisfaction with the investigation results. In particular, she said "Investigations into serious crimes such as the violence in the Maidan and in Odesa have been sluggish, opaque, and marred by serious errors — suggesting not only a lack of competence, but also a lack of will to hold the perpetrators accountable." It clearly states that we do not know who is behind this crime.

In addition, the statement that "Donetsk State University, one of several universities evacuated from Donbas, has been reorganized in Vinnitsa, some 300 miles from Donetsk, where faculty, their families and over 1,000 students are temporarily living" is not accurate. In reality the university was split into two parts — one moved to Vinnitsa while another has stayed in Donetsk. I actually believe that professors and students left in Donetsk need help as well as their colleagues in the government-controlled Ukraine.

Valeri Lebedev
Batavia, Illinois

Homeland Security Theater

It was with a mixture of amusement, sadness, and dismay that I read the May 2015 *APS News* front page article "Nuclear Needles in Cargo Haystacks," describing equipment being developed to detect nuclear weapons in cargo containers at U.S. ports. Unfortunately, cargo containers are but one — and perhaps the least likely — of numerous means for smuggling nuclear materials. To be really effective the system described in the article would need to scan every car, bus, truck, motorcycle, and bicycle crossing the Mexican or Canadian border, every railroad car, every airplane, and every boat and private yacht coming into the U.S. And let us not forget those tunnels under the U.S.-Mexican border, which provide such a reliable supply route for drug smugglers.

This approach is one example of a much larger problem which might be characterized as "homeland security theater." Such efforts serve to deceive people into thinking they are being protected, while their main function is to enrich weapons contractors and their political supporters and allies from the many billions that it would cost to build and operate such systems. It also diverts attention and funding from much more honest attempts to understand and deal with this issue.

Those interested in a carefully thought-out examination of the nuclear weapons problem might consult a recent book [1] which focuses on controlling or eliminating fissile materials themselves to eliminate the threat of nuclear war and terrorism.

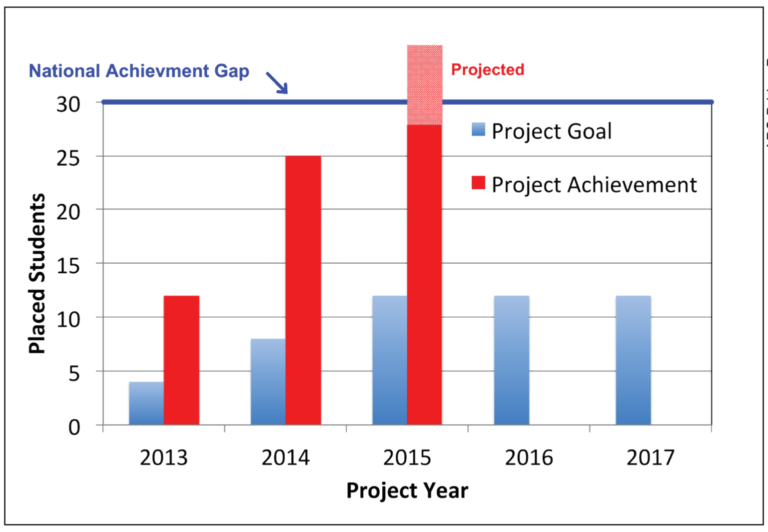
Alfred Cavallo
Princeton, New Jersey

1. *Unmaking the Bomb: A Fissile Material Approach to Nuclear Disarmament and Nonproliferation*, H. Feiveson, A. Glaser, Z. Mian, F. von Hippel, (MIT Press, 2015).

APS PROGRAMS

APS Bridge Program Expects to Increase Minority Ph.D. Numbers

By Bushraa Khatib



The red bars show the number of URM students beginning graduate physics study per year in the APS Bridge Program. The goal is to increase annual URM physics Ph.D. degree production by 30, indicated by the horizontal purple line at the top of the graph. The blue bars show the enrollments anticipated at the beginning of the project.

In 2012, APS Director of Education and Diversity Theodore Hodapp looked at graduation rates of underrepresented minorities (URMs) who earned degrees in physics. He was struck by the disparity between the graduation rates of URMs earning Ph.D.s and URMs earning bachelor's degrees. "There was obviously a break in the pipeline somewhere, and we were losing many students who probably had the potential to succeed at the graduate level."

Hodapp defines the national achievement gap as the difference between the percentage of physics Ph.D.s awarded to URMs (~10%) and the corresponding percentage of bachelor's degrees (~4%). Seen from this perspective, only about 30 more URM physics Ph.D.s per year would close this gap (see graph).

Three years after its inception, according to staff members, the APS Bridge Program expects to effectively erase that gap — an accomplishment far beyond what the organizers had originally planned — by placing more than 30 students into graduate programs in 2015. What's more, none of these students would be studying for their Ph.D.s today without the APS intervention, say program staff.

"The Bridge Program continues to surpass our expectations in placing students, and is providing opportunities for students to pursue doctoral degrees in physics," said Brian Beckford, the Bridge Program manager. "We hope to continue to be an avenue for students who are being overlooked and for departments that are aiming for a more diverse representation in their graduate student population."

The program received 56 applicants in the most recent application cycle (the program's third). The application pool was made up of students who earned bachelor's degrees in physics, but either did not apply to doctoral programs in physics, or were not admitted to any of the programs to which they applied. With mentoring, support, research experience, and additional coursework, the program aims to make these students competitive candidates for doctoral programs in physics, either at their bridge site or elsewhere.

The program recently announced that it would fund two new sites beginning in July 2015. The University of Central Florida (UCF) and and Indiana University (IU)

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MEMBER NEWS

IEEE Awards Medal of Honor to APS Past President Mildred Dresselhaus

By David Voss

Mildred Dresselhaus, a professor at the Massachusetts Institute of Technology and past president of the American Physical Society, has become the first woman to receive the IEEE Medal of Honor, in recognition of her "leadership and contributions across many fields of science and engineering."

Mildred Dresselhaus

The medal is the most prestigious award of the IEEE (formerly the Institute of Electrical and Electronic Engineers) and was created in 1917 to honor individuals who have made "a particular contribution that forms a clearly exceptional addition to the science and technology of concern to IEEE." Previous recipients have included physicists such as Nobel laureates Charles Townes, John Bardeen, and Norman Ramsey.

Dresselhaus, Emerita Institute Professor of Electrical Engineering and Physics at MIT, has focused her research on the properties and applications of carbon, including fullerenes, nanotubes, and graphene. She was president of APS in 1984 and currently serves on the editorial board of *Physical Review Applied*, published by the APS.

During her career, Dresselhaus has also served as president of the American Association for the Advancement of Science and director of the Department of Energy Office of Science. She is a member of the National Academy of Sciences, the National Academy of Engineering, and has served on many advisory committees and councils.

In 2012 she received the U.S. Department of Energy Enrico Fermi Award, followed quickly by the 2012 Kavli Prize. In 2014, Dresselhaus was awarded the National Medal of Honor, the United States' highest civilian honor, at a White House ceremony. Dresselhaus has also won the APS Dwight Nicholson Medal for Outreach and the APS Oliver E. Buckley Condensed Matter Physics Prize.

IEEE will present the award to Dresselhaus on June 20, 2015 at its annual honors ceremony in New York City.

For more information, see www.ieee.org/about/awards/bios/moh_recipients.html

PUBLISHING

Is Double-Blind Review Better?

By Shannon Palus

Referees reviewing a paper are always anonymous. But have you ever wished you, an author of a paper, could remain anonymous to a peer reviewer?

Maybe you have one or a few people who can't stand you for personal reasons. Maybe you're an up-and-comer in your research area — and want to be on a level playing field, with just as much opportunity as someone with a famous name. Maybe you are in the minority — i.e., not a white male — and want to buffer yourself against implicit bias.

With those benefits in mind, *Nature Geoscience* and *Nature Climate Change* decided to offer a double-blind option to authors: Take out all identifying materials from your paper, and the editors will not tell your paper's reviewer your name. After 21 months, fewer people had used the option than expected, and there was no notable difference in the quality of reviews. But the response from authors was positive, so as of March of this year, *Nature* started offering authors a double-blind peer review process across all its journals.

But double-blind peer review isn't a one-size-fits-all-fields proposition. Many factors affect the viability of the option.

Nature Physics is offering the option, as part of the *Nature* decision. To our knowledge, it's the only physics journal to do so currently. The journal's chief editor, Andrea Taroni, isn't sure that it will be popular. "Physicists work in a relatively open and collegial way and rely extensively on arXiv," Taroni wrote in an email.

We can also turn to history for one scenario of how it will work out. The *APS Physical Review* journals ran their own two-decade experiment in double-blind review. It did not go well.

Double-Blind Peer Review in Physics

The impetus came in 1980 from the APS Committee on the Status of Women in Physics (CSWP), recalls *Physical Review Letters* (PRL) Editor Emeritus Stanley Brown. "They thought that there was a possibility that papers written by women were subject to more critical review than papers written by men."

Indeed, recent studies confirm what the committee then suspected. A 2012 study in the Proceedings of the National Academy of Sciences showed that identical application materials for a lab position were more favorably read when the name at the top of the resume was "John," rather than "Jennifer."

So the CSWP suggested that double-blind review should be the standard. But, according to Brown, the editors felt that trying to hide every single author identity would probably be unsuccessful, and authors too recognizable, to be effective. Even in the days before researchers routinely uploaded their papers to the arXiv, a culture of openness and connections made authors easily identifiable, says Brown. "Communities were

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line in two years or less is simply not rewarding.

Corporations want the benefits of research and the discoveries that emanate from it, but unless the rules change, they won't pay for it — unless they're forced to. And now could be the time to make them do it.

Members of both political parties recognize that corporate tax rules are patently unfair. They benefit global companies that can take advantage of loopholes to reduce their taxes dramatically, while requiring most other companies and small businesses to pay the full 35 percent federal rate. Comprehensive corporate tax reform is in the Washington air. It would most likely reduce the tax rate and plug loopholes, keeping the legislation revenue-neutral.

Part of a likely reform package would be a sweetener to repatriate the more than $2 trillion currently stashed overseas by global American corporations — eight high-tech companies, among them Apple, Google, and Microsoft, account for more than a fifth of the total — and not subject to federal taxation so long as the money remains offshore. With interest rates low, American companies such as Apple have been happy to use their overseas holdings as collateral for loans to buy back stock or for other domestic purposes. But as rates rise, such tactics will become increasingly less attractive.

A 5 percent to 10 percent tax on repatriated money could generate a one-time capitalization of $100 billion to $200 billion for a self-sustaining research investment fund, generating an annual usable investment income of $4 billion to $8 billion. Private directors, drawn from the science and technology community, the finance community, industry, and labor, would largely control the operation of the fund. But representatives of selected federal science agencies would provide a public nexus.

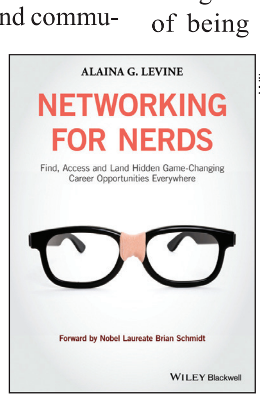
Describing in detail how the fund would operate requires more space than this column permits. Suffice it to say, it would contain safeguards to prevent appropriators from gaming the system; it could provide matching funds to encourage appropriators to boost science budgets; it would rely on agencies to provide prioritized lists of peer-reviewed projects; it could provide seed money for major initiatives and projects; it could allocate funds to long-term applied research for which neither industry nor government has any appetite; and it could develop strategies to increase its endowment.

Will it be easy to establish a research investment fund? No. Could it happen? Possibly. Do we need it? Absolutely yes.

BOOKS

Cultivate Your Career

APS News contributing correspondent Alaina G. Levine is the author of a new book, *Networking for Nerds*, that draws upon her experience in science and communication to advise and guide researchers in the care and feeding of their careers as part of scientific collaboration. From graduate students to senior researchers, *Networking for Nerds* offers tips for everyone. Levine goes into detail about myths surrounding networking, how to articulate your skills and expertise, whom to network with, and how to make best use of social media. In his introduction to the book, Nobel Laureate Brian Schmidt says "Networking is an important part of the scientific process and, therefore, doing it well is an important part of being a successful scientist. The innate skills each of us has in networking vary widely, but as with other skills, most of us can improve with training. This book is all about the basic skills you need to learn to better communicate with your colleagues."



Wiley

Networking for Nerds by Alaina G. Levine, published by John Wiley & Sons, will be released on July 13, 2015.

STEM SCHOLARSHIPS

"The Big Bang Theory" Team Supports STEM Students

The cast, crew, and one of the creators of the hit television show "The Big Bang Theory" announced in late May 2015 that together they are endowing a new scholarship at the University of California, Los Angeles for science, technology, engineering, and mathematics (STEM) undergraduates.

According to the university, the scholarship fund has raised more than $4 million from nearly 50 people associated with the television program, which is now in its eighth season. The show's science consultant, APS Life Member David Saltzberg, is a physics professor at UCLA.

In a press release, UCLA Chancellor Gene Block said "We are grateful for The Big Bang Theory Scholarship Endowment, whose contributors agree with us that economic standing should not hinder a deserving student's shot at a degree from a university of UCLA's caliber."

During the coming 2015-2016 academic year, 20 Big Bang Theory scholars will be chosen from among those admitted to UCLA, and these students will receive funding based on financial need. In each of the following years, five additional students will be selected.

Profiles in Versatility (Part 2)

A Physicist Among the Angels

By Alaina G. Levine

Matthew Davis acknowledges what we are all thinking: that being a physicist can generate major superhero status, no matter the sector. "[Having studied] physics sets me apart [in business]," he says. "It checks the box that says 'He's smart. He can handle anything.'" So when it came time for this entrepreneur and philanthropist to plan his career, he easily saw the discipline's broad value. Davis majored in the subject and received a professional science master's in science and business from the University of Utah. Following his graduation in 2004 and a stint as a consultant for the U.S. government, he launched RENEW Strategies, a company that manages a global network of investors who seek to make both social impact and financial returns on their investments in Africa. "I wanted to do something unique, and what better way to prepare me is there than study physics.

The investors who comprise his network are known as "angels," high-net-worth individuals whose funding decisions tend to be driven by their hearts as well as their wallets. Angels often form investing groups that are geographically focused and offer entrepreneurs the opportunity to pitch ideas that the angels can decide to support either independently or in subgroups. Angels play a critical role in the start-up pipeline because they often invest in ventures that are relatively new or too tiny to attract traditional venture capital.

Recognizing how invaluable angels are to entrepreneurial and overall business growth, Davis and his team at RENEW decided to harness this power for good. His company engages angels on a worldwide stage. These "accredited investors" (according to SEC rules), with at least $1 million in liquid assets, support companies in Africa in a "Goldilocks" zone: "We manage an angel network that makes investments that are too small for larger investment funds to be interested in and too big for microfinance," he notes.

RENEW's financial analysts, lawyers, and business consultants, with extensive experience in Africa, look for enterprises that have the potential to generate attractive returns and provide a major social kickback to their communities. The firm then funds these targeted businesses (with, on average, $500,000) and also provides other resources to scale up. This can include business support, such as helping the enterprise establish a board of directors, recruit senior management, strengthen its finances, and ramp up its sales and marketing. All the while, RENEW is keeping an eye on the bottom line, especially as it relates to creating jobs, improving economic development outputs, and developing new directions for business expansion.

"RENEW reduces the costs and risks of investing in developing and emerging countries by partnering with the development community, having a dedicated presence on the ground, managing an exceptional local network, using innovative structures and investment instruments, and providing hands-on consulting to our investments," says Davis.

Sectors range from high technology to manufacture. A recent success story showcases dVentus Technologies, a companybased in Addis Ababa, Ethiopia, that provides clean energy solutions. This is especially timely and relevant because "Ethiopia is trying to make itself a power exporter," says Davis, and its government is keen to invest in energy-related enterprises. But its

RENEW

Matthew Davis

national grid needs work, he admits. dVentus used RENEW's investment to successfully develop a smart meter customized for Ethiopia and for other countries in the region, and "is now negotiating contracts with a number of national and regional governments across sub-Saharan Africa and the Middle East — including Ethiopia — to modernize their power grids and save billions of dollars from poor grid management," he adds. Interestingly, the meter was designed and customized by Daniel Gizaw, an engineer who worked in the U.S. for many years before returning to his home country, Ethiopia, to develop the energy industry. dVentus is now working with prospective investors to develop a smart-meter-and-generator manufacturing plant in Ethiopia.

RENEW has also provided capital to manufacturers in the food industry. It has made investments in an Ethiopian specialty coffee farm, which ultimately helped to create 500 jobs, as well as Mama Fresh Injera, Ethiopia's largest commercial manufacturer and exporter of injera, a staple bread of Ethiopian cuisine. The investment is financing the construction of a new export-focused factory that will enable Mama Fresh to triple daily production of injera, and to hire 30 additional employees, primarily women, to staff the new facility. The investment is also allowing the company to explore new market opportunities for injera, including the growing gluten-free markets in the U.S. and Europe. RENEW's contribution is expected to achieve significant social benefits for employees, smallholder farmers, and the greater Ethiopian economy, and will more than double the purchases Mama Fresh makes from the thousands of smallholder farmers who supply grain to the company, according to RENEW's website.

And soon, RENEW will be in the tahini business too. Currently, the majority of tahini, which is eaten throughout the Middle East, Africa, and Asia, is processed in Israel from sesame that is grown in Ethiopia. But Davis plans to process it in Ethiopia as well, by scaling up the tahini processing plants in-country: "We are adding value to the sesame supply chain … So instead of exporting the raw sesame, we shorten the supply chain in Ethiopia and export a higher value of sesame in the form of tahini itself." This way, the country retains more profit. This seemingly simple change in how the business operates has the potential to have a huge impact in supporting higher-wage jobs and spurring growth in related businesses that are connected to this industry.

Davis' foray into impact investing started with his hunger to go into commerce. "I just loved the idea of getting into business," he says. "I wanted the top, corner office." And he realized that his physics degree could be a major springboard to achieving his goals. When he graduated, he headed to Washington, DC for a job at a consulting firm that he had landed due to some clever networking with former schoolmates. "This is where having a science background can get you into trouble," he notes with a chuckle. His colleagues would constantly pull him onto an assignment, echoing "'Oh you're a physics major? You're hired. Can you go help NOAA with their project?'" he says.

The concept behind RENEW sprung out of a personal trip Davis took to Africa in 2006. He noticed that the common western approach to development is "Here's a problem and how do we fix it?" But armed with his physics and business playbook, he looked at development differently, and asked "What are the opportunities and how can we maximize them?" He started thinking about venture-building. He consulted with potential investors who agreed to fund projects, as long as Davis did the legwork to ensure that they were legitimate and could provide both a solution to a development problem and a return on the investment.

RENEW's modus operandi reflects a shift in how charitable ventures typically operate, he explains. "Here, we are finding good opportunities, scaling up the companies and creating lots of jobs in the process," he says. Angel investing is nothing new in the U.S., but applying this business model to development projects abroad is innovative. "More traditional philanthropic endeavors are utilizing private-sector mechanisms to improve and increase social impact," he says.

The company focuses most of its resources on Ethiopia, where Davis

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frequently small enough that you could infer."

Still, the editors thought offering an option "would be an interesting experiment." So, in 1980, the *Physical Review* editors instituted the policy for their (then) five journals. The upshot — only an update to the submissions guidelines and a sentence in an editorial in PRL.

And publication at the *Physical Review* journals hummed along for 22 more years with no additional note that Brown can recall, positive or negative, for the double-blind option. In 2002, he thought he should check up on the results of the trial.

Between 1993 and 2001, authors on 121 papers requested the double-blind option. (Brown doesn't have data from before then.)

That's 0.06% of the total manuscripts submitted. Of those, only 7 were published. Compare that to the acceptance rate for *Physical Review* journals in general — which is 60%. "It amounted to less than one paper per year," Brown says.

No editor *APS News* spoke to could spin that as a success.

"In a nutshell it did not add to the efficacy of the process and had several other drawbacks," recalls Jack Sandweiss, a former lead editor of *Physics Review Letters*.

"It was difficult to manage. It was difficult to maintain," says Reinhardt B. Schumann, the current managing editor of PRL.

Brown sums up having the option as "basically cosmetic": a way to answer anyone who asked about the journals' efforts to prevent discrimination in the peer review process, which no one ever really asked about anyway.

Ultimately, "It wasn't practical in physics," says Brown. "I know that in other fields other journals routinely use it."

Peer Review in Other Fields

Some of the major journals in philosophy use triple-blind review, in which even the editor is anonymous. In art history, double-blind is used frequently. The American Economic Association used to have a double-blind system for its journals, but in 2011 switched to single-blind. The reason? Search engines made it too easy to uncover an author's identity.

But in science, single-blind is the norm. The journal of the same name, *Science*, only offers single-blind.

It goes against the grain, then, that the field of computer science is largely split between the two systems. That's according to Roch Guerin, Chair of the Association for Computing Machinery's Publications Board Conference Committee, which was tasked with a review of the respective roles of ACM's conferences and journals. (Yes, conference abstracts are peer reviewed in computer science).

Computer science, like physics, enjoys a fair amount of sharing and openness (though there is no arXiv equivalent). So that throws out the argument of it being easy to infer the author.

The double-blind system might flourish simply because a different model is not as deeply ingrained in the culture: The field is young, with its first journals born in the 1950s and 1960s [1]. "Computer science was a science, but also an experimental discipline," says Guerin.

Whether double-blind is the way to go over single-blind is an experiment with no clear conclusion.

"People on the double side believe it leads to a more objective outcome," says Guerin, who has sat in on a lot of discussions debating the merits of each. "Other people actually feel that knowing who the authors are provides additional qualifications."

Important to the functioning of the double-blind method, when it is used, is that a computer science conference or journal that operates under double-blind peer review does so across the board. It's not an option, it's a modus operandi.

And that might be crucial to its success.

Take the example of the *Nature Geoscience* trial, the one that spurred *Nature* to provide a double-blind choice. A reader survey a couple years ago showed an "overwhelmingly positive" response to the idea of offering double-blind, says Heike Langenberg, chief editor of *Nature Geoscience*.

But when the trial went into effect, only around 15% of the submissions opted for double-blind review, says Langenberg. The problems, she speculates, is that people don't know about the option before they start the submissions process and just want to get it done quickly (anonymizing a paper isn't hard, but it does take a few minutes).

Plus, many people think that their identity can be guessed anyway.

"People overestimate how well they can guess identities," says Langenberg. Right now, her evidence is just anecdotal, but she's collecting data to find out for sure. The journal has started asking referees if they can guess authors, though results might not be available for a few years.

As for the benefits for geoscience researchers whose data are less identifiable? According to Langenberg, the double-blind process gets to the point of what a good peer review should be, plain and simple. "It just takes away anything but the science in the paper."

Is double-blind worth fighting for?

Today, double-blind peer review isn't a topic of discussion among current APS Committee on the Status of Women in Physics (CSWP) members, or those of the APS Committee on Minorities in Physics, say the chairs of those committees.

"I wouldn't be surprised to hear there's bias in the peer review process," says Ashley DaSilva, a member of CSWP and postdoc at the University of Texas at Austin. "[G]ender differences in publication record start well before the peer review."

Double-blind peer review may strip a paper down to "just the science" — and may well be an effective and fairer option for some fields. It may even prove to work out nicely for *Nature Physics*. As Taroni wrote in an email to me, "obviously only time will tell!"

But, there are so many interactions between physicists — those every day in labs, classrooms, job talks, scientific meetings, and at the water fountain — that determine who gets to publish science, and therefore which science makes it through the review process. In those interactions within the community, as is the case in peer review within a field that relies on sharing, collaboration, and working with other human beings to move forward, it is impossible to strip our identities out.

Reference

1. www.oxfordjournals.org/our_journals/computer_journal/historypaper_mills1.html

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Bloomington were chosen through a competitive review process, similar to the review process at the National Science Foundation, bringing the total number of funded sites up to six. The two new sites will each receive $150,000 over three years to support URM students who will transition to doctoral programs in physics.

IU Bloomington will offer a two-year M.S. degree program that will include a wide array of lab-based courses, exposure to research in traditional as well as interdisciplinary fields of physics, and individual mentoring, advising, and professional development in preparation for doctoral studies. The program aims to have four to five students enrolled in the program every year.

Jon Urheim, Director of the IU Bloomington program, advocated for his university to join the APS effort because of his concern that its graduate physics enrollments were not representative of regional demographics, especially those of the African American– and rapidly-growing-Hispanic segments of the population. He sees the program as a "win-win-win" opportunity to contribute to the APS Bridge Program's national goals, immediately enhance diversity, and provide a natural avenue for URM students to transition from the Bridge Program into IU Bloomington's Ph.D. program. Urheim and his team were impressed with the quality of the program's first round of applicants. "Every one of the applicants we interviewed was engaging, interesting to talk with, and displayed qualities that indicated potential for excellence in Ph.D.-level research," he said. "It was a disappointment that we were not able to offer admission to all of them."

The new Physics Transitional Master's program at UCF will recruit four students per year and prepare them to continue onto a Ph.D. program at UCF or elsewhere. These students will be placed into undergraduate and graduate courses depending on their level of preparation, following a knowledge assessment taken by all graduate students before classes begin. During their first summer in the program, students will participate in research and develop presentation and writing skills by participating in the UCF Summer Research and Writing Institute.

Talat Rahman, Site Leader at UCF, said "A national program can be a real catalyst for change. If the program does well, it affects everyone." Rahman is most excited that the Bridge Program will encourage diversity in thinking. She's currently entertaining the idea of engaging Bridge students in some teaching, as all graduate students do at UCF, so that students can go through this experience together and learn from each other through the process. UCF is committed to funding the program for three years beyond APS funding, and hopes that heightened awareness will encourage more URM students to apply directly to UCF, thereby further increasing diversity in the applicant pool.

With the addition of IU Bloomington and UCF, there are now 12 new slots for Bridge students this year. At press time, 25 students were placed into APS Bridge sites and graduate programs. For students that aren't placed at APS Bridge sites, the Bridge Program circulated their applications to more than 45 additional doctoral- and master's-granting institutions. These institutions, each committed to improving diversity in physics, make offers based on funding availability and matches in research interest. Bridge Program staff expect that the total numbers of students placed will effectively erase the achievement gap.

The program also recently expanded to include Partnership Institutions — doctoral- and master's-granting institutions that are committed to fostering a diverse and safe environment for all doctoral students, including Bridge students.

The APS Bridge Program will hold its annual meeting October 9-11, 2015 at Florida International University (another Bridge site).

For more on the background of the program, see apsbridgeprogram.com/about/diversity.cfm

For information on bridge programs in physics, please see this *Physics Today* article [1].

The author is Outreach & Communications Specialist at the A.J. Drexel Autism Institute in Philadelphia. Until a few months ago, the author was the APS Bridge Program Coordinator.

Reference

J. Matthews, *Physics Today* **64** (March 2011).

Note: The Bridge Program is supported in part by the National Science Foundation, under award #1143070, and by the American Physical Society.

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and Fields; Aihua Xie, Oklahoma State University, Chair of the IUPAP Commission on Biological Physics; and Beverly Berger, representing the Affiliated Commission on General Relativity and Gravitation.

Please visit the IUPAP website (iupap.org/) for further information on IUPAP-sponsored conferences and awards. The nomination deadlines vary from one commission to another.

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than 60 nations. The national teams compete to solve challenging theoretical and experimental physics problems. U.S. participation began in 1986.

This year, team selection began in January with 4,300 high school students from around the country who took a rigorous physics test. Eventually, 20 students cleared the hurdles and arrived in College Park in early May for Physics Boot Camp, a two-week training and testing period. At the end of the boot camp, five students were selected for the traveling team headed to India.

The five are: Zachary Bogorad (Solon High School, Solon, OH), Adam Busis (Montgomery Blair High School, Silver Spring, MD), Kevin Li (West Windsor-Plainsboro High School South, Princeton Junction, NJ), Jason Lu (Adlai Stevenson High School, Lincolnshire, IL), and Saranesh Prembabu (Dougherty Valley High School, San Ramon, CA).

Helping the students train are college students, postdocs, and professors who volunteer as coaches. "This collection of junior coaches has been phenomenal this year in terms of their engagement and involvement with the students," said Paul Stanley, academic director of the team.

In addition to Stanley, they are JiaJia Dong (Bucknell University), David Fallest (North Carolina State University), Mikhail Kagan (Penn State Abington), Jeffrey Yan (Harvard University), and Kevin Zhou (Massachusetts Institute of Technology).

"It's been a year's worth of work by the students, and 10 hard-working days for the coaches and the academic director to bring the team to this point," said Beth Cunningham, Executive Officer of AAPT.

The International Physics Olympiad will be held July 5 - 12, 2015 in Mumbai.

For more information on the 2015 U.S. International Physics Olympiad team, visit www.aapt.org/physicsteam/2015/

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currently spends 70% of his time. Next year, he expects to expand to another country in Africa. As he looks to grow his own business, he sees opportunities for scientists who are also business-minded. "I would love to see more physicists leading companies and potentially making that interaction between the people on the floor of the factory and in the lab and those who invest," he says.

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microwave oven-sized device became known as UV Waterworks, and Gadgil says this has improved the lives of more than five million people.

In 2000, Gadgil took on a new drinking water challenge: removing arsenic from groundwater. In India and Bangladesh, surface water is often contaminated with fecal matter, and municipal water treatment facilities do not exist in many places. Governments have responded by encouraging people to drill millions of rudimentary wells to tap groundwater. But this has created another problem: Much of the groundwater has natural levels of the toxic element arsenic that can be more than 100 times the concentration that the World Health Organization considers safe.

Here again, technology had been tried and failed. Gadgil himself developed a new kind of absorbent that could remove arsenic, and that could be manufactured with readily available materials. But he had trouble getting anyone interested in producing the absorbent at scale, because there was no clear way to recoup costs in a country where people are not used to paying for drinking water.

At about that time, Gadgil learned of a process developed in Nepal that uses iron oxide, i.e., rust, to bind to arsenic; the arsenic-iron mixture clumps and can then be filtered out. Amrose joined the project in 2006, and they discovered that they could create the rust on demand, as it were, by applying a small voltage to steel plates submerged in arsenic-laced water. In other words, the absorbent was "manufactured" directly in the water where it was needed. Amrose named the process electrochemical arsenic remediation, or ECAR.

In the lab, they tested a version of their device that could process up to three liters of water at a time. They found an Indian company, Luminous Water Technologies, to license the technology and develop it further; they have field-tested a 100-liter prototype. Amrose and Gadgil recently traveled to West Bengal, India to launch the demonstration of a device that can process 10,000 liters of water per day. If the device succeeds (a complete field test can take up to a year or more), they hope to move to large-scale manufacturing and distribution.

Stove science

Sometimes Gadgil finds projects that need his expertise, and sometimes projects come to him. In 2004, someone from the U.S. Agency for International Development called Gadgil and told him about the dire situation of women in refugee camps in Darfur. These women, displaced from their villages by war, needed large amounts of firewood to cook on their traditional stone fireplaces. But wood is scarce in the semi-arid Sahel region, so the women had to look for it far beyond the camps' borders, where they were exposed to increasingly frequent sexual violence and kidnappings.

Gadgil says he never intended to make a better cookstove, but he recognized that his years spent modeling airflow gave him the skills he would need to produce one that would burn less wood. He spent a year raising funds to travel to Sudan, along with several colleagues. They brought four fuel-efficient cookstoves that other groups had developed, and asked women in the refugee camps to try them out. None proved to be acceptable, and often the women rejected them for reasons that would have been impossible to know without visiting in person. For instance, the women insisted that they be able to see the flame, so they could know when to add wood. "All the time we paid attention to what the women cooks wanted," Gadgil says.

Amrose and other students in Gadgil's Design for Sustainable Communities course chose to take on the challenge and design a stove that met multiple criteria: cheap, made out of readily available materials, and culturally acceptable. The researchers returned to Darfur several times to field-test prototypes and improve the design. When they couldn't find a nonprofit interested in manufacturing the stove (Gadgil notes that many nonprofits working in the developing world can be technophobic), Gadgil helped found one himself. In 2009, that nonprofit, called Potential Energy, began distributing a sheet-metal stove that can be produced for $20, stamped in India and shipped to Sudan, where local workers assemble it by hand. It uses less than half the firewood and produces far less black carbon and carbon dioxide emissions than the traditional fires the women were using, thereby improving women's health in multiple ways.

Potential Energy has distributed more than 46,000 stoves, with plans to distribute another 5,000 by year's end, and Berkeley researchers are modifying the design for use in other countries. The ultimate goal is to distribute millions of stoves around the world, Gadgil says, and make a dent in the commonly-cited figure of four million people who die every year from indoor air pollution. A study that measured stove use in a refugee camp with sensors and cell phone surveys found that among people given stoves, around three-quarters used the stoves to cook at least some of the time.

A growing community

The development engineering community that Gadgil has seeded at U.C. Berkeley and Lawrence Berkeley Lab continues to grow. More than 200 students have now been through the design course; it has been fully subscribed every semester it has been offered. Course instructors bring in representatives from Bay Area firms to advise students and help them take on real-world engineering challenges. When Amrose tallied up the statistics on students who had taken the course from 2006 through 2014, she found that 55 percent were women. By comparison, women make up only around 14 percent of the working engineers in the U.S.

The university is now scaling up its efforts, offering both an undergraduate and a Ph.D. minor in development engineering. Gadgil co-directs Berkeley's three-year-old Development Impact Lab, which supports dozens of engineering projects for the developing world, including ECAR, further stove design projects, and ReMaterials, a company Amrose collaborates with that produces modular, recycled roofing materials for use in low-income urban neighborhoods.

In 2014 Gadgil was inducted into the National Inventors Hall of Fame. And earlier this year, the APS Forum on Physics and Society gave Gadgil its Leo Szilard Lectureship Award, which his mentor Rosenfeld won 29 years ago. "In my mind, Ashok is the best heir apparent to Arthur Rosenfeld," says Ramamoorthy Ramesh, who heads the Lawrence Berkeley Lab division where Gadgil works.

"We didn't have any difficulty deciding that he deserved to win this award," says Valerie Thomas, an industrial engineering professor at Georgia Institute of Technology who chaired the prize committee. She commends Gadgil for "really going out there and understanding the needs of people .... He really has a comprehensive approach, and he's able to do that over and over again."

The author is a freelance writer based in Mount Rainier, MD.

ANNOUNCEMENTS

Reviews of Modern Physics

Lévy walks

V. Zaburdaev, S. Denisov, and J. Klafter

Lévy walks are random walks in which the distribution of step length does not decay exponentially and the velocity of the moving particle is finite. Building on earlier concepts, they reconcile anomalously fast diffusion with a finite propagation speed and have applications that range from basic statistical mechanics and transport theory to optics, cold atom dynamics, and biophysics. This review gives an introduction to this important class of models and discusses applications in both physics and biology.

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The Back Page

Nature Does Not Always Give Us What We Want

By Fred Schlachter

Reducing CO_2 emissions to address global warming is a high priority for many policymakers in Washington and in capitals throughout the world. One of the most obvious targets for achieving such an objective is the transportation sector that currently relies heavily on the use of fossil fuels. Several approaches immediately come to mind, although each has its own set of challenges.

For example, we could adopt new social patterns to reduce our transportation needs. But that would take time and almost certainly disrupt the way we live. Alternatively we could substitute hydrogen made from a renewable energy feedstock (water or biofuels) for gasoline, diesel fuel or natural gas. But we don't yet have the technologies needed to produce or store hydrogen efficiently.

Or we could substitute electricity obtained from a green grid. At present, an electric car probably offers the most promising path. Hybrid-electrics, plug-in hybrids, and all-electric cars already exist. Unfortunately, most of us don't drive all-electric cars because they have limited range and often create "range anxiety" for their drivers. And of course they cost more.

Many of us would be delighted to drive an electric car powered by renewable energy, such as solar and wind, as long as it costs the same as a car with an internal combustion engine (ICE), has a range comparable to an ICE car, and can be charged in the several minutes it takes to refuel an ICE car. None of that is possible at the present time.

Moreover, a widespread infrastructure for charging cars is an imperative, and it does not yet exist. Today only 10,000 public-access charging stations are available in the entire country, compared with approximately 120,000 gasoline fueling stations, and charging time is generally too long to be truly useful. Even though electric car owners can charge them at home or in some cases at work, it will be many years before a charging infrastructure will be able to satisfy the nation's needs if every American is driving an electric car.

At the moment the closest thing to a widely useful electric car is the Tesla, which has a range of a few hundred kilometers. But it comes at a price that is out of reach of most Americans, and with the exception of rapid charging at Tesla Supercharger Stations, it generally takes hours to fully charge.

Batteries lie at the heart of the limitations of electric cars. The best chemistry for portable applications today is lithium-ion technology, which American-born physicist John Goodenough developed at Oxford in the 1970s and SONY first commercialized in the 1990s.

Lithium-ion batteries have a relatively high specific energy (energy stored per unit weight and volume). But they are expensive. And despite a major concerted worldwide research effort, their specific energy has increased only marginally, still leaving them far below that of gasoline.

Halting the use of fossil fuels for transportation will require either major improvements in hydrogen fuel-cell technology and hydrogen-production energy efficiency or building much-improved batteries to power electric cars, or finding a means to use electric cars with batteries at their present state of development by changing the relationship of private ownership of a car to providing transportation.

I recently attended a conference at Oak Ridge National Laboratory focused on new and better chemistry to bring us closer to an all-electric-car goal. "Beyond Lithium Ion (BLI) VIII," was the latest in an annual series of such meetings. Compared with the irrational exuberance of the 2009 BLI conference, when lithium/air chemistry seemed to be feasible, and the gloom which permeated the 2012 gathering, when researchers had little to show for their endeavors — see my report, "Has the Battery Bubble Burst?," in *APS News*, August/September 2012 — the mood at the 2015 convocation was cautious optimism.

There has been an explosion of interest in alternative chemistries, with the periodic table being explored for new options. For example, lithium/sulfur is a major topic of research today. Researchers are studying lithium/air and many other chemistries involving sodium, magnesium, tin, potassium, nickel, and iron, many both as intercalation and as metal/air cells, as well as aqueous lithium/air. The objective is to find a new chemistry to greatly improve battery performance.

Improving specific weight and volumetric energy density are primary objectives, but lowering cost, improving calendar and cycle life, and using widely distributed and readily available resources are also high on the agenda. Indeed, reducing cost may be even more important than increasing battery

Google

Steve Jurvetson

(Top) Self-driving cars might eventually lessen the need for personal car ownership, while improvements in electric car charging infrastructure (bottom) could reduce "range anxiety" among drivers.

performance in furthering the sale and use of electric cars. The Tesla model S is widely seen — *Consumer Reports* recently called the Tesla Model S the best car it ever tested — as a very successful technological demonstration of what is possible with an electric car, were it not for the very high price.

Lithium/air, which seemed so promising in 2009, now appears to be extremely difficult to implement. Lithium/sulfur has become a leading candidate, although its chemistry is extremely complex. Even though a small company has begun to market a lithium/sulfur battery, experts believe that we are many years from a practical product suitable for mobile applications. Indeed, it is not clear that any chemistry beyond lithium-ion will be practical in the foreseeable future. If and when researchers find a suitable chemistry, we should recall that it took more than 20 years after their invention for lithium-ion batteries to be commercially produced.

Toyota, which uses lithium-ion batteries in its plug-in Prius — the standard Prius presently uses nickel-metal-hydride batteries —is studying a magnesium-ion battery. This chemistry shows promise because magnesium has two valence electrons, it does not form dendrites (which can cause a short in a battery), and it is plentiful and inexpensive. Although it is unlikely a magnesium-ion battery will have an energy density better than that of lithium-ion batteries, it might cost significantly less.

It appears at present that nature is not giving us what we want: greatly improved battery chemistry. It almost certainly won't, anytime soon, and maybe it never will. But we can always hope that the intense research currently underway will bring about the battery breakthrough we so desire some time in the future.

Cars are not the only important application for batteries. If the price is right, utilities could use batteries to store energy generated by renewable sources for load-shifting and load-leveling and for reducing both carbon emissions and the capital cost of electricity generation. Of course a battery for stationary use does not have to be light in weight nor fit in a small volume. Scalability, long life, and especially low cost are the dominant concerns. But here too we are awaiting a breakthrough that will allow low-cost energy storage on a utility scale. At present, only pumped-hydro provides such a capability, and it is practical in relatively few geographic areas.

Electricity storage in residential and commercial buildings is in the news now that Solar City is selling Tesla batteries for home use. Lithium-ion batteries are not required for building energy storage, and, although they are efficient, they are expensive. A new chemistry might make home energy storage cost effective.

If reducing the use of fossil fuels for transportation is a primary goal, powering cars with electricity (i.e., using electricity produced in a power plant as an energy-transfer medium) is not the only possible means. We can power a car with hydrogen, but as I already noted, using hydrogen is fraught with difficulties. Producing it is inefficient, presently requiring a platinum catalyst; it has a low mass density and must be stored onboard as a liquid or a high-pressure gas; and it is generally produced from natural gas, so emission of CO_2 takes place in the hydrogen production process. Nonetheless, Toyota is introducing the Mirai, a hydrogen fuel-cell car, for sale in Japan and soon in the U.S.

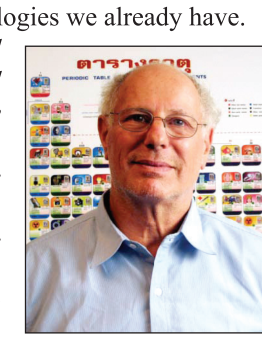
Social means of reducing the use of fossil fuels for transportation also exist, but they too face significant adoption hurdles. Encouraging the use of public transportation, car- and ride-sharing services, and someday perhaps self-driving electric cars could all reduce fossil-fuel consumption. But mass transit does not exist in most parts of the United States, and, until the "last-mile" problem is solved or Americans move to communities with higher population density, it will not be able to compete with the personal automobile.

So, for the foreseeable future the passenger car will be with us. But information technology could make the personal vehicle an unnecessary luxury. Imagine the following: Using a smart-phone app (think Uber/Lyft) you would summon a self-driving car. The car would fetch you, deposit you at your destination, and then proceed by itself to its next pickup. Of course, such a service would still consume fossil fuel unless it used an electric car that ran on a green grid. Nonetheless, it could reduce personal car ownership and achieve efficiencies by transporting multiple passengers and collapsing such disparate services as car pools, rental cars, taxis, and ride-on-demand. It would alleviate traffic congestion and reduce parking demand.

A self-driving electric car could also minimize range anxiety and the inconvenience of recharging. It would take itself to a recharging station when it was low on charge and resume service when charging was complete. It even could accomplish the recharging task without human intervention, provided the station used induction technology.

A self-driving car or van could fetch groceries or goods for delivery to customers and make scheduled rounds of a neighborhood, picking up passengers to take them to the nearest public transportation. Range and charging times would be inputs to a business model rather than sources of frustration for drivers. Google's experience with self-driving cars suggests they may be in our future well before batteries that require new chemistry.

Whatever the future holds — all-electric vehicles, hydrogen cars and trucks, or self-driving cars — there is no doubt we are on the cusp of a transportation revolution. We can only hope we will be able to develop better battery chemistries and new energy-efficient technologies rapidly enough to address the challenges of global warming. But in the meantime, we need to better deploy the technologies we already have.



Fred Schlachter recently retired as a physicist at the Advanced Light Source, Lawrence Berkeley National Laboratory. He is a Fellow of the APS and co-author of the 2008 APS report Energy Future: Think Efficiency, *for which he wrote the chapter on transportation. He has worked temporarily as a Policy Analyst in the Washington DC office of the American Physical Society and is an occasional consultant to APS on transportation issues.*