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Physical Review Materials
Publishes First Issue
Page 3

Michael Thoennessen Appointed New APS Editor in Chief

By David Voss

Nuclear physicist Michael Thoennessen has been selected to become APS Editor in Chief on September 1, 2017. Currently an Associate Director of the Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU) in Lansing, Michigan, and University Distinguished Professor of Physics at MSU, he was appointed following a vote of the APS Board of Directors on June 16.

"It is a great privilege and responsibility to serve as Editor in Chief of APS," said Thoennessen. "I am excited about the opportunity to work with the outstanding editors and staff at Ridge to shape the future of the *Physical Review* journals." Thoennessen will partner with APS Publisher Matthew Salter to take the journals through future challenges and opportunities.

Thoennessen received his Diploma from the University of Cologne in 1985 and obtained his Ph.D. in experimental nuclear physics from the State University of New York in Stony Brook in 1988. He joined the MSU physics faculty in 1990 and was named Associate Director of FRIB in 2015. FRIB is a $730 million user facility funded by the U.S. Department of Energy for nuclear science and is slated for

Michael Thoennessen

completion in 2020. From 2004 to 2016, he was Supervisory Editor of the journal *Nuclear Physics A*.

"Michael Thoennessen has a broad knowledge of physics, extensive leadership experience, and the ability to work well with others. He is forward-thinking, especially regarding the future of our journals," said Caltech professor of physics and 2011 APS President Barry Barish, who chaired the search committee. "We are very fortunate to have attracted him to become our next Editor in Chief."

"I'm very pleased that Michael Thoennessen will become our next Editor in Chief and will be joining the APS Senior Management Team," said APS CEO Kate Kirby. "His past leadership experience in publishing, his engagement with APS programs in education and diversity, and his service in many capacities, including as Chair of the APS Division of Nuclear Physics, provide him with valuable perspectives and a deep understanding of APS."

Thoennessen will succeed Pierre Meystre as Editor in Chief. Meystre, named to the position in 2016, announced his resignation earlier this year in a message to APS staff, indicating that he felt miscast in the role. Meystre will continue as Editor in Chief until Thoennessen steps in.

"I am delighted that Michael

EIC continued on page 6

Expanding the Fourth State of Matter

By Rachel Gaal

2017 APS Division of Atomic, Molecular, and Optical Physics Meeting — A typical phase diagram paints a picture of three states of matter: solid, liquid, and gas. But what about plasma? It's the most abundant state of matter in the universe, but plasma can't exist for long under normal terrestrial conditions.

Out in space, exotic plasmas can occur inside white dwarfs, large planets like Jupiter, and the Sun and other large stars. On Earth, researchers are studying fully ionized forms of plasma created under artificial conditions hovering just above absolute zero temperatures. By studying these in the lab, they hope to learn more about some astrophysical plasmas deep in space.

While the mechanism of its formation is known, the first such ultracold plasma was observed in the lab less than two decades ago, which might make this a budding field in physics. A number of recent results were presented at the 2017 DAMOP meeting in Sacramento, California.

Thomas Langin of Rice University was one speaker who has trekked down new paths in the field. As a graduate student, Langin worked with Thomas Killian of Rice University, a long-time researcher in ultracold plasma physics. Killian's work over the years has spanned the first observations of plasma itself and of disorder-induced heating, all the way to present day with more detailed studies of plasma dynamics.

The experiment reported at DAMOP focused on the ion temperature evolution in strongly coupled plasmas, and what factors contribute to heating mechanisms during their lifespan. "I'm very excited to present my talk, which is no longer on the progress … but rather the actual laser cooling of an ultracold neutral plasma," he announced during his lecture.

To create these ultracold neutral plasmas, a neutral, cold gas is photoionized to free the atomic electrons. Through a process known as disorder-induced heating, the newly created ions rapidly heat

MATTER continued on page 5

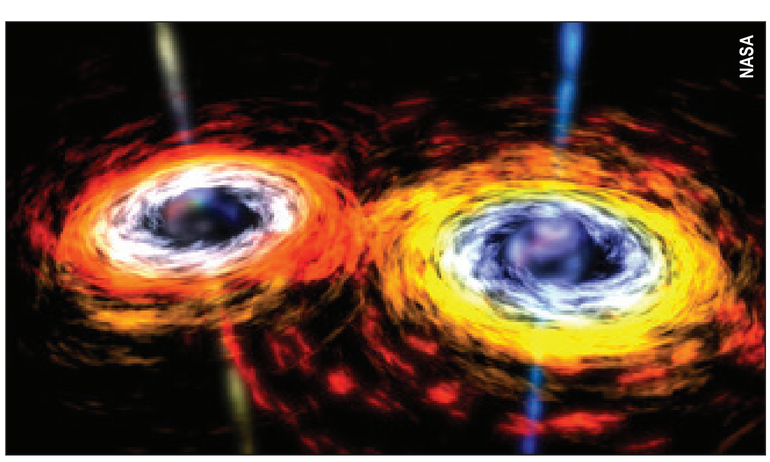
Research News: Editors' Choice

physics.aps.org

A Monthly Recap of Papers Selected by the Physics Editors

Putting a Spin on Black Hole Mergers

As the number of black hole merger observations continues to rise, astrophysicists may soon be able to figure out where these merging black holes come from. To date, the Laser Interferometer Gravitational-Wave Observatory (LIGO) has detected three gravitational-wave signals—each bearing the mark of a violent collision of two black holes that eventually became one. The estimated mass in these gravitational pile-ups is relatively large, suggesting that the two initial black holes may themselves have been the product of earlier mergers between smaller black holes. If this so-called hierarchical formation is at work, then it could leave an imprint in the rotation rate, or spin, of the final black hole. Fortunately, spin is one of the quantities that can be inferred from LIGO data. Assuming hierarchical formation, Fishbach et al. calculated the expected distribution of spins and found it skewed towards black holes with high spins, as reported in *Astrophysical Journal Letters (*DOI: 10.3847/2041-8213/aa7045). They showed that LIGO would only need about ten merger observations to determine whether or not all black holes formed hierarchically.



How black holes spin may reveal how they formed.

Squeezing Out the Petawatts

Claiming the latest prize in the high-power laser sweepstakes, a research team has used an all-optical technique to compress and amplify optical pulses down to less than 20 femtoseconds in a petawatt-scale facility. In *Optics Letters*, Zeng et al. (DOI: 10.1364/OL.42.002014) report their use of chirped-pulse amplification (CPA) to reach a peak laser power of 4.9 petawatts. CPA involves imparting a frequency sweep to the pulse then sending different frequency components along paths of various lengths. At the output, the components pile up into a shorter pulse. CPA is a standard method for shortening laser pulse durations, but the research team was able to implement the method with an all-optical amplifier system. Conventional amplifiers that use doped glass or sapphire are limited to one or two petawatts, but the laser-pumped parametric amplifiers used here can go higher. Zeng et al. used lithium borate crystals to boost the pulse energy from hundreds of millijoules to over 168 joules. The authors believe that with larger crystals they can triple

RESEARCH continued on page 6

Spotlight on Development

Through Creative Philanthropy, the Braslau Family Honors Loved Ones and Supports Students in Need

When David Braslau's brother, Norman died in 1996, David began thinking of how to honor him in a way that would make a real impact on people's lives. "I wanted to endow an APS prize or something for him," he says. "He was a Ph.D. physicist with a long and impactful career at IBM, making some significant scientific contributions." But, Braslau says, "I also felt that all the same people win the prizes, and that sort of annoys me, so I wanted to do something different, although at the time I didn't pursue it."

Then when his brother Bob, an aerospace engineer who worked on the Apollo program, passed away in 2014, David says the idea of a memorial for his brothers gained momentum. "I met with Ted Hodapp [then director of education and diversity programs at APS] and Darlene Logan [then director of development] and I said I wanted to contribute something besides a prize," he says. A travel grant program was an ideal solution.

The *Braslau Family Travel Grant Endowment* provides funding for low-income physics students to travel to APS meetings. During its first year of operation, grants have been awarded to six physics students, each receiving about $1100 for travel and lodging. These students, who would otherwise be unable to attend the conferences, were able to give talks and meet other physicists.

Like his brothers, David followed his scientific and technical interests. He received his undergraduate degree in civil engineering from MIT and a Masters and Ph.D. in structural and engineering mechanics from UC Berkeley. Braslau wanted to try teaching, so he became a geophysics professor at the University of Minnesota but became more interested in the challenges of acoustics and aircraft noise. This led to his founding David Braslau Associates, Inc., in 1971 to work on transportation and industrial noise, blast wave analysis, and building acoustics.

Braslau says that initiating the travel grant program is a way to remember his brothers but also to help disadvantaged students. "I recently got a nice letter thanking the Braslau family for travel support," he says. "I'm not interested in just being a benefactor; I am interested in long-term results."

If you too would like to make a difference in the lives of others, please contact APS Director of Development Irene Lukoff (lukoff@aps.org) to explore ways you can help.

The Braslau Family Travel Grant program was started by David Braslau (left) to honor his brothers, Robert (center) and Norman (right).

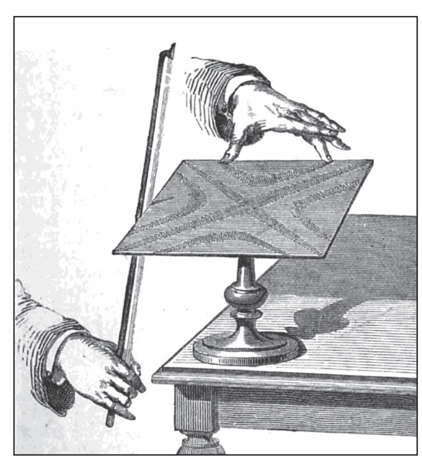
This Month in Physics History

July 8, 1680: The First Experiments that Inspired 18th century "Chladni figures"

Leonardo da Vinci noted the unusual patterns formed by particles in response to vibrations. So did Galileo, who noticed that bits of bristle on the sounding board of an instrument would move in some areas but not in others. But these so-called "Chladni figures" bear the name of the man who conducted the first in-depth investigations of the phenomenon: a German physicist and musician named Ernst Florens Friedrich Chladni.

Chladni was born in Wittenberg in 1756, to a long line of academics. His father was a law professor and dean of law at the University of Wittenberg. Both his mother and his sister died when he was still quite young. Chladni was mostly educated at home by his father, a strict disciplinarian. The boy was often confined to his room to study by day, and discouraged from fostering friendships, but he loved studying the stars and maps, yearned to travel, and began reading about science at age seven. As a teenager he was sent to boarding school near Leipzig, rooming with one of his teachers rather than with the other students. His father nixed his desire to study medicine and insisted he earn a law degree instead.

Ernst Florens Friedrich Chladni



Sand placed on a vibrating plate exhibit distinction patterns called Chladni figures.

Chladni went on to earn degrees in law and philosophy from the University of Leipzig, but his father died just as he completed his studies, leaving Chladni to provide for his stepmother. But it also freed him to finally pursue his scientific interests. He eked out a nomadic living giving lectures, initially on law, but eventually on geometry, geography, and the field to which he would go on to contribute so much as a researcher: acoustics.

Chladni first began conducting experiments in his flat, moving beyond the usual studies of vibrations in string and wind instruments to focus on transverse vibrations of rods—inspired by earlier work by Leonhard Euler and Daniel Bernoulli—before turning to vibrations of plates, then largely an unknown field. Chladni might not have known it at the time—there is no specific mention in his surviving writings—but a century earlier, on July 8, 1680, Robert Hooke sprinkled sand over a solid metal plate, ran a violin bow along the edge to make the plate vibrate, and noted the unique patterns that formed as the sand grains rearranged themselves along the vibrational nodes.

Chladni would take that work to the next level with his systematic investigation of the sound patterns of circular, square, and rectangular plates. By his own account, Chladni found inspiration in the work of Georg Christoph Lichtenberg, who scattered powders over the surface of electrified resin cakes to produce the patterns known today as Lichtenberg figures. Figuring he could do the same thing with sound, Chladni began scattering sand on his rods and plates. He had a musician's ear and could discern slight changes in frequency, so he noticed that different frequencies produced different distinct patterns, and he recorded them assiduously. Also, he developed a formula that predicted the sand patterns for vibrating circular plates. He published the results—including 11 plates and 166 figures—in his 1787 treatise *Entdeckungen über die Theorie des Klanges*. But his most seminal treatise was 1802's *Die Akustik*, a systemic description of the vibrations of elastic bodies that earned him the moniker "father of acoustics."

As for the underlying mechanism moving the particles, it appeared to be twofold. The sand particles were bouncing on the rapidly vibrating plates, impinging on the surface at the crests and moving towards the nodes. But Chladni also noticed that his bow shed even finer particles as it moved across the plate, and these finer particles migrated toward the antinodes. This is due to a second transport mechanism, acoustic streaming, first observed by Michael Faraday back in 1831. It is the opposite of how airflow generates vibrations in a musical instrument; in this case, the vertically vibrating plates produce a lateral fluid flow along its surface.

Because the vibrational patterns showed exactly where modes of vibrations fell in the back plates of musical instruments, Chladni's technique soon became a vital tool for violin makers and other instrument makers. It is still widely used today. Chladni himself invented two musical instruments: the euphony, inspired by Benjamin Franklin's glass armonica, and the clavicylinder, an improvement of

CHLADNI continued on page 3

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News from the APS Office of Public Affairs

Senator Responds to APS Member Op-Ed

By Tawanda W. Johnson

A week after an APS member wrote an op-ed in the *St. Louis Dispatch*, asking U.S. Sen. Roy Blunt (R-MO) to support STEM education funding in President Trump's fiscal year 2018 budget, Blunt responded in a letter to the newspaper.

The comment that stood out in his response: "I have serious concerns with some of the cuts included in the president's budget."

U.S. Sen. Roy Blunt

"This is a significant statement from the vice chair of the Senate Republican Conference, who is responsible for establishing the public message for Senate Republicans," said Francis Slakey, interim director of the APS Office of Public Affairs (APS OPA). "Working with APS members to write op-eds is a cornerstone of our integrated advocacy program. Members of Congress often respond privately, but they rarely have public reactions. Sen. Blunt's response is more than what we could have hoped for."

In her May 28 op-ed, Karen King, assistant teaching professor in the Department of Physics and Astronomy at the University of Missouri, urged Blunt to work with his colleagues to fully fund Titles II and IV of the Every Student Succeeds Act. Such funds could be used to train and prepare high-quality STEM teachers and pay for STEM-related after-school programs.

"I'm elated that Sen. Blunt responded in such a positive manner," said King. "STEM education is crucial to preparing students for the best-paid and fastest-growing jobs during the next decades. And to accomplish that goal, we need highly trained teachers who have degrees in physics."

After the op-ed was published, APS OPA initiated another aspect of its integrated advocacy approach: sending emails to APS members who belong to the Forum on Education. The emails requested that they contact their own senators and underscore the op-ed's key message.

"Forum members were able to add their voices to the issue and bring attention to it beyond Missouri. This campaign is just one example of how we're working to give APS members the opportunity to speak out about different issues that matter to them," said Greg Mack, APS government relations specialist. "It was great to work with Forum on Education leadership to develop the campaign as well."

In other recent APS OPA advocacy campaigns, APS members underscored, in op-eds across the country, the importance of scientific research and infrastructure, most recently in the *Auburn Daily Journal* in California and the *Ithaca Journal* in New York.

Additionally, APS OPA has worked with individual APS units to develop targeted emails or social media posts asking members of Congress to reject proposed cuts to science in the fiscal

SENATOR continued on page 6

Physical Review Materials Publishes First Papers

By Rachel Gaal

Chris Leighton

The first articles to appear in *Physical Review Materials*, the newest addition to the APS journal family, were published on June 19, and judging from the response, the publication is off to a healthy start.

From the beginning, the journal has been envisioned as a broad-scope international journal for high-quality papers from physicists, materials scientists, chemists, engineers, and researchers in related disciplines.

"The first batch of papers is just great, and they cover all the bases for us," said the journal's Lead Editor Chris Leighton. "In terms of subject matter, areas like energy storage materials and energy conversion, 2D materials, and nanomaterials are all hot areas."

Leighton is Distinguished McKnight University Professor of Chemical Engineering and Materials Science and a graduate faculty member in Physics at the University of Minnesota. He obtained his Ph.D. degree in condensed matter physics at the University of Durham in the UK, and carried out post-doctoral research at the University of California San Diego. His research deals with the electronic and magnetic properties of a wide range of novel materials, including complex oxides, oxide heterostructures, metallic spintronics, complex alloys, organic conductors, and photovoltaics. He is a Fellow of the APS, and is Chair of the Topical Group on Magnetism and its Applications (GMAG).

"I am proud and excited to be the inaugural Lead Editor of PR Materials," Leighton wrote in an editorial accompanying the first issue. "The APS and PR Materials staff have been hard at work for the last two months handling a volume of submissions that already indicates significant interest from the community. Managing Editor Athanasios Chantis, Editor Mu Wang, along with myself as Lead Editor, provide a mix of expert professional editors and research scientists active in the community, which we plan to maintain as the journal expands." The journal is backed by an Editorial Board of 22 researchers from the U.S., Europe, Asia, and Australia, representing universities, national laboratories, user facilities, and research institutes.

"We definitely have people who are already publishing in APS journals, but we also want to bring in people from outside the APS community," Leighton emphasized. "It's a very interdisciplinary field—people from physics, materials science, or even engineering or chemistry—and they don't necessarily have a home right now in the APS journals to publish their work."

Visit the journal website at journals.aps.org/prmaterials

CHLADNI continued from page 2

Hooke's earlier musical cylinder, or "string phone."

And his research continues to inspire other scientists. Last year, a *Physical Review Letters* paper described how physicists at the University of Grenoble in France performed their own version of Chladni's pioneering experiment. Rather than scattering sand on metal plates, they suspended polystyrene microbeads in water, injected the suspension into a microfluidic device, and stretched a membrane of polysilicone across a circular opening at the base to create a drum that vibrated. Then they recorded the positions of the microbeads with a camera attached to a microscope. When the plate vibrated, the beads arranged themselves at the antinodes, forming inverse Chladni figures—the result of acoustic streaming in the fluid. The ability to form such patterns in a microfluidic device opens the door to using sound waves to organize objects into specific patterns for various technological applications, such as grouping cells into colonies and then using changing frequencies to shift their size and distribution, thereby affecting their development.

Chladni died in April 1827 while on a lecture tour in Breslau, having never held a formal academic position. He never married, nor did he have children, and the site of his grave has been forgotten. But his patterns continue to inspire scientists and artists alike. While the great German author Johann Wolfgang von Goethe was mildly dismissive of Chladni when he first met him in Weimar in 1803, by the time of the latter's death he had changed his tune. "Who will criticize our Chladni, the proud of the nation?" Goethe wrote. "The world owes him gratitude, since he made the sound visible."

Further Reading:

Rossing, T.D. 1982. Chladni's Law for Vibrating Plates. *American Journal of Physics.* 50:271-274.

Ullmann, D. 2007. The Life and Work of E.F.F. Chladni. *The European Physical Journal: Special Topics.* 145(1).

Vuillermet, Gael et al. 2016. Chladni Patterns in a Liquid at Microscale. *Physical Review Letters.* 116: 184501.

Profiles in Versatility

Lennard Zinn's Wild Ride

By Mike Lucibella

Zinn shows off the details of a bikes he built in the 1980s.

Next to the wrenches and oil cans in almost any bike repair shop you'll find well-worn copies of Lennard Zinn's *Zinn and the Art of Mountain Bike Maintenance*, and its sibling *Zinn and the Art of Road Bike Maintenance*. The guides have taught countless aspiring mechanics nearly everything they could want to know about fixing bicycles.

Relying on his background in physics and years as a bike-builder, Zinn followed an unconventional career path, tying physics and bike mechanics together to bring cycling science to the general public. "Bicycles are all just physics and math problems really," Zinn said.

Throughout his life, bicycles and physics have gone together. "I grew up in Los Alamos, New Mexico—it's a good place for bike riding," Zinn said. Los Alamos is also a good place for physics. "My dad was a Ph.D. physicist at the Los Alamos National Laboratory," Zinn said. "Everybody's dad worked at this lab, it was a one-company town, and everybody's dad was a physicist."

Zinn started down that same path in the early 1970s and attended Colorado College for his bachelor's degree. He majored in physics and capped it off with a project on the physics of bicycles. Inspired by an article in *Physics Today*, he used early Fortran computer models to investigate why bikes stay upright.

However, he was not an indoor lab rat. Zinn competed as a cross-country skier before switching to cycling following a leg injury. By the time he graduated, he was on the U.S. Olympic cycling team, competing in races all over the world. "In Los Alamos, it's kind of accepted you get one year to play around after college, before you go to graduate school," Zinn said.

But he never quite made it back to school. For a time he worked as a petroleum geophysicist but was soon laid off following a downturn in the oil market. Out of a job and living in Mountain View, California, Zinn found himself thumbing through the phonebook and spotted a name that he recognized: Tom Ritchey, one of the world's master bike builders.

"It's just like fate or something," Zinn said. "I was like, 'Whoa, I wonder if that's the Tom Richey who makes those bikes." It was, and as fortune would have it, one of his employees had just quit that morning. Zinn convinced Ritchey to take him on and teach him the craft.

The late 1970s was an exciting time to be a part of the biking scene in Northern California. There, a tightknit community of bike enthusiasts had been prototyping the world's first mountain bikes. It was an invention poised to revolutionize the cycling industry, and Tom Ritchey was right at the center of it. "This was all new territory—we were the first ones," Zinn said.

ZINN continued on page 7

Letters

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

Elementary Inspirations

The "Top Ten Physics Newsmakers of 2016" (*APS News*, January 2017) included the discoveries of the new elements 113, 115, 117, and 118, with the statement that "moscovium (mg) and Tennessine (Ts) have slightly more obvious inspirations (the Russian capital Moscow and Tennessee home of Oak Ridge National Laboratory, respectively)." Neither of these are correct. Here are the names proposed and their justifications by our collaborators of the Joint Institute for Nuclear Research in Dubna, Lawrence Livermore National Laboratory, Oak Ridge National Laboratory (ORNL), and Vanderbilt University, from the announcement of the International Union of Pure and Applied Chemistry:

Moscovium is in recognition of the Moscow region and honors the ancient Russian land that is the home of the Joint Institute for Nuclear Research, where the discovery experiments were conducted using the Dubna Gas-Filled Recoil Separator in combination with the heavy ion accelerator capabilities of the Flerov Laboratory of Nuclear Reactions.

Tennessine is in recognition of the contribution of the Tennessee region, including Oak Ridge National Laboratory, Vanderbilt University, and the University of Tennessee at Knoxville, to superheavy element research, including the production and chemical separation of unique actinide target materials for superheavy element synthesis at ORNL's High Flux Isotope Reactor and Radiochemical Engineering Development Center.

Joseph H. Hamilton
Oak Ridge, Tennessee

Magnetism and Health

"Easing the Heartache with Magnetic Fields" in the May 2017 *APS News* was fascinating reading. Skeptical scientists have spent years criticizing the use of magnetism to cure a variety of ailments [1, 2]. The article calls this stand into question. Some of the promised health benefits might be explainable by lower blood viscosity, and, whether or not the work is correct, magnetic medicine fans can point to a *Physical Review E* article (Ref. 1 in the *APS News* article) to demonstrate the efficacy of magnetic cures.

Medical magnets are a big business, driven by pseudoscience. In view of this, *APS News* could have cast a more critical eye on the current work, by at least citing some of the numerous studies that have not found medical effects from magnetic fields, to put this result in a better perspective.

Spencer Klein
Berkeley, California

1. J. R. Basford, "A historical perspective of the popular use of electric and magnetic therapy," Archive of Physical Medicine and Rehabilitation 82, 1261 (2001).
2. B. Flamm, "Magnet Therapy: A Billion-dollar Boondoggle," Skeptical Inquirer 30.4, July/Aug. 2006 (www.csicop.org/si/show/magnet_therapy_a_billion-dollar_boondoggle)

To Disperse or Not To Disperse: Debating Negative Mass

By Rachel Gaal

Newton's second law of motion tells us that objects will accelerate in the same direction as the applied force. But in a recent experiment, atoms in an atomic vapor accelerated in the opposite direction from the applied force. Does this mean the motion of the vapor defied the laws of physics?

In *Physical Review Letters*, Khamehchi et al. of Washington State University report their recent experimental work with a Bose-Einstein Condensate (BEC). They observed that this small, incredibly cold cloud of rubidium (Rb) atoms exhibited a "negative effective mass" while expanding.

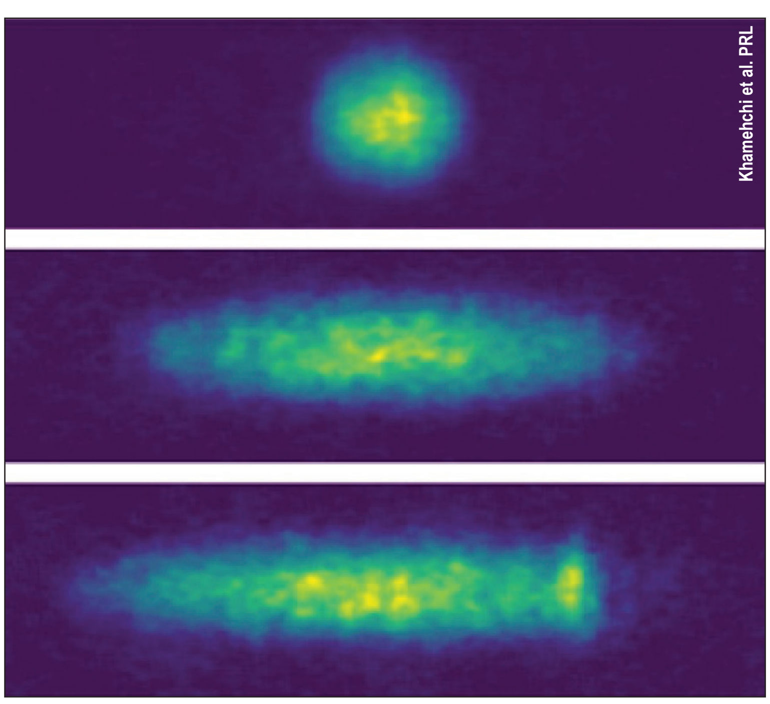
The phenomenon is subtle, and some news sources inaccurately described the paper as heralding the advent of a fluid with "negative mass." Some headline writers, connecting the results with warp drives, antimatter particles, and the end of "physics as we know it," had many physicists wagging their fingers.

"Undeniably, a number of news outlets sensationalized the results," Peter Engels and Michael Forbes, senior researchers on the experiment, told *APS News.* "[This was] mostly due to a confusion [with] mass … and the incorrect implication that our fluid could exist in empty space … "

But some media, including BBC, Live Science, and *The Guardian*, contacted Forbes and Engels about the results, and appropriately interpreted the physics. "A number of news outlets actually did their research."

How to define mass, and the difference between "negative mass" and "negative effective mass," was a topic that Engels and Forbes often had to clarify to reporters. Creating a fluid with "negative mass" is technically correct, they said, but only if "mass" is interpreted in a specific way.

"One main confusion by some of the media was interpreting the term 'negative mass' [as] negative gravitational mass, which indeed could have drastic consequences," Engels and Forbes said. The correct concept is the "inertial mass," they emphasized, which is what we think of in Newton's second law: If you push an object, how does it accelerate? In fact, all inertial masses are "effective masses" by definition, since the term describes what someone actually observes.



By tuning the spin-orbit coupling in a Bose-Einstein condensate (top), the expansion of the atomic cloud (middle) can be stopped in a region of "negative" mass (bottom).

In the experimental setup, Khamehchi et al. used a high-tech suite of lasers to trap, cool, and manipulate the BEC by tuning the "spin-orbit coupling," which is an interaction between an atom's spin and its motion.

When one of the crossed laser beams used to trap the atoms was switched off, the BEC was allowed to expand along one axis. When they filmed this controlled expansion in the lab, a region appeared where the fluid hits an "invisible dam," slowing the condensate from dispersing further in the direction of its momentum.

The reason for this sudden block goes back to the dispersion relation in quantum systems, which relates the total energy of the system, E, to the momentum of the system, p.

DISPERSE continued on page 7

Oppenheimer and Teller

The March 2017 *APS News* story, "Little Boy and Fat Man Cast Shadow over April Meeting" portrayed how physicists gained status as the result of the weapons that ended World War II, stating "Most famously, Edward Teller argued for the development of the hydrogen bomb …"

Yet nowhere is the name of J. Robert Oppenheimer, the father of Little Boy and Fat Man, even mentioned. Teller was Oppenheimer's nemesis, having been instrumental in causing Oppenheimer to have his security clearance revoked, and even resulting in suggestions that he was an agent of the Soviet Union.

The present generation of physicists may not be aware of the bitter fighting that went on back in the forties and fifties. Teller's "most famous" role should be carefully examined, for example as set forth in my article, "We don't mess around in Texas," which appeared in *APS News* (October 2002, p. 5).

Robert A. Levy
El Paso, Texas

Internet of Things and e-Waste

In the article "Building an Internet of Things" (*APS News*, May 2017) there is no mention of the impact that the Internet of Things may have on electronic waste, which is tens of millions of tons annually and rising. Anecdotes about worthy applications of some new technology are often touted as justification when consumer purchasing drives the technology into unnecessary and environmentally destructive gadgetry. There is simply no need for LEDs to be in my clothing and sensors in my milk carton. There is a need to reduce energy consumption and responsible production, use, and recycling of electronics. Can APS lead a critical discussion about the IoT that extends beyond anecdotes?

Elton Graugnard
Boise, Idaho

Decoherence Eases Bit by Bit

By Rachel Gaal

2017 APS Division of Atomic, Molecular, and Optical Physics Meeting—Between a binary bit and a quantum bit, cryptographers and code crackers alike would choose the quantum route every time. The ability of quantum systems, making use of entities called qubits, to carry out powerful computations through superposition and entanglement, is compelling. But it has also driven physicists up the wall trying to implement them in actual applications. Correcting quantum errors in particular poses a large problem because of the sensitivity of these bits to noise and loss of coherence.

"We all know there is a problem, that quantum information processing suffers from decoherence … [with] a loss of quantum information due to interaction of a system and environment," explained Florentin Reiter of Harvard University at the 2017 DAMOP Meeting in Sacramento, California. Formerly a postdoc at the University of Innsbruck, he has taken on a common problem that most quantum systems face: dissipation, or loss of energy. "There are some people who came up with the idea to do quantum information not against dissipation, but quantum information by dissipation," Reiter said. In effect, dissipation drives the system to a desired outcome.

To deal with errors, most correction schemes map the information of one qubit onto highly entangled multiple qubits whose coherence has to be carefully maintained. By intentionally coupling a qubit to a specifically designed dissipative environment, surprisingly, several advantages like enhanced coherence lifetime can be achieved. "The goal [here] is to realize dissipation, without the use of time-dependent unitary gates, and without use of classical measurements," said Reiter.

To fully achieve this, Reiter and his team created a combined correction system that harnesses both dissipation and a trapped-ion scheme, a well-known workhorse in the quantum computing world.

They start with three trapped ions, each one storing a single qubit in the ions' stable electronic states. The dissipative error correction acts like a watchdog to correct any random errors on the qubits that occur during information processing, such as spin flips. This scheme immensely improved the coherence of quantum system, meaning enhanced precision for quantum measurements.

"A single qubit [is known to] decay exponentially, whereas if we use three decaying qubits, and use error correction on top of that, it can stabilize very well, close to [a fidelity] of 0.9," Reiter presented. "We've achieved a suppressed decay rate, and increased lifetime … a huge improvement for quantum information processing."

The challenge of implementing these types of innovative strategies has recently led to novel theoretical proposals for superconducting circuits, one of which was presented by Yiwen Chu of Yale University.

"These systems do a lot of nice things, ranging from making complex circuits, doing error correction, [or] using fancy states of microwave resonators," Chu explained. "But unfortunately the things we [quantum researchers] are most infamous for is convincing people to spend a lot of money on what may or may not be a quantum computer."

Chu explained that despite the typical challenges faced in quantum computing today, like decoherence, she wants to create a quantum system that is useful for long distance quantum communication. "I believe that one of the possible solution is to use a hybrid system,

QUANTUM continued on page 6

MATTER continued from page 1

up over nanoseconds, and the system quickly expands, giving the plasma a lifetime on the order of microseconds.

"[The] electrons expand and drag the ions with them, and over 20-30 microseconds, [the plasma] doubles and triples in size," Langin explained. "Even at these relatively high temperatures, you're still in this interesting regime, where the coulomb interactions [of the molecules] are so strong ... With this [experiment], we have a platform for studying systems similar to Jupiter's core, white dwarfs, and number of other systems in regime of strongly coupled plasmas."

Measuring the coulomb coupling parameter (the ratio of the potential energy between neighboring particles to their kinetic temperature) is a central focus of research in ultracold neutral plasmas. As the coulomb parameter increases above unity, the potential energies between ions starts to dominate thermal motion, and it becomes difficult to distinguish the small thermal motions of ions from the expanding plasma.

"In steady-state plasmas, the temperature is determined by the comparison of heating to cooling rate," Langin continued. "If you can change the cooling rate, you can make the plasma go to a lower temperature." This has been tried with single particles, but so far it's only been discussed theoretically for plasmas.

"We have the ability to cool along all three axes with cross-polarized beams … after 10 nanoseconds, we imaged the expanding cloud," he described. By using laser-induced fluorescence spectroscopy, they were able to see the temperature evolution of an ultracold neutral plasma with laser cooling, which to Langin is "pretty exciting" for the field of ultracold plasmas.

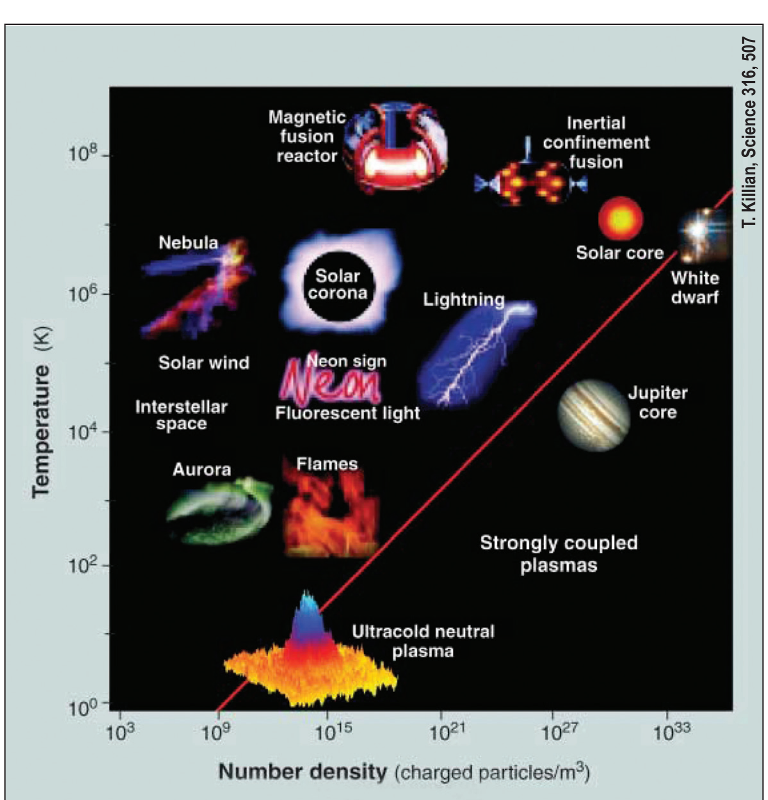
Characterizing the plasma temperature, however, is an equally daunting task. Although there are a few measurements of electron temperatures in ultracold neutral plasmas, they tend to be applicable only at early times in the plasma evolution and have large uncertainties. Duncan Tate of Colby College has sought to tackle this problem, and he has finally scratched the surface of defining a precise range in what are known as Rydberg plasmas. Rydberg atoms are highly excited species where the electron orbitals can be very large.

"I think the last 15 or so years, [physicists] have developed a sense of how Rydberg atoms evolve to plasma, but understanding what the temperature of a sample of ultra-cold Rydberg atoms is … to my knowledge that has not been explored all that much," Tate explained during his DAMOP presentation.

Similar to the way in which temperature was measured in Langin's research, Tate and his colleagues measured the plasma expansion velocities spectroscopically. "We've done this for a bunch of Rydberg states and densities, and we've come up with values for the [electron] temperature of a Rydberg plasma," said Tate. "The smaller distance [between atoms], the hotter the plasma." This relationship turned out to be a universal curve, in which the binding energies of different Rydberg states could be plotted as a function of Rydberg atom density.

"Once you have a critical density of ions so the electrons cannot escape, [the plasma] reaches what is called the 'avalanche regime'," Tate described. In this avalanche, the plasma quickly becomes fully ionized. "Our understanding right now is that the end of the avalanche process is what determines the subsequent electron temperature of the plasma, and the plasma will expand as if it had no [un-ionized] atoms at all."

Plasma temperature is only one of the basic characteristics needed to understand this state of matter, and new tools in atomic physics shouldl expand the ability of researchers to test the parameters of plasma under more extreme conditions. Tinkering with the densities, cooling rates, and charges of this odd state of matter could expand the understanding of plasmas in the lab—and much of the universe around us.



Neutral plasmas in the laboratory and in nature.

International News

Bringing the Joy of Scientific Inquiry to Girls in Pakistan

By Imrana Ashraf

The year 2015, which was designated by the United Nations as the International Year of Light and Light-based Technologies (IYL 2015), was particularly special for many of us in Pakistan and elsewhere, and especially for me, since I am a physics teacher and have a Ph.D. in quantum optics. This name created a special environment and "endorsement" that gave life to many ideas for outreach that could have a positive and lasting impact on society.

This story begins during the second half of 2015. Having tutored young students each year for a decade during the Preparatory School to the Winter College on Optics at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, I found it easy to generate and refine those ideas. During the past 28 years, I have visited ICTP as a student, as an associate, as a tutor, and as a lecturer; I realized that scientists there are committed to work in and for underdeveloped countries, like Pakistan. Joseph Niemela, an APS fellow and 2016 recipient of the APS Dwight Nicholson Medal for Outreach, is one of them.

During a coffee break at the 2015 Winter College on Optics, Joe and I discussed IYL 2015 and decided to add a UNESCO teacher-training workshop called Active Learning in Optics and Photonics (ALOP), to be financially supported by the International Society for Optics and Photonics (SPIE) and held in Islamabad, Pakistan. We also discussed the need to take some of this material directly to students at both the undergraduate and high-school levels, and in particular to give special opportunities to young women to participate in related hands-on activities in optics. He had very kindly given me some Photonic Explorer kits (EYEST). Later he received some APS "PhysicsQuest" kits from the APS Head of Outreach, Becky Thompson.

"PhysicsQuest" is a story-based activity that exposes students to the fun and relevance of science in a comic-book format, with a young superheroine named Spectra who battles a new villain each year, such as General Relativity and Miss Alignment. These PhysicsQuest stories weave four physics experiments into the comic-book's narrative. The APS PhysicsQuest kits are provided to teachers and include a user's manual to accompany the story and materials for four physics experiments. Joe Niemela personally delivered these kits during a visit to Islamabad in July 2016, in which he was able to observe and photograph an outreach event for 20 female undergraduate students at Quaid-i-Azam University.

Going back to 2015, I realized that I had all the needed ingredients to take hands-on activities to schools and do something personal for IYL 2015. After returning to Pakistan, I discussed this with my colleague Raheel Ali, a laser physicist who at that time had agreed to work with me for the ALOP project held during the second week of December 2015. Our dream was to do something to help inspire a new generation to study science, through a hands-on, active learning-based session in optics dedicated to IYL 2015.

Young students in Pakistan explore physics with the APS PhysicsQuest kits.

As our first outreach visit we went to a private school in Islamabad. When we were discussing the possibility of this visit with their science teacher, he was very enthusiastic about it. At that school the teacher was deeply involved in the learning process. This experience taught us a number of things, and one of them was the realization that private schools didn't really require our support, whereas public or government schools had a real need. That is where we decided to focus our efforts.

In January 2016, we started our optics activities on a large scale by inviting undergraduate girls from local government colleges and schools for a one-day active learning event in optics. Each experience inspired us to do more. It is hard to describe the enjoyment of seeing young enthusiastic girls so keen to learn, so eager to get their hands (and minds) engaged. In fact, it was always difficult to say goodbye to these girls at the end of the day and they always wanted us to invite them again.

And this was not something they got credit for. They did it presumably for the enjoyment of discovery, the same motivation that often inspires graduate students and established researchers to work the long hours that are necessary. It of course is our hope that some of these girls will decide to continue in science and that we may see them in our classes and, most of all, that they may choose to do outreach themselves one day and be a role model for a new group of girls.

We found that the active learning environment provides a very friendly atmosphere (perhaps different from their normal class experience), where students are encouraged to ask questions (also perhaps different!) and make predictions about the possible outcomes of an experiment based on a carefully chosen set of observations, rather than going into mathematical equations. During this process they are encouraged to interact with their fellow students as well as their facilitators. Unheard of! Speaking of light, their smiles, their laughter, the glow in their eyes reminded me of exactly that: a light as beautiful as any rainbow, or reflection from a pool.

If I seem overly poetic about the experiences of these girls it is because I have been affected as well. Being a woman, being a daughter and later a daughter-in law, being a wife, being a mother of a young girl and also knowing the realities of how female children have been treated in remote areas of my beautiful country makes me want to do so much more, especially in those areas where having an uneducated male heir is a greater source of pride to a mother than a daughter with an advanced degree.

Maybe it is not so much about

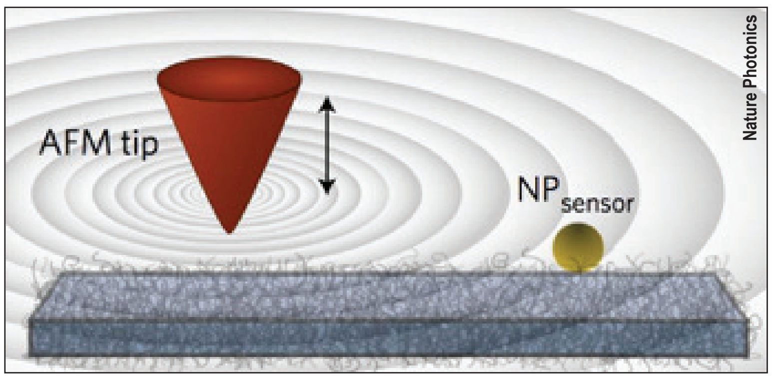
PAKISTAN continued on page 7

RESEARCH continued from page 1

the peak power to 15 petawatts—a power level with which they could study exotic states of matter under extreme conditions.

Peeking at Piconewtons

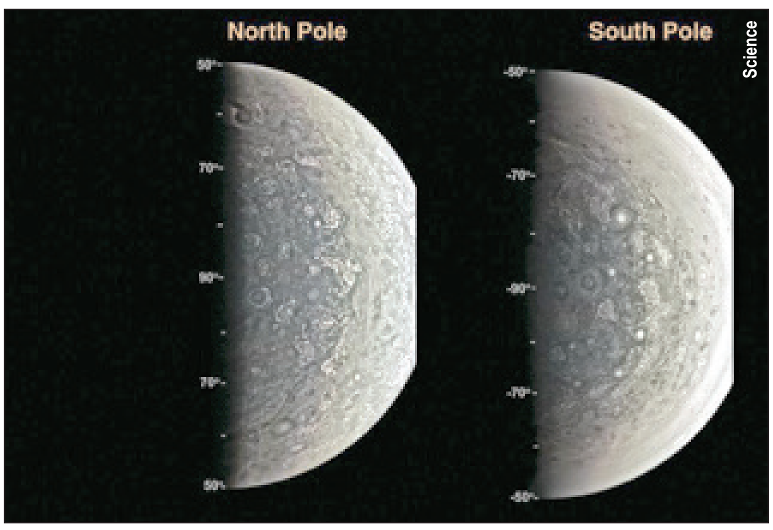
What is the propulsion force of a single swimming bacteria? Unless you've got a probe with a resolution smaller than their movements, you're at a loss for an answer. Thanks to delicate nanofibers and nanoparticles, however, researchers have now been able to develop a compact device that can measure forces with a sensitivity on the subpiconewton scale (less than 1 trillionth of a newton). In a paper from *Nature Photonics* (DOI: 10.1038/nphoton.2017.74) Huang et al. described their optic force transducer (NOFT), which is made from gold nanoparticles bonded to a compressible glycol film coating a bed of nanofibers. Like a ball being pushed into a cushion, a stronger applied force on the nanoparticle causes it to move closer toward the fibers. The closer these gold particles are to the fibers, the stronger the optical signal they can emit. Thus the light intensity provides a quantitative force measurement. From calibration to detection, the NOFT platform was able to successfully detect forces associated with the swimming action of bacteria, not to mention small acoustic signatures from a beating heart cell. The team hopes to implement this compact device in microorganism environments for use in biomechanical and intracellular studies.



An atomic force microscope (AFM) tip wiggles a bed of nanofibers; the oscillation is detected with light from a nanoparticle (NP).

Juno's Jupiter Odyssey

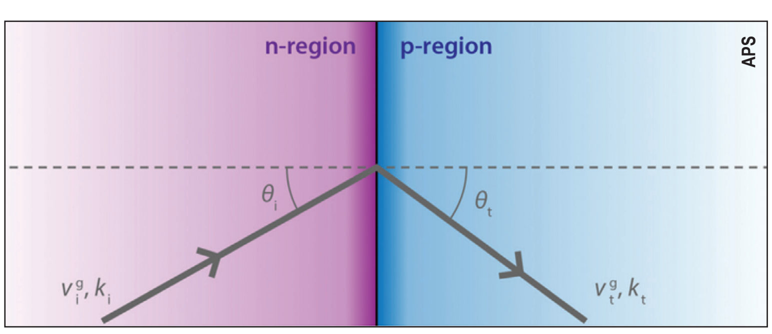
Juno's first lap around the Milky Way's jovian giant in August 2016 was a milestone in space exploration. Hovering less than 5000 kilometers above the surface of Jupiter, the NASA spacecraft collected a plethora of observational data, which scientists have analyzed to better understand the ins, outs, and in-betweens of the gas planet. Two papers in *Science*, one by Bolton et al. (DOI: 10.1126/science.aal2108) and other by Connerney et al. (DOI: 10.1126/science.aam5928)reported the highlights of Juno's initial discoveries—confirming some speculations and defying some modeling predictions. To name but a few, the pole-to-pole fly-by painted a picture of cyclones (counterclockwise areas of rotation) clustered at the poles, and an Earth-like "weather layer," a giant area of circulation hundreds of kilometers below the ammonia cloud tops. Infrared and thermal images confirmed the theory that hot spots are dry regions of the upper atmosphere, but Juno's magnetometer debunked the predicted magnetic field of Jupiter—finding a value of nearly eight gauss, almost twice as strong as expected. Particle instrumentation on board the spacecraft measured electron and proton populations within Jupiter's ionosphere, magnetosphere, and auroras, revealing the physical mechanisms in each. Juno's next close fly-by on July 11, 2017, will hover over Jupiter's iconic giant red spot, where NASA scientists hope to peek below the swirling crimson cloud tops.



NASA's Juno mission sent back high-resolution images of Jupiter's atmosphere.

Putting Weyl Materials to Use

New work indicates that an unusual kind of semimetal discovered in 2015 could be used to build a range of electronic devices, from transistors to superlenses for electron microscopy. These solids host electronic excitations known as "Weyl" fermions that act like massless particles similar to photons. Researchers have speculated that these exotic materials could be used in nanoelectronics, spintronics, or quantum computing. Writing in *Physical Review B (DOI: 10.1103/PhysRevB.95.214103)* Hills et al. have presented a theoretical analysis of three possible applications of Weyl semimetals. The authors found that a structure made of multiple layers of Weyl semimetals should have a negative refractive index for electrons traveling through it. Such a structure would act as a lens that is able to focus a scanning tunneling microscope's electron beam beyond the limits imposed by diffraction. They also suggest that Weyl semimetals could be used to build transistors potentially smaller and faster than conventional silicon transistors. Finally, their calculations reveal that an applied pressure could cause electrons in a Weyl semimetal to propagate similarly to light moving near a black hole. (For more, see the Viewpoint by Adolfo Grushin and Jens Bardarson in *Physics* "How to Make Devices with Weyl Materials" at physics.aps.org/articles/v10/63).



Weyl semimetals might produce a negative refractive index lens that beats the diffraction limit.

EIC continued from page 1

has accepted this position and the Board's vote was unanimous," said 2017 APS President Laura Greene. "I know the challenges, especially in this rapidly changing publishing landscape, having personally spent more than a decade as Editor in Chief of *Reports on Progress in Physics*," she said. "Michael has had a great deal of experience in this area, and in working with professional publishers."

QUANTUM continued from page 4

basically [to] couple a quantum circuit to a mechanical oscillator," Chu said.

"To generate more complex states, like Schrodinger cat states, you need a source of nonlinearity," said Chu. "That's where the qubit comes in … we have still been looking for a more robust, scalable, easily fabricated system that allows us to increase the complexity and performance of these kinds of devices.“ The team's approach is to use a small acoustic resonator coupled to the qubit.

"[The] mechanical resonator in our system is basically the sapphire substrate where we base our qubits," said Chu as she showed a figure of their experimental setup. "When you think about the two polished faces of the sapphire wafer, it forms an enclosed cavity for bulk acoustic waves." Chu admitted that her system was "embarrassingly simple," and agreed that there is significant room for improvement, but the first steps to a quantum acoustic platform have opened doors that could lead to enhanced coherence and strong coupling interactions in the system. By re-imagining the limits of quantum physics, the results may help qubits become the basis for powerful computers.

SENATOR continued from page 3

year 2018 budget. In addition to the Forum on Education, the units include the Forum on Graduate Student Affairs, Forum on Early Career Scientists, Division of Nuclear Physics, Topical Group on Hadronic Physics, and others.

As a result of APS OPA's concerted activities, more than 1200 APS members have contacted more than 335 members of Congress (including more than 100 in-person meetings) and urged them to reject proposed funding cuts to science.

And those efforts have paid off: Members of Congress rejected proposed science cuts in the fiscal year 2017 budget, and many have pledged to do the same in the fiscal year 2018 budget.

To learn about key issues that APS OPA advocates for and to take action on them, visit the Advocacy Dashboard at www.aps.org/policy/issues/

To stay informed on current science policy issues and ways to take action, sign up for APS OPA's video newsletter, *Signal Boost*, at eepurl.com/czjbmX

ZINN continued from page 3

After a few years, Zinn started his own company in Boulder, Colorado in 1982. He looked for untapped niches in the market, and became best known for his custom bikes for tall people.

Zinn, who himself is six-foot six-inches tall, used his background in physics to fix a problem that had been plaguing large bicycles for years. At high speeds, the front ends of big bikes developed a violent wobble. "The shimmy would start and then the oscillation would just build and build and build until you crashed or you figured something else out to slow it down," Zinn said.

He realized that big riders put the bike's frame under a lot of stress, particularly at high speeds. The complex forces caused small vibrations to grow, eventually hitting a sort of resonance frequency (technically a "Hopf bifurcation") where the bike became totally unstable. Zinn eliminated the problem by making his bike frames torsionally stiffer and smaller, while lengthening the handlebars, seat posts, and cranks to still fit taller riders comfortably.

In 1989, he started writing articles about bicycle technology. A friend of his who edited *VeloNews* wanted a technical column to balance out the publication's racing coverage and reached out to Zinn in part because of Zinn's background in physics. Zinn has been writing his weekly "Technical FAQ" column ever since.

And the column led to his ubiquitous repair manuals. The owner of a bookstore in Boulder was an avid bicyclist and read Zinn's column. Each time Zinn's wife visited the shop, the owner would tell her to get Zinn to write a book, and to title it *Zinn and the Art of Mountain Bike Maintenance*, a riff on the popular philosophy book *Zen and the Art of Motorcycle Maintenance* by Robert Pirsig.

"One time she went in there and he had made up a dummy cover and he gave it to her," Zinn said. "She came back home and handed me this dummy cover and there it was."

The book was published in 1996 to immediate success. With clear, concise writing, easy-to-follow cartoon diagrams by illustrator Todd Telander, and a healthy dose of humor, the books taught readers how to do everything from fix flats to build complex wheels.

Since then, it's been through five editions, and sold more than 160,000 copies. He followed it up with his road bike edition a few years later. They're popular with both advanced mechanics and beginners just starting to tinker with their machines.

Zinn's latest book, *The Haywire Heart*, delves into cardiology in endurance athletes. He developed a heart arrhythmia when he was 55 and realized many of the other athletes of about the same age did too. "Everybody had been a believer that exercise is really healthy and you can't overdo it," Zinn said. "Well I think there's very strong evidence to show you can."

Zinn still rides every chance he gets when he's not building a custom bicycle or penning a new column. "I still find it quite interesting writing and designing and building bikes and bike equipment," Zinn said. "I imagine I'll keep doing that for a while."

The author is editor of The Antarctic Sun *(part of the U.S. Antarctic Program and funded by the National Science Foundation), and is an avid mountain biker.*

DISPERSE continued from page 4

This relationship can be altered, using a second set of lasers and the spin-orbit-coupling technique to create an asymmetrical relationship between E and p. As a result of this alteration, there exists a small region of negative curvature in the dispersion relation—and in the experiments, this is equivalent to negative inertial mass occurring at certain values of the velocity. When the condensate nears and then enters this velocity regime while dispersing, the expansion first slows, and then reverses.

"The negative mass results from the spin-orbit-coupling lasers," explained Forbes. "These alter the momentum of the atoms, shifting the dispersion relationships. Because of this shifted relationship, atoms moving at higher speeds are more strongly affected by the lasers, resulting in the velocity-dependent negative effective mass."

Mark Hoefer, a lead faculty member of the Dispersive Hydrodynamics Lab at the University of Colorado Boulder, has worked with Forbes and Engels in the field of dispersive hydrodynamics of BECs. "Dispersive hydrodynamics and integrable turbulence have developed significantly in the last years, but somewhat separately," Hoefer told *APS News*. "[Engels] beautiful result brings the two together … demonstrating how dispersion curvature can violently impact the dispersive hydrodynamics during the course of dynamics."

The fluid's pileup, which might appear to defy physics, is just an innovative use of the dispersion relation in a BEC. But this peculiar result has caught the eye of other atomic and molecular physicists. At the 48th APS Division of Atomic, Molecular, and Optical Physics (DAMOP) Meeting, an entire session was devoted to spin-orbit coupling in cold gases, where quantum researchers gathered to share their ideas of next steps forward in the field.

"We've noticed that this has brought about a nice discussion within the community about the meaning of masses," Engels said at the DAMOP meeting. "It's nice that it gets people thinking about what is mass, why we call it effective, and [if it] make sense to call it negative."

He mentioned a recent commentary article published in *Physics Today* on why physicists should take the idea of negative mass seriously. The author, Manu Paranjape of the University of Montreal, wrote that the debunking of negative gravitational mass dismissed the possibility of negative mass altogether, whether inertial or effective.

"The term is very specialized … even physicists who know the term and know what it is don't realize the term for fundamental mass [is] effective [mass]," added Forbes.

Looking forward, many physicists in the field are hoping use BECs to test the theory behind the Forbes and Engels experiment. The Excitations in Degenerate Quantum Gases session at DAMOP featured talk of soliton trains, quantum turbulence, and the dynamics of BEC's in different types of traps. "We've done all of this analysis with Gross-Pitaevskii [simulations], but then there's a quantum correction that comes in," Forbes mentioned. "I want to start adding correction to the theory, and then we could have a new experiment to try."

The two agreed that the negative mass results and discussion highlighted an exciting fact about physics research. "It's an interesting way of probing nonlinear dynamics," Engels chuckled. "When things become nonlinear, they become a lot more interesting."

PAKISTAN continued from page 5

what the girls learned on any particular day, but rather that they had on that day their own voice, a level of respect independent of their gender, and the chance perhaps to just have fun and follow the path where their natural curiosity took them.

We talk about the power of science in terms of great discoveries that have improved our quality of life. That was highlighted extensively in 2015 in the context of light technologies. All very true. But some of us learned in 2015 another lesson: that scientific inquiry in its most humble form, as an exercise for young girls, also has the power to significantly improve the quality of life, perhaps only for a day in our case, but probably for much longer.

Therefore, I slip back into poetry. For me, these young Pakistani girls really do embody light and their faces transmit a positive energy that says clearly: We are your future, take care of us and we will take care of you, as good citizens, mothers, teachers, and as productive members of an enlightened society, where culture and traditions do not have to be in conflict with the realization of the potential of young girls.

I am very grateful to APS for the opportunity to do outreach with their kits, to the Abdus Salam ICTP and Joe Niemela for helping to get them into my hands, and to the many friends around the world who believe as I do in a brighter future enabled by young people having access to education and fueled by the joy of scientific inquiry and discovery.

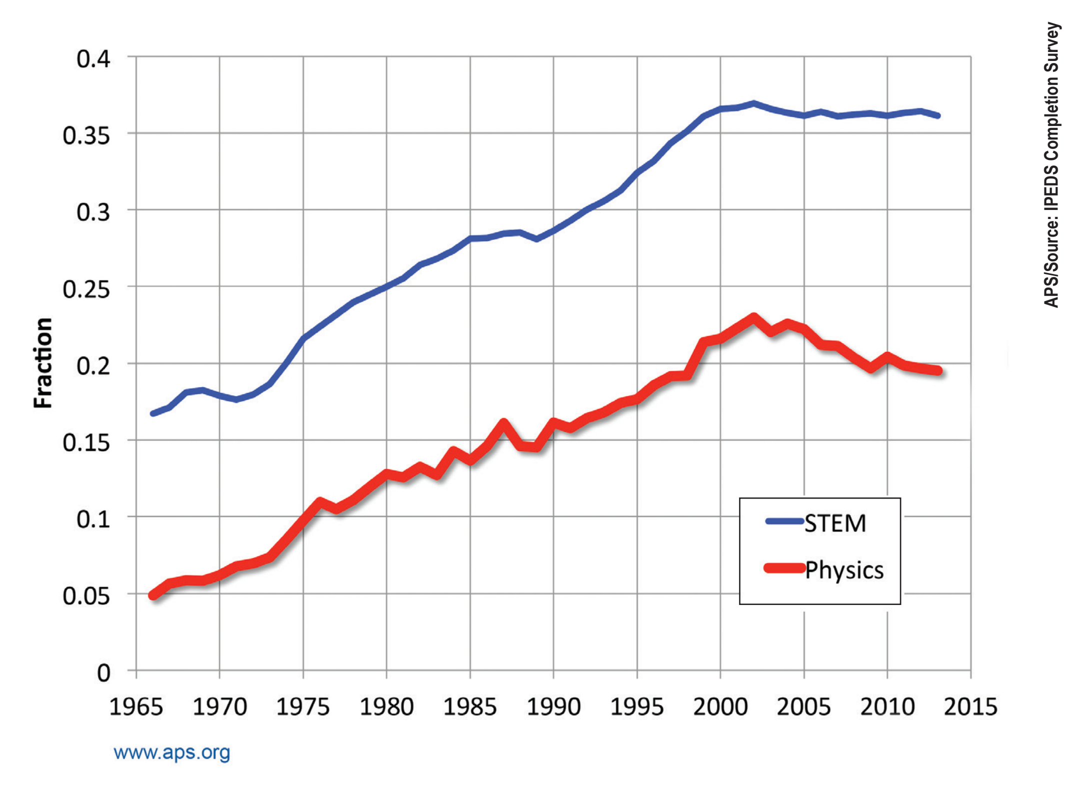
The author is associate professor of physics at Quaid-i-Azam University in Islamabad, Pakistan.

The Back Page

Diverse Leadership Matters

By Patricia Rankin

If we physicists are going to become a more inclusive community, we need to pay more attention to how we develop our leadership. As an example, after many years of slow but steady increases, the fraction of women undergraduates studying physics in the U.S. has recently decreased (see figure). This may be a short-term fluctuation, but even so, we should be concerned that we have not made more progress over the last 50 years.



The fraction of undergraduate women studying physics has recently declined. Here, STEM fields include biological and biomedical sciences, computer and information sciences, engineering and engineering technologies, mathematics and statistics, and physical sciences and science technologies.

Concerned, not just because it is hard to argue convincingly that our field offers equitable opportunities for all, but also because we badly need the skills that are currently being lost. Scott Page [1] has put forth a convincing case that a diverse skill set promotes better problem solving. The essential argument is that redundant skill sets do not improve the likelihood of finding a solution. To open up a broader solution space you need to increase the variety of tools available to solve the problem.

Page takes this further, which helps in understanding what types of problems are most likely to benefit from a diverse group approach. He notes that some fields are more "ladder-like" than others: Later concepts build upon earlier ones, so there is a generally agreed-upon order in which to learn tools. Physicists, for example, generally study Newton's work before Einstein's. This means if you take two physicists, the one with the less advanced education will typically add little to the overall skill set of the pair. And crowds do very well at estimating because low and high guesses tend to average out. They also do well on complex problems where there is likely to be a range of possible solutions, each with advantages and disadvantages. In these cases, where skills from several disciplines are needed, a diverse problem-solving group is more likely to generate a wider range of possible solutions and more likely to find a robust solution.

Perhaps this is why physics has been slower than some other fields to become more diverse. We traditionally have dealt with problems where there is a high probability of there being one right answer and a well-defined way to approach finding that answer, and these problems are ones where individual experts outperform groups in finding solutions. But the problems we are working on are changing scope, and as they become increasingly inter- and multi-disciplinary, we need to adapt.

Page discusses the importance of intellectual diversity. Keeping people with diverse backgrounds in physics does not automatically ensure that intellectual diversity increases; however, there is evidence from other fields that increasing the representation of women has a positive impact. Having more women automobile engineers increases the attention paid to the safety of women drivers or passengers. (Women sitting in seats that cannot be adjusted, and which are designed for men's comfort, are more likely to be injured in crashes.) In medical research, noting that women are often the primary caregivers can lead to a shift in vaccination priorities in order to slow an epidemic's progress. Having women present at the table makes it more likely that women's perspectives are considered and that better solutions are found.

Brickman et al. [2] developed a model to look at the attribution of the responsibility for causing a problem and the attribution of the responsibility for solving the problem. For example, nurses take on a high responsibility for providing solutions to their patient's problems though they are not responsible for causing them. I'd argue that over the past fifty years, we have concentrated on how to help individuals succeed in the current environment. This "fix the women" approach to gender equity assumes that women lack the skills needed to succeed and thus that providing the skills will solve the problem; attributing both the cause of the problem and the responsibility for solving it to women.

This approach has had limited success, though a recent study [3] indicates that some people in STEM leadership roles still consider that "fixing the women" is the right way to go. This study employed semi-structured interviews of 31 STEM department chairs and deans at a large public university in the U.S. The outcome of the study was to divide leaders into one of two classes—as either Low Responsibility (LR) or High Responsibility (HR) leaders.

When LR leaders were asked to describe if change was needed to address gender imbalance in their departments, they said things such as "Things are good enough," or "[We are doing] better than others," or "better than before," or "simply not a problem [because] 20% of our faculty are female, which is great," or "More time will take care of the issue," etc. If these LR leaders admitted change was needed, then they saw the needed change as something outside of their control; for example, there needed to be more women students in the pipeline or more institutional support for hiring women [3]. LR leaders did not see a role for themselves in changing the situation.

In contrast, HR leaders described themselves as "actively involved" in hiring women and saw themselves as responsible for ensuring fair treatment of the women in their organization. For instance, one department head, probably aware of the studies showing that women faculty are often asked to serve on more committees than their male colleagues, actually took steps to quantify this. It would be interesting to look at the demographics of departments with LR and HR leaders and track how these demographics change with time. I expect that HR leaders are more likely to be found in units that are doing better than the average at recruiting and retaining women. While it would be nice to have that confirmed, I am confident enough of the results not to wait before arguing that we need more HR leaders in physics.

Ann Nelson has made an excellent case [4] that we all need to take responsibility for making our field more inclusive. We need to learn how to work in diverse groups and how to manage selection processes in our field in an unbiased way. And as our field evolves, it is becoming increasingly important that we have competent and informed leaders. As a graduate student, I was one of fewer than a hundred people working on a hybrid bubble chamber experiment. Today, the CMS collaboration at the Large Hadron Collider has about 3000 members. Not only are physics research groups becoming larger, but also many physicists are now members of multi-disciplinary efforts working to address complex problems. Leading these teams is a demanding job.

For some time now, we have recognized the need to provide opportunities for researchers to learn how to be effective teachers, rather than expecting them to just pick up teaching skills on their own. I would argue that there is an equal need to enable all researchers to develop their professional management and leadership skills through training rather than by trial and error. Everyone benefits from competent managers and leaders who follow established best practices, for example, in hiring and promotion. Wouldn't everyone agree that we need to ensure that we have the best possible applicants in the hiring pool? Wouldn't everyone agree to reduce the impact of our individual biases in selecting the best candidate for a job?

Why should we add even more material to the standard physics curriculum when there are already so many important concepts to master? The short answer is that having people use these skills in their work is a key to providing a good working environment for all of us. While we are providing these skills, we can also be discussing what good leadership is and encouraging people to take on responsibility.

We can debate if interest in leadership is nature or nurture, but there is no debate that we can improve people's ability to manage and lead by providing support. One promising approach is the "T-shaped" professional movement. The idea behind this movement [5] is that we need to be producing individuals who have both deep skills in a single discipline such as physics (the vertical part of the T) and the broad skills (the horizontal part of the T) needed to succeed in working in teams and across discipline boundaries.

All of our students and junior faculty will benefit from explicit training in the basics of goal-setting and career-planning. Having meetings run by people who know how to set an agenda, encourage broad participation from attendees, and accurately attribute contributions from the group, will help address a common complaint from women that their comments are often overlooked until repeated by a man. If people understand the basics of dealing with workplace conflicts, the less likely it is that those conflicts will fester until things are so bad that people quit. The better-able people are to advocate for themselves and negotiate solutions that benefit everyone, the faster we will advance on addressing work/life issues.

T-shaped training programs do not directly aim to increase inclusion, but seek to help individuals manage themselves and work with others. I am not arguing for special treatment for anyone. I am asking that we all up our collective game, make sure we have all of the professional skills we need to do our work, and ensure that we are well led.

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References

1. Page, S.E. *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools and Societies.* Princeton: Princeton University Press, 2007.
2. Brickman, P., Rabinowitz, V.C., Karuza, J., Coates, D., Cohn, E. and Kidder, L. Models of Helping and Coping. 1982. *American Psychologist.* 4. 37: 368-84.
3. McClelland, S.I. and Holland, K.J. 2015. You, Me, or Her: Leaders' Perceptions of Responsibility for Increasing Gender Diversity in STEM Departments. *Psychology of Women Quarterly* 39. 2: 210-25.
4. Nelson, A. 2017. Commentary: Diversity in physics: Are you part of the problem? *Physics Today* 5: 10-11 (physicstoday.scitation.org/doi/10.1063/PT.3.3536).
5. A brief introduction to the T-shaped movement can be found at agileleanlife.com/t-shaped-skills-every-area-life.
6. Rankin, P. and Caccamise, D. 2017. Why Women Aren't Where They Are Needed in the Workforce: Putting the Pieces Together. *The Sasakawa Peace Foundation Expert Reviews Series on Advancing Women's Empowerment*, (tinyurl.com/Rankin-Caccamise).

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