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Physicists Reach for the Exascale
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APS OFFICE OF PUBLIC AFFAIRS

Open Access Could Mean Authors Pay to Publish

By Michael Lubell and Mark Elsesser

"Open Access" – the unrestricted access to online, peer-reviewed research journal articles – has been gathering impressive momentum. In some cases, it has already altered the way scientific information is disseminated and how peer review and other publication activities are paid for.

During a recent discussion, APS President Sam Aronson noted that "Many commercial scientific publishers consider open access an existential threat to their business. But as a nonprofit publisher," he emphasized, "APS considers its impact on the research enterprise to be of far greater importance."

Mac Beasley, the society's past president and interim treasurer, agreed, adding, "Who will bear the financial burden of open access, what rules will govern it, and how will its implementation affect resources otherwise available for research? These are questions all APS members should be asking."

APS has long been a supporter of open access, as underscored by its 2009 statement, balancing its innovative initiatives with the need to maintain the viability of its publishing responsibilities. For several years, APS has offered its journals free of charge to all public libraries and high schools for use on their premises. APS has

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Physics in Iran After the Nuclear Agreement

By Emily Conover

The Obama administration's nuclear deal with Iran may have repercussions far beyond its nuclear program — scientific research in the country could blossom in the wake of the agreement. The Joint Comprehensive Plan of Action, an agreement between Iran and the P5+1 (China, France, Russia, the United Kingdom, the United States, and Germany), announced in July, would remove sanctions on Iran in exchange for restrictions that aim to prevent Iran from acquiring nuclear weapons. But included in an annex of the deal is a call for increased scientific collaboration between the P5+1 and Iran. In addition, under the deal Iran will convert its Fordow uranium enrichment plant into an international physics center.

Google Earth (c) DigiGlobe, 2015

According to the agreement with Iran, the Fordow enrichment facility will be converted into an international research center.

Sanctions imposed by the U.S., the United Nations, and other countries have significantly hindered research efforts of scientists within Iran. Obtaining necessary equipment and materials has been difficult, as has international travel to conferences and even publishing papers in foreign journals, says Reza Mansouri, an astronomer at

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CEO Robert Brown Discusses Plans for American Institute of Physics

By Emily Conover

The American Institute of Physics (AIP) announced the selection of its new chief executive officer (CEO), Robert Brown, in May. And according to Brown, change will soon be coming to the 80-year-old federation of scientific societies. He has plans to revamp the organization — which unites 10 different membership societies, including APS — by improving the benefits it provides, like *Physics Today* magazine, and by boosting the AIP presence on digital platforms and social media. Brown adds that with his background in private-sector physics he can help the organization better serve scientists who work outside of academia.

"I've arrived to find a really vibrant and high-quality set of people here," says Brown." To a large extent, people, I think, are willing and ready and looking for change and improvement in the future, so that's what I'm going to be trying to bring."

Brown is prepared to implement these changes, he says, thanks to diverse experience throughout his career. An applied physicist focusing on optics and photonics, Brown has worked in government labs, in academia, and in the private sector, from small startups to the largest international companies, as well as in scientific publishing.

Brown's interest in optics is a long-term love affair. The subject piqued his interest at a young age,

Robert Brown

he says, when he began performing some simple experiments and "just realizing that there's some really interesting questions to be asked and some fascination in playing with light."

Brown spent his early career at the Royal Radar Establishment, a military research center in Malvern, England, where he worked in photonics, quantum optics, and in photon-correlation systems. He then became head of optoelectronics research and general manager at Sharp Laboratories of Europe, creating a new lab from the ground up. That was followed by a stint as editorial director for the Institute of Physics (IOP) in the U.K., where he was responsible for the IOP's peer-reviewed journals, before heading to Northern Ireland to become director of nanotechnology and professor at Queen's University Belfast. After moving to the U.S. about ten years ago, Brown became chief technology officer of Ostendo

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Charges Dropped for Physicist Accused of Sharing Sensitive Technology with China

By Emily Conover

Charges have been dropped against Temple University physicist Xiaoxing Xi, who faced the possibility of 80 years in prison after the U.S. government indicted him on four counts of wire fraud in May. Xi, an expert in superconducting magnesium diboride thin films, stood accused of illegally sharing sensitive technology with China. The government moved to drop the charges on September 11, after Xi and his legal team presented statements from expert scientists indicating that the government had failed to understand the science behind the accusations.

"I am relieved and really hope that this will [be] the end of a nightmare," says Xi, an APS Fellow and naturalized U.S. citizen originally from China. "Of course, the damage it has done, I don't know how long [it] would take for me to repair it."

In 2006, Xi signed a non-disclosure agreement with a company called STI, for a device he had purchased known as a Pocket Heater. The device is used to make thin films of magnesium diboride, which is superconducting below 39 K. The indictment alleges that Xi, "repeatedly reproduced, sold, transferred, distributed, and otherwise shared the Device and the technology of the Device with and exploited it for the benefit of third parties in China, including government entities."

Xiaoxing Xi

The government's case, Xi's legal team says, relied on a flawed understanding of the science and technology underpinning Xi's work. On August 21st, Xi's legal team made a presentation to the government outlining the errors. "These weren't problems that made the case weak; these were problems that made the case against Professor Xi nonexistent," says

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Statement from APS President Sam Aronson on the Xiaoxing Xi case:

"The leadership of the American Physical Society is immensely relieved to learn of the government's dismissal of the charges against Professor Xiaoxing Xi. We are deeply concerned for Prof. Xi and his family regarding the ordeal that they have recently endured. We hope that Prof. Xi will rapidly be able to resume his research and teaching career in physics. On behalf of our members and the physics community, we are continuing to explore ways to work with U.S. government entities to provide guidelines that we can communicate widely, in order to ensure the safety of scientists collaborating in perfectly legitimate ways with Chinese colleagues."

Members in the Media

"I went into this putting myself in the mindset of a nuclear proliferator in Iran and saying, 'What if I try that? If we find this is impossible or blocked by the agreement, what are the alternatives?' So you go through these 'what if' questions, making sure we have all the leaks plugged."
***Bill Foster**, U.S. Congress, on the Iran nuclear deal,* Science, *September 9, 2015.*

"This was helped by the fact I didn't drive like a lunatic."
***Chad Orzel**, Union College, New York, in explaining the physics of why his cell phone didn't slide off his car roof,* DailyMail.com, *September 2, 2015.*

"There's a limit to how loose the strings should be. A butterfly net would clearly be no good."
***Howard Brody**, who passed away on August 11, in an earlier interview on the physics of tennis rackets,* The New York Times, *August 18, 2015.*

"It was an incredibly big breakthrough. … But nobody seems to care."
***Siegfried Hecker**, Stanford University, New York, on Iran's agreement to give up plutonium production, while most of the world's attention has been on uranium,* The New York Times, *September 7, 2015.*

"I don't expect them to understand everything I do … but the fact that they don't consult with experts and then charge me? Put my family through all of this? Damage my reputation? They shouldn't do this. This is not a joke. This is not a game."
***Xiaoxing Xi**, Temple University, following the U.S. government's dismissal of charges against him for sharing sensitive technology with China,* The New York Times, *September 11, 2015.*

"I just want to say, you are my ideal student. … As a theoretical physicist, I would love it if you took an interest in the mathematical side, although you're clearly very adept with your hands and at building things."
***Chanda Prescod-Weinstein**, MIT, in speaking with Ahmed Mohamed, the high-school student in Texas who was arrested for bringing his home-made digital clock to school,* Huffingtonpost.com, *September 17, 2015.*

"You can memorize the periodic table, but that's only 5 percent of the universe."
***Jonathan Feng**, University of California at Irvine, on the search for dark matter,* Popular Science, *October 2015.*

"We are there; we are in the ballpark now. It's clear that this is going to be pulled off."
***Kip Thorne**, California Institute of Technology, on the chances for detecting gravitational waves,* The Nation *(Pakistan), September 20, 2015.*

"Less like Harry Potter's cloak and more like Harry Potter's shed."
***John Pendry**, Imperial College London, commenting on the typical "cloaking" technology,* Science, *September 18, 2015.*

"They get full grades for weirdness and paradoxicality."
***Seth Lloyd**, Massachusetts Institute of Technology, on a paper claiming that sending quantum messages becomes more difficult if there are more delivery options,* Science News, *September 22, 2015.*

This Month in Physics History

October 8, 1945: First Patent for the Microwave

In January 1947, commuters in New York City's Grand Central Terminal took note of a fast-food vending machine, the Speedy Weeny, offering hot dogs cooked in a new invention: the microwave oven. Now a staple of the modern kitchen, it was the brainchild of Percy Spencer, a self-educated Maine farm boy with an insatiable curiosity about how the world works.

Born in Howland, Maine, in 1894, Spencer was just 18 months old when his father died. His mother, unable to cope as a single parent, left the boy's upbringing to his aunt and uncle. Spencer's uncle died when he was seven, so he and his aunt began traveling around New England, she working as an itinerant weaver and he working whatever odd jobs he could find. He later recalled that he had to "solve [his] own situation" during that difficult time, and that resiliency and "Yankee ingenuity" served him well in life.

His education was intermittent, too, and by the fifth grade he dropped out of school completely to work in a factory. When a local paper mill decided to install electricity four years later, he volunteered to help set up the new system, even though he knew nothing about the subject, and was just sixteen years old. Through a combination of experimentation and poring over textbooks at night, he ended up a highly skilled electrician.

Inspired by the heroic actions of the radio operators on board the sinking Titanic in 1912, Spencer became interested in the new wireless technology. He joined the Navy to become a radio operator, boning up on trigonometry, calculus, chemistry, physics, and metallurgy in his spare time. "I just got hold of a lot of textbooks and taught myself while I was standing watch at night," he later recalled. When World War I ended, he joined the fledgling American Appliance Company (later changed to Raytheon), founded by physicist Charles Smith and engineers Lawrence Marshall and Vannevar Bush.

Early in his research career at the company, he noticed a small leak in one of his photoelectric tubes. Usually scientists discarded such tubes as defective, but Spencer was curious about what might be happening. He discovered that the leak actually increased the tube's efficiency — an insight that proved to be a critical step in the development of the television cameras.

Then World War II broke out, and the company became responsible for building prototypes of combat radar equipment for the war effort. As a result, Spencer's tube division at Raytheon grew from 15 employees to more than 5000. Early in the 20th century, a German inventor named Christian Hulsmeyer realized that reflected radio waves could reveal the direction and range of nearby ships, a handy safeguard for avoiding harbor collisions. Wartime research gave rise to the cavity magnetron, a high-frequency tube with multiple built-in resonant cavities for producing a high-power microwave beam. The magnetron enabled British radar systems to spot approaching German bombers.

Spencer figured out how to mass-produce the magnetrons in those systems. Originally the cavities had to be machined out of solid copper; it took a skilled machinist weeks to complete just one. But Spencer found a much better way: He adapted a machine to stamp out thin cross-sections of the metal, stacked them, and then fused them to form the cavity via an oven with a conveyer belt.

wikimedia commons/acroterion

The first Radarange microwave oven weighed over 300 kg, had to be water cooled, and cost $52,000 in today's dollars. This model was installed on the nuclear-powered cargo ship Savannah.

Radar helped win the war, and for his microwave cavity assembly system, which vastly increased production, Spencer received the Navy's highest civilian honor: the Distinguished Public Service Award.

Heating materials with high-frequency electromagnetic waves was first proposed in 1934, based on research at Bell Labs, which filed for a patent in 1937. One day, as Spencer stood near an active radar set, he noticed that a candy bar in his pocket had melted, and realized that microwaves might be used to cook food. To test his hypothesis, he placed popcorn kernels near the magnetron. As he suspected, they began to pop. Next he cut a hole in the side of a kettle and put an egg in it before directing microwaves through the hole. It worked again, except the egg exploded, splattering the face of a skeptical colleague who was peering into the kettle at the wrong time.

Following up on these simple experiments, Spencer soon realized that a rectangular metal box would make a fine resonant cavity for cooking. Recognizing the commercial potential, Raytheon filed a patent for a microwave cooking process on October 8, 1945, and the Radarange hit the market in 1946.

The invention didn't catch on at first, hampered by public fears of microwave radiation, and by the sheer cost and size. Those microwave ovens were huge, nearly six feet tall and more than 750 pounds, and cost $5000 — the equivalent of more than $50,000 in today's currency. The first countertop home model went on sale in the 1950s for a more affordable $495, and by 1997, fully 90% of U.S. households owned

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Diversity Update

APS Conference for Undergraduate Women in Physics

APS Conferences for Undergraduate Women in Physics (CUWiP) are three-day regional conferences for undergraduate physics majors. The 2016 series will be held at nine regional sites Friday, January 15 through Sunday afternoon, January 17, 2016. Students must apply to attend. The deadline to apply is Friday, October 16, 2015. Learn more at aps.org/cuwip

Interested in hosting a 2017 APS CUWiP?

The 2017 APS Conferences for Undergraduate Women in Physics will be held January 13-15, 2017 at multiple sites throughout the U.S. APS is now accepting applications to host a 2017 conference — apply by November 1, 2015. Find out more at aps.org/programs/women/workshops/cuwip-host.cfm

APS Speakers List Featuring Women and Minorities

Planning a colloquium series and want to include a minority or female speaker? Check out the APS Speakers List! The lists contain names and contact information for physicists who are willing to give talks on a variety of subjects (with titles included). Check it out here: aps.org/programs/women/speakers/index.cfm

Cycling Across America … For Science!

Two young scientists spent this summer biking across America, teaching physics along the way. Elizabeth Case and Rachel Woods-Robinson met as undergrads at UCLA, where they majored in physics. On their 3500-mile trek from San Francisco to New York, they visited 10 schools, summer camps, and libraries. Their lessons revolved around "Sol Cycles": tiny, 3D-printed, solar-powered bicycles that the two designed. "I think it's just important for us as scientists to have a duty to get as many people in the next generation interested in science," Case says. After their three-month adventure, Woods-Robinson has returned to work at Lawrence Berkeley National Lab, and Case is studying for her Ph.D. in mechanical engineering at Cornell University.

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Technologies, and later worked at Rockwell Collins' Advanced Technology Center.

"This position as chief executive of AIP is a position where I'm challenged to use everything that I've learned in all those different background places in the past," Brown says. "So in a way the last 40 years has been a training course."

Besides APS, AIP member societies also include the American Astronomical Society, the Acoustical Society of America, and the American Association of Physics Teachers. Simultaneously supporting the 10 member societies, which vary widely in their needs, is a challenge, Brown says. Some of AIP's member societies have a few thousand members, and others, like APS, have tens of thousands.

Brown wants to increase the number of membership societies that are a part of AIP, and attract different types of member societies. "We have to have more features and more functionality, we have to have a much wider range of offerings to make AIP a 'must-belong-to' member society federation," Brown says.

And to enable AIP to better support APS in particular, Brown wants to deepen the relationship between the two organizations. "There are real opportunities to work together to build a better future."

Brown also hopes to push AIP to take advantage of digital platforms and social media to engage with scientists in the U.S. and around the world. "We have this wonderful technology available to us today where we can instantly be communicating with anybody on the planet in any country, and at the moment we're not doing that perhaps anything like as well as we could do," Brown says.

Brown will also work on increasing AIP's focus on applied and engineering physics, and on the corporate physics community. "The reason is, frankly, corporate physics in its entirety globally is much bigger than academic physics," Brown says. "In a way, to be honest, I feel the applied and engineering physics side is underrepresented at the present time."

Although AIP is also known for its suite of journals, those are published by AIP Publishing (AIPP), a wholly owned subsidiary of AIP, created after a reorganization which took place in 2013. "AIP Publishing is a company that's really worked out what it is and how it's going to operate," says Brown, who served as treasurer of AIPP before becoming CEO of AIP. "They are really tightly focused on their publishing activities. They've got plenty of ideas for the future — development of new journals, development of delivery platforms, and suchlike."

Brown highlighted *Physics Today* as perhaps the organization's most important perk for member societies. The magazine has a circulation of over 120,000 in the 10 member societies. "It is the principal membership benefit for many of our member societies," Brown says. "What we're trying to do now is see what else we can be doing with that magazine."

The magazine will soon be getting a new editor-in-chief, as current editor Stephen Benka will be retiring. The choice of the new editor will fall to Brown. "I've got to get somebody who's right, not just for the existing *Physics Today*, but the way that we imagine it could be in the future," Brown says.

Brown's enthusiasm for the job thus far is clear: "I'm loving it, I really am," he says. "The excitement for me in every position that I take, not just at AIP, is the range of challenges, the diversity of the challenges. … How do we make it really work efficiently and effectively and really well for everybody?"

Note: As this issue went to press, Brown announced several changes to AIP's structure at aip.org/commentary/structural-organization-changes-aip

APS PRIZES & AWARDS

Blewett Fellowships Help Women Return to Physics

By Emily Conover

In July, APS announced the winners of its 2015 M. Hildred Blewett Fellowships. These awards help women to return to careers in physics research after an interruption. Blewett was an accelerator physicist who had worked at Brookhaven National Laboratory and CERN, and when she died in 2004, her bequest to APS endowed this award. Since then, the yearlong fellowships, which provide up to $45,000 for dependent care, salary, travel, equipment, and tuition and fees, have helped nearly 20 women get their physics careers back on track.

The APS Committee on the Status of Women in Physics selected two new fellows this year: Huey-Wen Lin, and Nicole Lloyd-Ronning. Two others, Monique Tirion and Ani Tshantshapanyan, are returning as fellows, after their selection last year.

Nicole Lloyd-Ronning

Huey-Wen Lin

Nicole Lloyd-Ronning

For some women, childcare can be an all-consuming task. So it was for Lloyd-Ronning, an astrophysicist who took ten years off to care for her three children. Now that the youngest is in grade school, she feels ready to jump back into research. "I knew ever since I was very young that I wanted to do astrophysics," Lloyd-Ronning says. "I never stopped loving it — I just wasn't finding the balance I wanted to when the kids came along."

After studying physics and astronomy as an undergraduate at Cornell University, Lloyd-Ronning earned her Ph.D. from Stanford University. She then went on to a postdoc at the Canadian Institute for Theoretical Astrophysics in Toronto, during which she had her first child. She continued her research, working from home and part time as necessary. She then moved on to a second postdoc at Los Alamos National Lab (LANL) in New Mexico and had her second child.

But balancing work and home life left her feeling unsatisfied. "I was really bad at switching gears," Lloyd-Ronning says. "I was just thinking about work all the time when I was at home." So she decided to take a hiatus from research. All the while, Lloyd-Ronning says, she was still keeping up with the field, staying in touch with colleagues, and reading new papers on the arXiv every night.

Lloyd-Ronning studies gamma-ray bursts, extremely intense flashes of gamma rays that can occur when massive stars violently explode and collapse. A few years ago, she started dipping her toe back into research, working with one of her postdoc advisors at LANL. In her year as a Blewett Fellow, Lloyd-Ronning plans to use computational techniques to better understand how particles are accelerated in gamma-ray bursts and how they radiate. "The details of the physics are really not understood well," she says.

The Blewett Fellowship will allow Lloyd-Ronning to commit her time to research again. "It's giving me resources to be at work all day and find childcare when I need it for the kids," she says.

Huey-Wen Lin

Physicist Huey-Wen Lin encountered a "two-body problem" that made it challenging to keep her career on track as well as her husband's, especially when coupled with the demands of caring for their two children. As a visiting assistant professor at the University of California, Berkeley, Lin works when she can, but usually is able to make it into the office only one day a week. She says that the fellowship will help her get her children in full-time day care and get herself back to a regular work schedule.

In 2006, Lin received her Ph.D. in physics from Columbia University. This was already a complicated undertaking for Lin, who is from Taiwan. "No one in my whole family tree has ever lived as far as America," she says, and it was a particularly difficult move for a daughter to make. "It's more acceptable if a son tries to do something wild."

She then went on to a postdoc at Jefferson Lab in Newport News,

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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.

Double-Blind Review

In the article "Is Double-Blind Review Better?" (*APS News*, July 2015) Shannon Palus states that the only physics journal she knows of that allows authors to remove all self-identifying materials from their manuscripts is *Nature Physics*. However, one of the two flagship journals of the American Association of Physics Teachers, namely *The Physics Teacher*, requires it of all authors. I believe their reason for doing so is to ensure that all articles stand on the strength of their potential value in contributing to physics education, even if the authors are first-time contributors with no academic affiliation and live in some obscure international location.

I think we physicists have all heard of (or even been involved in) cases where games have been played with names and affiliations of authors on a manuscript for the sole purpose of impressing potential referees. (If Joe Superstar from Big-Name University is on a paper, referees may be more likely to be favorably disposed toward it before even reading it.)

If a journal is going to try double-blind, it should not be an option. Otherwise as a referee I can't help wondering if the authors have something to hide by choosing that option. It should be required of all submissions, at least on a trial basis for a select number of issues, to see if it changes the acceptance statistics. It is true that some authors will still be recognized (as I can report happens when I review for *The Physics Teacher*). That is no more an argument against blinding their authorship than the fact some referees will be recognized is an argument against blinding their identities. A system may be imperfect but still better than the alternatives.

Carl E. Mungan
Annapolis, Maryland

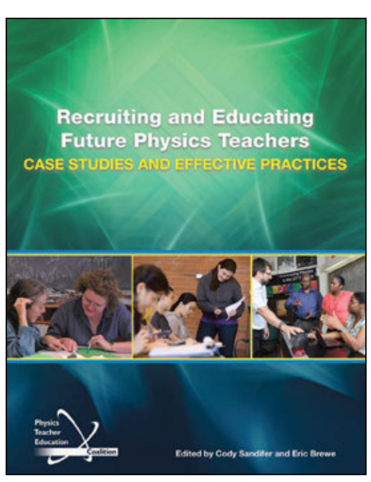
PhysTEC Book Shares Strategies for Educating Physics Teachers

By Emily Conover

A new resource is available for physics departments that want to boost the number of their graduates qualified to teach high school physics: a book that catalogs best practices for teacher preparation in physics. *Recruiting and Educating Future Physics Teachers: Case Studies and Effective Practices* targets physics faculty members who haven't previously thought much about encouraging undergraduates to become physics teachers, says Cody Sandifer of Towson University, a co-editor of the peer-reviewed compilation. "We're trying to get them excited about it and show them ways they can do that."

Qualified physics teachers are in short supply these days. According to APS Director of Education and Diversity Ted Hodapp, fewer than half of high school physics courses are taught by someone with a significant background in the subject. Hodapp and others hope to improve that statistic by encouraging successful physics teacher education programs to share their methods. "This was born out of the idea that we actually wanted to get people writing about effective practices" for teaching physics, he says.

Although physics teacher education is typically handled by education departments, physics teacher production shows up when physics departments are engaged, says Hodapp. Encouraging physics departments to produce teachers is the goal of the Physics Teacher Education Coalition (PhysTEC) — a partnership between APS and the American Association of Physics Teachers — which produced the book.



Two print copies of the book will be mailed out to every physics department in the country, and it is also available online. It comprises 21 papers, including case studies of thriving programs at institutions like the University of Arkansas, Middle Tennessee State University, and Seattle Pacific University. The book includes sections on recruiting students to become physics teachers, preparing them to teach effectively, and mentoring them. And it provides an important avenue for researchers to share their work. "There aren't a lot of places where you can publish peer-reviewed articles that are really focused on the practice of preparing physics teachers," says APS Associate Director of Education and Diversity Monica Plisch.

A previous PhysTEC book, published in 2011, collected existing literature from journals like *Physical Review Special Topics — Physics Education Research* and the *American Journal of Physics*. While this earlier book was intended for physics education researchers, Sandifer says, the new one has a more general audience, aiming to reach

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Physicists Set Course for the Exascale

By Emily Conover

The next frontier in supercomputing is the exascale — computers that can perform 10^{18} floating-point operations per second, or exaflops. Such computers tantalize scientists from across a significant technology gap. But with President Obama's recent announcement of a National Strategic Computing Initiative (NSCI), the machines are beginning to feel within reach. The much-anticipated supercomputers could be as few as ten years away, and physicists are already hatching schemes to take advantage of them.

"Exascale computing in many ways is a game-changer," says Robert Roser, chief information officer at Fermilab. The NSCI calls for supercomputers that are at least a hundred times as powerful as the current generation and capable of working with exabytes of data.

Created by an executive order on July 29, the NSCI directs government agencies to work together to achieve exascale computing, citing the Department of Energy (DOE), Department of Defense, and National Science Foundation as major players in the effort.

Supercomputers are already essential tools in many fields of physics, running the gamut from nuclear physics to fluid mechanics, from particle physics to astrophysics and cosmology, among others. And the impact is just as huge in other scientific disciplines — including climate science, neuroscience, and materials science — and in solving national security problems, like maintaining the U.S. nuclear weapons stockpile now that treaties ban test detonations.

"It's an impressive array of possibilities. I think the categories are going to grow in depth and become deeper and deeper," says Douglas Kothe, Deputy Associate Laboratory Director, Computing and Computational Sciences Directorate at Oak Ridge National Laboratory, who is spearheading the applications development for DOE's exascale initiative.

The top U.S. supercomputer is Titan, located at Oak Ridge. With over 17 petaflops, it is the second-most-powerful computer on the planet, according to the TOP500 ranking of the world's supercomputers. As of June 2015, China holds the global top spot with Tianhe-2, which boasts a performance of over 33 petaflops — a meteoric ascent given that a dozen years ago China failed to break the top 50. Japan has also garnered first place in recent years.

Titan's second-place finish reveals one reason for the exascale push that goes beyond just the usefulness of the tool: "Internationally, this is a huge deal, because it's very competitive," says plasma physicist William Tang of Princeton University.

A number of challenges stand between us and exascale computing, says Steve Binkley, head of DOE's Office of Advanced Scientific Computing Research. For one, the new supercomputers can't be made just by beefing up current machines. Without new technology, an exascale computer would have a power consumption of hundreds of megawatts — consuming much of the output of a small nuclear reactor. Getting that number down to 20 MW is one goal of exascale pioneers.

Another sticking point is simply programming the machines. They will be massively parallel, with a billion calculational steps taking place at once. "Getting software that can do that effectively is a major challenge," says Binkley. And ensuring the resiliency of exascale machines will also demand care. "Anytime you have a large system made up of many, many individual parts, getting reliable operation is hard," Binkley says.

Overcoming these obstacles, Binkley says, will require an R&D stage of about four years before beginning collaboration with computer vendors to work towards production of an exascale computer by the mid-2020s.

Applications of extreme scale computing intersect nearly every area of physics. For instance, in nuclear physics, lattice quantum chromodynamics calculations are "an incredibly nonlinear problem; we can't do it with pen and paper," says David Richards of Thomas Jefferson National Accelerator Facility. And higher-precision predictions of the interactions of quarks and gluons, and first-principles calculations of the properties of nuclei will be possible with the new machines, says Martin Savage of the University of Washington. 3-D simulations of core-collapse supernovae will likewise become more manageable. "These are things that are just a dream at the moment," says Savage. "I'm looking forward to the machines hitting the floor."

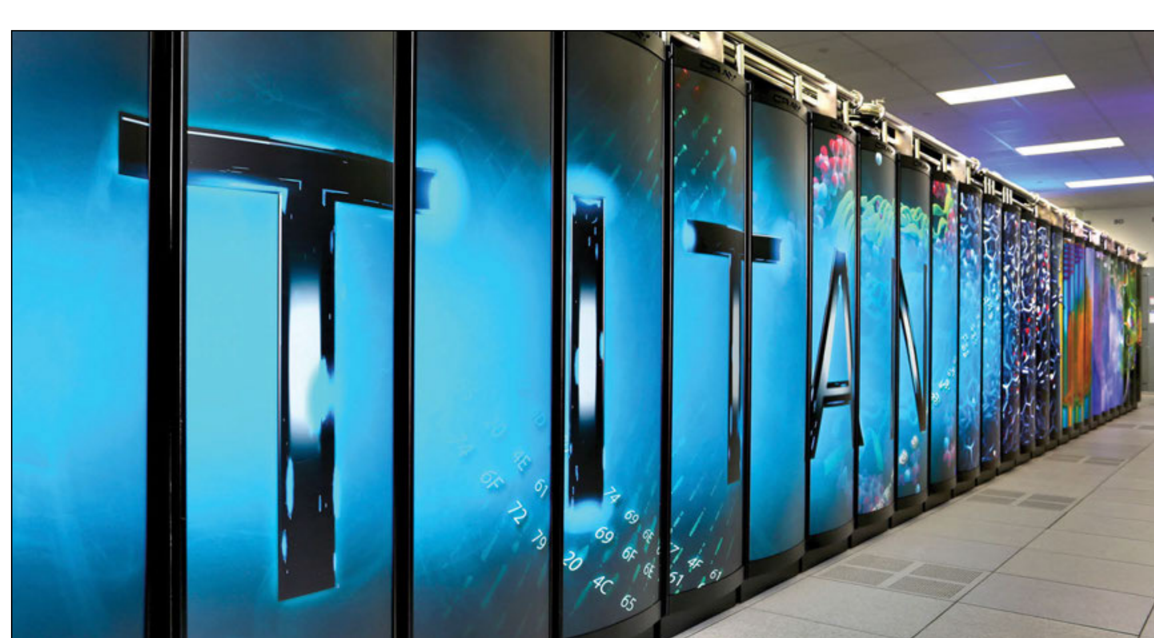
Supercomputers allow plasma physicists to make simulations of fusion reactors on the variety of distance scales relevant to the ultra-hot plasma within — from a tenth of a millimeter to meters in size. Better computers allow for more detailed simulations that more closely reproduce the physics, says Choong-Seock Chang of Princeton University. "With bigger and bigger computers, we can do more and more science, put more and more physics into the soup." Plus, the computers allow scientists to reach their solution faster, Chang says. Otherwise, "somebody with a bigger computer already found the answer."

High energy physicists are beginning to jump on the supercomputing bandwagon as well. The LHC currently relies on grid computing instead, harnessing a collaboration of computing centers across the globe. But as the LHC looks forward to a high-luminosity upgrade planned for 2020 that will boost its collision rate by a factor of 10 beyond the original design, the grid may not be able to keep up.

But it's not just a problem of capacity, it's also a problem of complexity, says Tom LeCompte of Argonne National Laboratory, who is working to make LHC code run on supercomputers. As LHC scientists simulate more complicated events, increasingly powerful supercomputers will be essential tools.

The NSCI doesn't stop at the exascale. The end of Moore's Law — which holds that computing power doubles every two years, thanks to improvements in semiconductor technology — is looming. The NSCI tasks scientists with going beyond Moore's Law to future computing technologies, possibly including quantum computing or neuromorphic computing, which attempts to mimic the nervous system. "A practical quantum computer is still years away, but it's time to start investing in the necessary research now," Binkley says.

Exascale computers will invigorate a variety of fields, researchers say. "It enables the young people to do things that haven't been done before and that brings a different level of excitement to the table," Tang says. And exascale is only the beginning, he adds: "To me an exascale supercomputer is just a signpost along the way. Human creativity will drive you further."



Oak Ridge National Laboratory

The 17-petaflop Titan holds second place among supercomputers. Researchers now want to reach exaflop speeds.

IRAN continued from page 1

the Institute for Research in Fundamental Sciences (IPM) in Tehran. "We have had many occasions that people from different disciplines have received emails from editors that they cannot even review such papers coming from Iran."

Now, Iranian physicists are anxious to expand their international collaboration, says Mansouri. Iran currently collaborates in two major international physics projects — the SESAME synchrotron light source (under construction in Jordan), of which Iran is a full member, and the Compact Muon Solenoid (CMS) experiment at CERN. "We scientists within Iran are ready for any collaboration," Mansouri says, assuming that funding is available. "There are lots of very, very peaceful projects that could be done."

The nuclear agreement supports "a broader opening of scientific engagements" with Iran, and lists several specific areas of possible cooperation, including nuclear physics and nuclear astrophysics, plasma physics, nuclear fusion, and neutrino astronomy.

"I think this opening is sure to happen," Shahin Rouhani, a physicist at IPM and president of the Physics Society of Iran, wrote in an email. "In existing collaborations such as CERN, what I guess will happen is promotion of Iran's role to a more involved one. But I expect that many new collaborations will start."

One experiment is specifically listed in the deal as a possible option for future collaboration — ITER, the massive nuclear fusion project in Cadarache, France. Although leadership of ITER was not involved in the inclusion of this item in the deal, says ITER Director-General Bernard Bigot, "The ITER mission is by design global and inclusive."

The agreement, Bigot says, has "opened the door" to the possibility of Iran joining ITER. "The very basic principle of the fusion program … is peaceful use of nuclear technology." Any question about that commitment makes it difficult for a country to participate, he says.

There is much work to be done before Iran could begin to cooperate with ITER, including sorting out what contributions Iran could make to the project. "We know Iran has a long-standing fusion program … but we have no relationship so far with Iran in detail, so we don't know if it could contribute and how much it could," says Bigot.

At CERN, Iran is involved in the CMS experiment, as well as in studies for future accelerators like the Compact Linear Collider and the Future Circular Collider, says Patrick Fassnacht, CERN's International Relations Advisor for Non-Member States in the Middle East and North Africa. "They are really very active on CMS and their contribution is very much appreciated," he says. About 25 Iranian users are involved with projects at CERN. In addition, Iranians regularly attend CERN's Summer Student Program and High School Physics Teacher Program.

Sanctions have thus far made it difficult for Iranian users to get visas and to transfer money to meet the financial obligations necessary to be a part of experiments at CERN. "This is hopefully now going to change," says Fassnacht, adding that Iran's role isn't going to expand overnight. "This is something that will take quite some time."

The Fordow facility, built under a mountain near the city of Qom, could be used for a variety of possible physics experiments, including a neutrino detector or a linear accelerator, Rouhani says. According to the deal, Iran will request "specific proposals for cooperative international nuclear, physics, and technology projects and will host an international workshop to review these proposals" with the goal of achieving collaborative projects within a few years.

But others are markedly more skeptical about the possibility of Fordow becoming an international research facility. "I wouldn't bet my house on it," says Hossein Sadeghpour of the Harvard-Smithsonian Center for Astrophysics, a former chair of the APS Committee on International Freedom of Scientists who has closely followed human rights issues in Iran.

A few major scientific facilities are currently under preparation within Iran, including the Iranian National Observatory, a 3.4-meter telescope planned to perch atop Mount Gargash in central Iran, and the Iranian Light Source Facility, under construction near Qazvin. These could see more international collaboration under the deal as well.

Despite the possible improvements for Iranian scientists under the deal, it will not address Iran's human rights issues, says Sadeghpour, citing the case of imprisoned physicist Omid Kokabee as a recent example. Kokabee, an Iranian citizen, was studying at the University of Texas at Austin when he was arrested while visiting Iran in 2011, a punishment Kokabee said was connected to his refusal to participate in Iran's military research.

"It's a pity in my view that the inspection does not extend to where it really is important for the people of Iran, including the scientists — especially those who are languishing in Iranian prisons right now," says Sadeghpour.

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a microwave oven.

Spencer died in 1970, having never earned more for his microwave than the $2 bonus Raytheon typically awarded employees for their patented inventions, although all told he racked up 300 patents during his career there. But he reaped plenty of recognition, including an honorary doctorate from the University of Massachusetts and a Raytheon building named in his honor. Above all, Vannevar Bush said that Spencer "earned the respect of every physicist in the country, not only for his ingenuity, but for what he has learned about physics by absorbing it through his skin."

Further Reading:

Scott, Otto J. *The Creative Ordeal: The Story of Raytheon*. Atheneum, 1974.

Profiles in Versatility

Surfer, Science Outreach Specialist, Weight Loss Researcher, Physicist

By Alaina G. Levine

Who is Ruben Meerman? He wears so many hats it is sometimes hard to tell. He's a writer. He's a science outreach specialist. He's an entrepreneur. He's a physicist. He is also a surfer, and 20 years ago started calling himself "the Surfing Scientist."

Driven by a love of nature and the need to inspire others to pursue careers in science, technology, engineering, and mathematics, Meerman launched his own science communications and outreach business. He crisscrosses his native Australia presenting science to kids from high school to preschool. Over the last 20 years, he has visited approximately 1300 schools; in 2014 alone, he went to 114 schools, sometimes doing two or three shows a day. "A great science demo is worth 1000 pictures," he says.

Among other talents, physicist Ruben Meerman hosts science programs for Australian television

In the midst of all this activity, he has written four science books for kids, as well as a number of resource books for teachers concerning how best to teach science. He regularly speaks at conferences and appears on Australian television — in particular, Catalyst, the nation's leading science television program. But he started out on a fairly routine track.

Meerman received his bachelor's degree in physics from Queensland University of Technology in 1993, and immediately started working at Laserdyne Technologies Pty Ltd, where he designed and manufactured multilayer optical coatings for gas and solid-state laser applications.

By 1995, the ivory tower was beckoning him back. He enrolled in and completed a graduate diploma in science communication at the Australian National University. As part of the coursework, Meerman toured the country with the Shell Questacon Science Circus, presenting science shows in schools. "The minute I did this I was hooked," he says. As soon as he finished the program, "I started setting up my own business to keep visiting schools [and] doing demos for kids on my own. It was so cool to find a career that I love so much."

But along with his company, he also had another interest he wished to chase — getting a Ph.D. As a surfer on Australia's Gold Coast, he had a specific interest in sharks and decided to pursue a doctorate in physics with a focus on reducing shark attacks. He enrolled at Griffith University in 1997. "I approached [the university] to sponsor the science outreach business I was starting and they offered me a scholarship to do the Ph.D.," he says. "And I said 'heck yeah!'" As he dove into his studies, he also tutored in the university's school of education to enhance his teaching techniques. As much as he enjoyed the doctoral program, presenting scientific demos was where his heart was, so after two years he decided to put his degree on hold and focus exclusively on his business.

Like many creatives, Meerman is always on the alert for his next playing field. So now he's added another title to his lengthy resume: weight-loss researcher.

In 2013, Meerman found himself inclined to lose a little weight. He started exercising and "I had lost about six to seven kilograms in just a few weeks," he says. But slimming down wasn't enough — he had to know exactly there the weight was going as it left his body. "This is where being a physicist really helps. I love numbers and I'm such a geek. I couldn't let it go," he says. "So as I was losing weight, I wanted to know what proportion of that mass had come out of my lungs. I wanted to answer this precisely."

When a person loses weight, it doesn't disappear into a black hole. "Most people think that the fat is converted into energy or heat, but this violates the law of conservation of mass," explains Meerman. People also mistakenly assume that the fat is somehow excreted in the feces or converted to muscle. So where does the fat go?

As he pondered this question, Meerman kept coming back to a Feynman quotation: "Everything is made of atoms." He realized that most people "forget the 'golden rule' in chemistry — you have to have the same number of … [each kind of atom] at the beginning and the end" of any chemical process. So he set out to track every atom's route as it passed through the body. For every jalapeño-bacon double cheeseburger a person gobbles, the excess carbs and protein (in a person's diet) are converted to organic molecules called triglycerides (e.g., $C_{55}H_{98}O_6$). The carbon and hydrogen atoms in triglycerides ultimately leave the body as CO_2 and H_2O.

But the triglycerides' own oxygen atoms pose a puzzle. "Dietary fat is mainly [converted] to triglyceride before being stored" in fat cells, he explains. "The formula for the average dietary triglyceride will vary with the diet, as animal fats tend to be more saturated so slightly higher in hydrogen," he explains. In addition to the water and carbon dioxide produced, each triglyceride molecule has six oxygen atoms that needed to be accounted for.

Meerman read up on the subject and discovered a paper from 1949 that described how "the oxygen atoms of body water and respiratory carbon dioxide are rapidly exchanged through the formation of carbonic acid," he wrote. He realized that the leftover oxygen atoms wind up in CO_2 and H_2O, where "four are exhaled and two form water," he says. "The results show that the lungs are the primary excretory organ for weight loss, and the water formed may be excreted in urine, feces, sweat, breath, tears, or other bodily fluids. For carbohydrate and triglyceride, there really is no other way to lose the mass of those carbon atoms," he says.

"Of course, the other variable in the weight loss equation is consumption, so losing weight also requires eating less carbon atoms than are exhaled," he notes. "It's also true that the rate at which carbon atoms are exhaled depends on physical activity … but even if you sit perfectly still 24/7 or slip into a coma, the basal metabolic rate demands fuel and oxygen and produces CO_2 and water so a living human is always losing weight and it can only be regained by eating (or via a drip if you happen to be in a coma). But I also agree that there is more to safe, healthy weight loss than just living and the benefits of physical activity extend far beyond weight loss."

To be clear, "all I have done is quantify [a bit more precisely] what scientists had figured out and, in the process, I stumbled onto a gigantic misconception amongst doctors and health professionals," he says.

Meerman completed all the calculations on his weight loss project and presented them as a TEDx talk in 2013. Early in 2014, Meerman convinced his Catalyst producers to let him put it together as a short feature for the program. "To give the story credibility, we needed a biochemist and we approached Andrew Brown, Head of and Professor in the School of Biotechnology and Biomolecular Sciences at the University of New South Wales who agreed to be interviewed and look over my work," he shares. "The day

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after we filmed that story, Andrew emailed me suggesting we publish what I'd done. We decided that a survey of doctors, dietitians and personal trainers would be a great way to demonstrate the misconceptions and the need to change how this topic is taught." The two worked together to refine the analysis and on December 16, 2014, *The BMJ* (formerly the *British Medical Journal*) published their paper.

Not surprisingly, the study generated worldwide media attention. It even got Meerman a book contract. But it also got him thinking about something else: going back for his Ph.D. Encouraged by Brown, Meerman is now pursuing a doctorate in science communication with an emphasis on how best to teach weight loss causes to both specialists and the public. "[We] hope to see [work] from the *BMJ* paper incorporated into biochemistry textbooks and explained in the lectures so that doctors, dietitians and biochemistry students don't end up with the misconception that fat mass can be converted to energy," he says.

He is conducting his doctoral research while continuing his science outreach performances. His business is booming, thanks to his ability to design and present fascinating demos. One of his favorites is related to his hobby of surfing, something he has done for 30 years. "About 10 years ago, I put together a talk on the science of surfing," he explains. "It explains that when you catch a wave, it has its origins in the middle of the sun, where heat was generated to make a storm which makes the wave. It takes 170,000 years for the energy released at the core of the sun to reach its surface, and then 8 minutes to reach Earth. Then it might take another 3 months while the heat is absorbed into the Earth's atmosphere and turned into a storm and then a wave. By the time the wave hits the beach for surfers to tackle, another week or so has gone by but all of that is negligible compared to those 170,000 years it took for the energy to escape the Sun."

"So when you're riding a wave, the energy that pushes you began 170,000 years ago," he declares. "It's beautiful and it's thanks to physicists that we have this figured out. I'm so glad I studied physics. It's amazing what we have done."

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The physics of human-fluid interactions

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Peter Zeidenberg, Xi's lawyer.

The devices Xi shared with colleagues in China were not the STI Pocket Heater, but entirely different magnesium diboride heaters — a fact confirmed by affidavits written by expert witnesses, including Ward Ruby of Shoreline Technologies, a co-inventor of the Pocket Heater. Additionally, according to the expert witnesses, the Pocket Heater itself was simply an alteration of a device previously developed for producing yttrium barium copper oxide films, rather than the revolutionary invention that the government had claimed.

David Larbalestier of the National High Magnetic Field Laboratory at Florida State University, who wrote one of the affidavits, said he read about 300 pages of emails presented as evidence in the case. "When finally I got to review what was put before the grand jury, it was just outrageous, because it's obvious that it's not the Pocket Heater," Larbalestier says.

Additional expertise that Xi offered to share with Chinese researchers, in emails presented as evidence of his intent to share the device, was focused not on magnesium diboride thin films, but on entirely different materials — oxide thin films. "This is a serious mistake — the two materials cannot coexist. In other words, MgB_2 can only be fabricated in the absence of oxygen," says Paul Chu of the University of Houston, who wrote an affidavit. "How could he steal the technology for a purpose which it is totally not suitable?"

Additional affidavits were written by John Rowell of Arizona State University, and Thirumalai Venky Venkatesan of the National University of Singapore. The experts confirmed that the communications between Xi and his Chinese colleagues were typical of routine academic collaboration, and did not involve the Pocket Heater.

"It seems to me the government has unambiguously done something quite wrong," says Larbalestier. "It's wrong in process because if you are going to bring charges where the technical details really matter, then those technical details should be cleared with experts in the field before charges are leveled, not afterward."

The U.S. Attorney's Office in the Eastern District of Pennsylvania had no comment on the case. The government's motion to dismiss stated only that "additional information came to the attention of the government" after the indictment.

Physicists' response to his indictment, Xi says, had been "overwhelmingly supportive." And although contact with his research group at Temple University was limited after the indictment, he was allowed to have videoconferences with a few senior members. "I was told they have been working very hard ... just to show me their support by producing more results, so I was very moved."

Still, Xi says the indictment has caused "serious damage" to his research. At the time of the indictment, the group had been working on several manuscripts that Xi calls "groundbreaking." And with nine projects in his lab, funded by a variety of agencies, Xi is concerned about delays in his work funded by grants that are coming up for renewal. "If we cannot produce results obviously the renewal will be in doubt."

But worse still is the damage done to his reputation, he says. The fact that he was indicted may lead colleagues to assume that he has done something wrong, and he is worried about what funding agencies may think. "If I don't have a chance to clear my name, and try to repair my reputation, then it's damaged."

Xi maintains that he did nothing wrong. Funding agencies encourage collaboration with other countries, he points out. When asked if there was anything he would have done differently in hindsight, he responded, "absolutely nothing, because I have not done anything beyond the normal and the routine functions of a university professor."

Xi's case is one in a string of indictments involving Chinese-American scientists allegedly sharing secrets with China, only to have their cases dismissed before trial. In October 2014, the government accused Sherry Chen, a hydrologist with the National Weather Service, of illegally accessing a government database in order to provide information about U.S. dams to a contact in China. Prosecutors dropped the charges in March. And in 2014, the government dropped charges it had filed against two Eli Lilly scientists, accusing them of providing information about drugs to China.

The trend is causing concern in the Chinese-American community. After Chen's case was dismissed, 22 members of Congress sent a letter to Attorney General Loretta E. Lynch asking for an investigation into whether race played a role in her indictment. A response from the Department of Justice denied any racial prejudice. In a statement issued following the dismissal of charges against Xi, Representative Ted Lieu (D-CA) called the case, "another example of apparent discriminatory arrest and discriminatory charging by federal officials."

In interviews with *APS News*, several of the expert witnesses also speculated that race played a role. "Were he to be Irish-American or German-American, I think he would not be picked on," says Chu, who says he worries about the emergence of an environment reminiscent of the days of McCarthyism. "It's more serious than Xiaoxing Xi, it appears to me."

"There's a real problem here with theft of information," says Larbalestier. "But if we're going to protect ourselves against it, we've got to be smart, we've got to be clever, and we've got to do it right."

As a result of the indictment, Xi and his family have suffered "professionally, mentally, physically, and financially," he said in a statement on his website, xiaoxingxi.org. Xi's family members have been consumed with worry about the case; Xi was unable to travel to visit his mother on her 90th birthday; and now he must cope with the legal expenses associated with his defense.

The government, Xi says, simply made a mistake. But, he says, "This is not a casual mistake; this is a mistake that is ruining people's lives and reputations." It's important for the United States to protect its sensitive information, he says, but it can go too far by criminalizing the routine activities of scientists. "That's really the very, very scary part of this story," he says. "I think that academic freedom is really under assault."

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physics faculty and department chairs. It consists of brand-new invited and contributed papers.

The book touches on some important strategies for physics departments looking to encourage would-be teachers. "There's not one thing you should be doing — there are usually lots of things you should be doing to make sure you have a successful program," Sandifer said. These include mentoring, working with local teachers, and giving students early opportunities to get a taste of leading a classroom.

"It's oftentimes easier to get an undergraduate research experience than it is to find an early teaching experience as an undergraduate," says Plisch."That is a problem because many students don't realize they might really enjoy teaching unless they've had that experience"

Coordination between physics departments and schools of education is important to make sure that students get a good experience, Sandifer says, as is making sure that students can graduate with both a teaching certification and a physics degree in as short a time as possible.

It's important that physics departments themselves employ good teaching practices, Sandifer says. Otherwise students will be doomed to repeat the mistakes of their instructors — for example, over-reliance on lectures. In the best programs, "They get to see effective physics instruction and then they get to do it themselves when they get out into the schools."

BLEWETT continued from page 3

Virginia, before becoming a research assistant professor at the University of Washington (UW). Each time she moved, she says, her husband, also a physicist, would follow a year or two later. But the bouncing around wasn't good for her husband's career, she says — each time he'd have to start over again in a new place, sometimes leaving previous projects unfinished.

In July 2014, when Lin had her second child and her position at UW ended, things got more complicated. Her husband decided to take a job outside of physics, working for Google in Mountain View, California, where the couple now lives. Lin tried to keep up with research, but it was a challenge. Housing in the area turned out to be incredibly expensive, she says, and finding day care for an infant was very difficult. "A lot of things didn't really work out as we had planned."

Lin's research is in lattice gauge theory, using supercomputers to calculate the strong interactions between quarks and gluons. The work, she says, is relevant for providing standard model inputs for experiments at the LHC and also for low-energy precision experiments (e.g., measurements of the neutron electric dipole moment). Lin also plans to work in collaboration with Lawrence Berkeley National Laboratory, taking advantage of the supercomputer located there to enable the search for physics beyond the Standard Model.

Being selected for the Blewett fellowship means a lot, Lin says — and it's not just about the money. "This fellowship gives me hope to move forward." Now that she can work full time again, Lin hopes to make the final push to publish the research that she has accumulated in the past few years. And she's optimistic about her prospects: "I think with just a couple more years I should be able to have a tenure-track position."

ANNOUNCEMENTS

ACCESS continued from page 1

also allowed journal authors to freely post the accepted, author-formatted manuscript on personal or institutional websites and on arXiv. Finally, APS has worked with other scientific publishers (See *APS News*, August/September 2015) to create the Clearinghouse for the Open Research of the United States (CHORUS). But as new policies are enacted and immediate open access becomes more widespread, it is likely that APS will have to alter its publishing practices if it is to continue providing the physics community with affordable, top-quality journals.

"Free Access" Is Not Free

Free and unfettered access to the results of research has been the dream of a number of constituencies: Members of the public with serious medical problems; university librarians whose budgets cannot cope with escalating subscription costs; entrepreneurs involved in high-tech ventures; scientists, whose work is increasingly international; and political leaders who must respond to their constituents' demands.

In the United States, for example, elected officials in both parties have embraced the politically appealing argument that "If the taxpayer paid for the research, the taxpayer should be able to see the results free of charge." Unfortunately, the cost and value of conducting peer review, composition (including embedding links in the version of record, for example), archiving, and other sundry publishing activities go unrecognized.

Throughout the world, almost all scientific publishers of high-quality journals rely on subscriptions to support peer-review operations, editing, composition, and archiving. But if governments begin to compel publishers and authors to make articles freely available immediately after publication or if the vast majority of authors simply choose to make their work freely available immediately after publication, subscribers would have no reason to continue paying for content. The subscription model would vanish, and publishers would have to find other sources of revenue to support the services they currently provide, especially peer review.

At present the "time to free access" set by U.S government directives is 12 months. But pressure to reduce the time has been building both in the U.S. and elsewhere. Pending legislation (H.R. 1477, "The Fair Access to Science and Technology Research Act of 2015," also known as FASTR) in the U.S. House of Representatives, for example, would require access "as soon as practicable" but no later than six months (See *APS News*, August/September 2015.) Similar legislation is under consideration in France. And in the UK, Research Council policies in place since 2013 are setting the "time to free access" on a glide path to zero.

The Problems with "Author Pays"

APS believes that it won't be long before the "time to free access" will shrink to zero both at home and abroad. In that case, the way APS currently pays for peer-review operations will no longer be viable. And APS and other scientific publishers will likely have to adopt an "author pays" model. Unless they have access to other sources of revenue, authors will have to use their research grant money, institutional funds or cash from their own pockets to cover the cost of publication (which may be in excess of two thousand dollars per article). Moreover, a change to an author-pays model would especially harm researchers with small grants or no grants at all. And if federal science budgets remain fixed, the amount of money available for conducting research would decline.

Some authors might be tempted to publish in free or extremely inexpensive journals, but, as recent analyses have shown, the quality control in such journals is likely to be very poor. John Bohannon in *Science* magazine (October 4, 2013), for example, reported that a significant fraction of open access journals are predatory in nature and have, at best, questionable peer-review operations.

Differing open access rules around the world could complicate matters even further for a scientific enterprise in which international collaborations are becoming more and more common. The UK "author-pays" model, for example, bars authors who publish their work in journals that impose a delay before open access – as current U.S. policies allow – from using Research Council funds to cover article processing charges (APCs). UK policies also prohibit scientists from using Research Council funds to cover APCs even if their journal of choice provides immediate open access but relies on a third-party repository, such as CHORUS, arXiv or an institution's website, to do so.

It is possible that models other than "author pays" could become viable, but APS believes they contain substantial risks. For example, CERN has been strongly promoting SCOAP^3 (Sponsoring Consortium for Open Access Publishing in Particle Physics). In that model, CERN and other institutions, predominantly libraries in various countries, would directly reimburse publishers using a formula that depends on the average number of particle physics articles they publish and the publishing costs of the journals.

Here's the rub: So long as all partners maintained their commitments, SCOAP^3 would survive. But unless international treaties bind SCOAP^3 participating institutions to their support pledges, future budget stringencies or changes in political will could cause SCOAP^3 to collapse. It is possible that other enforcement mechanisms could be developed, but APS believes that at present the SCOAP^3 model is not without risk.

Final Thoughts from APS Leaders

Reflecting on the rapidly changing landscape of scientific publishing, APS CEO Kate Kirby summed up the situation this way: "As an international publisher, in the short term APS will have to provide mechanisms that satisfy the patchwork of open access mandates across the globe. As a membership organization that advocates for physics and physicists, in the long term APS will have to remain attentive to the impact of 'author pays' on scientific research budgets."

Sam Aronson added, "It is critical that APS members recognize that the publishing world is going to change dramatically in the next decade, and the way they have become accustomed to disseminating their work is going to change with it. We hope APS members will engage actively in the open access discussions."

Michael Lubell is the director and Mark Elsesser is the senior policy analyst in the APS Office of Public Affairs.

Michael Lubell's October Inside the Beltway *column will again run in November, and then resume its normal bimonthly schedule in December.*

The Back Page

Towards An Industrial Physics Community

By John Rumble

Physics plays a central role in modern industry because it is critical for explaining, extending, and predicting technology and its resultant products. Moreover, physics-inspired analysis leads to improved results in the non-technological aspects of industry as well as in technical matters. Some of the evidence for this is the strong demand from industry: more than 50% of persons with advanced physics degrees get their first permanent job in the private sector [1].

Given this importance of physics to and in industry, it is appropriate to ask what, if anything, needs to be done in

- Ensuring the flow of physicists into industry remains strong,
- Supporting industrial physics, and
- Fostering the industrial physics community.

In this brief essay, I will discuss these three issues and highlight ideas by APS's Forum on Industrial and Applied Physics (FIAP) as responses. Many of the ideas presented here result from the October 2014 APS/FIAP Workshop on National Issues in Industrial Physics [2].

Ensuring the flow of excellent physicists into industry

In working towards an advanced degree, a physicist learns how to formulate a significant physics problem, develops enough experimental and theoretical skills to solve the problem, and then presents the results to the community at large. In most cases, however, employers are looking for the ability to develop technical skills required for their industry rather than expecting a young physicist to come in ready to contribute immediately. Our present educational system does a very good job preparing the physics side of being a physicist.

What we have heard, however, from both industry and students alike, is that the non-technical aspects of working in industry are not well addressed. Young physicists receive little or no training in how industry operates, in how physicists work in industry, and on how to best prepare themselves for a career in industry. APS, FIAP, physics departments, and physics funding agencies all have roles to play. A number of opportunities have been identified.

Mentoring: A clearinghouse for potential mentors could arrange matches with students. At the same time, there need to be guidelines for effective mentorships and increased emphasis on the importance of being mentored. APS's Local Links and other means can be used to recruit industrial physicists as mentors. Overall, the definition of relationship between mentoring and thesis advising need to be clarified.

Internships: Internships are useful in introducing physicists to industrial practice, so a clearinghouse for arranging placement is needed, and companies need to be recruited to participate. Intern opportunities have to be more widely publicized. Questions about how to cover costs and what happens when degrees are delayed need answers. Ultimately, there has to be recognition of the importance of internships to graduates going into industry.

Industrial career guidance: We need to upgrade career development guidance. This can be accomplished with additional industrial career sessions at national and especially at sectional APS meetings. Guidance and resources about industrial careers can be provided to department coordinators and thesis advisors, including links to local industrial physicists and encouraging regular seminars featuring industrial physicists.

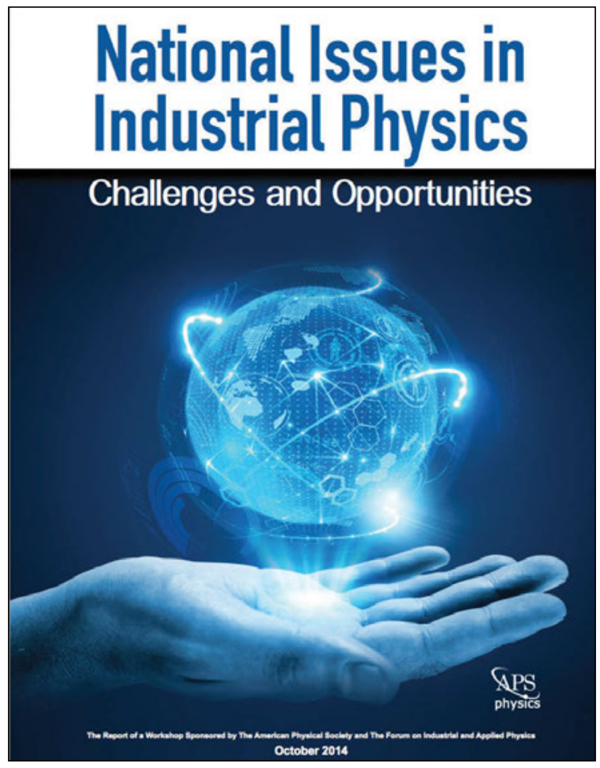
Entrepreneurship: Entrepreneurial spirit is a quality valued in industry, and sessions on entrepreneurship at national and sectional meetings will bolster it among young physicists. These sessions could be complemented with departmental sponsorship of "entrepreneurial" days featuring local entrepreneurs.

Training for teams: The lone genius is not the typical style in industry; instead industry uses teams whose members bring complementary expertise to the table. Guidelines need to be established for advanced physics degrees in team projects, and team projects for advanced physics degrees should be encouraged.

Mid-career transitions: Early career physicists are not the only story. Mentoring and career information for those in mid-career is vital, and this could be aided by departmental lists of alumni willing to provide mentoring and support.

Supporting industrial physics

Industrial physics is a broad activity that ranges from large research centers in international corporations to one physicist supporting a medium-size but thriving company to entrepreneurs in the latest start-up, and everything in between. It includes basic research discovering new physics, solving physics-related technological problems, and using physics to develop and improve products in both traditional physics-



related industries such as electronics, and rapidly emerging areas in nanotechnology and bio-medicine.

One common feature of today's industrial physics environment is the breadth of interactions with diverse organizations, involvement in business practices, and collaborations with multiple scientific and technical disciplines. While this environment has been in place for decades, the last twenty years have seen significant changes due to the decentralization of research, the explosion of connectivity of people and organizations through the internet, globalization of industry, and a renewed entrepreneurial spirit within the US and abroad.

These changes have impacted industrial physics in many ways, some of which were highlighted in the National Issues Workshop including:

Intellectual property rights (IPR): Best general practices are emerging, especially in recognition of the cost involved in complex arrangements; while the Bayh-Dole Act that has facilitated patenting for individuals in academia and the government has been quite successful, developing IPR agreements between industry and academia and government continues to present barriers.

Government-industry partnerships: Government agencies recognize the benefits of close partnership with industry in addressing societal and technological problems. To achieve higher returns for such investments, user facilities must accommodate industrial needs for timely decisions, program managers should more aggressively pursue industrial input prior to launching major initiatives, innovation programs should reflect greater agility and less bureaucracy, and steps should be taken to retain and employ U.S.-trained foreign physicists.

Industry-academia partnerships: The steady improvement in these partnerships can be further enhanced by clearer definition of roles (specifically industry's need to turn investments in products) as well as use of best IPR practices (with recognition by universities that new or improved products usually require multiple patents for success).

Fostering the industrial physics community

The role of 21st Century industrial physics continues to be important, with a focus on its growing impact to industry and to society. The pace of technological advances seen in the 20th Century has not diminished in the first 15 years of this new century. Not only do industries such as electronics, telecommunications, and computing seem to advance with no slowdowns, other major industrial sectors are now drawing on the skills of physicists to understand, control, and manipulate physical processes to advance areas such as bio-medicine, transportation and energy, nanotechnology, and food production and delivery. As these industries take advantage of new physics, industrial physicists are finding themselves working on problems far afield from those of the 20th century.

The environment in which this takes place is also considerably different. Industrial physicists often work as teams containing few other physicists. Many work in start-up organizations or are entrepreneurs themselves. They work in international settings with scientists and engineers from diverse disciplines. Yet these industrial physicists still identify as physicists and want to be associated with a community of like-minded industrial physicists.

The APS has been proactive in engaging with the industrial physics community including many programs to educate students about industrial careers, hiring an Industrial Physics Fellow to manage programs focused on industry, and continuing focus from APS leaders. The APS should build on these steps including the following proposals for concrete actions.

Prepare a report on the successes and impact of U.S. industrial physics: In spite of its importance the success and impact of industrial physics in the United States has not been fully documented; such a report would identify areas in which U.S. leadership in industrial physics is challenged as well as areas in which emerging economic sectors and industry would benefit by new investments related to industrial physics.

Build and brand the industrial physics community: It is time for APS to recognize the breadth of industrial physics and to provide 21st century level services in building and branding this significant physics community. Highlight the innovations and successes of industrial physicists with the same attention given to academic physics.

Establish an Industrial Physics Advisory Board: An important first step in highlighting industrial physics is to set up an APS industrial physics advisory board with the mandate to identify the needs and opportunities for serving industrial physics. This advisory board should not only review present APS services and how they can be enhanced for industrial physicists, but also consider the specialized needs of industrial physics and identify new and innovative programs to meet those needs.

Timely access and networking on emerging ideas and innovation relevant for industrial physics: APS's programs that provide information in a timely fashion through outstanding publications, national and local meetings, and informal networking opportunities need to be extended to meet the demands and realities of industrial physics. Industry is schedule driven, and few industrial physicists can afford to attend week-long, multi-disciplinary meetings. They need short, focused, and high payoff meetings, highlighting state-of-the-art work on topics of industrial interest. They need publications that focus on topics of broad industrial interest to keep them abreast of new ideas in fields outside their present focus. Many other societies do this successfully and APS is best positioned for providing such meetings to the industrial physics community.

Actions, not just words

Perhaps the most important message I can convey now is that the opportunity to advance industrial physics complements and builds upon the outstanding work the APS does in serving academic and private sector physicists today. APS has built a broad and effective leadership in academic physics that both serves the integrated needs of the diverse fields of physics and represents that community effectively to international organizations, national policy makers, and the university community.

Actions aimed at industrial physicists will require investment by APS, but given the large number of advanced degree physicists working in industry, there is a vast audience waiting to be served. As we acknowledge that science, technology, and solutions to societal problems are intricately intertwined, APS, as the world's leading physics organization, is well positioned to serve the broadest possible physics community. Now is the time to effectively include the industrial physics community in this global organization.

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1. Douglas N. Arion, *Physics Today* **66**, 42 (2013).
2. http://www.aps.org/units/fiap/meetings/upload/FIAP-2014.pdf

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