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APS Membership on the Rise
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Gravitational Waves Caught in the Act

By Emily Conover

In the culmination of a decades-long quest, physicists have directly detected the minuscule ripples in spacetime known as gravitational waves. Predicted one hundred years ago as part of Einstein's general theory of relativity, gravitational waves stretch and squeeze space itself. Such waves are generated by some of the most violent cataclysms in the universe, like the exploding stars known as supernovae, or pairs of neutron stars or black holes coalescing into one.

In a paper published in *Physical Review Letters* on February 11, the Laser Interferometer Gravitational-wave Observatory (LIGO) and Virgo collaborations announced the detection of just such a black hole merger — knocking out two scientific firsts at once: the first direct detection of gravitational waves and the first observation of the merger of so-called binary black holes. The detection heralds a new era of astronomy — using gravitational waves to "listen in" on the universe (see related article on p. 5).

In the early morning hours of September 14, 2015 — during an engineering run just days before official data-taking started — a strong signal, consistent with merging black holes, appeared nearly simultaneously in LIGO's

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Caltech/MIT/LIGO Laboratory

The LIGO Laboratory operates two detector sites, one near Hanford, WA, and another near Livingston, LA. This photo shows the Livingston detector site. The detector arm stretching off in the distance is 4 km long.

APS Addresses Sexual Harassment Scandals

By Emily Conover

Sexual harassment scandals have rocked the astronomy community in recent months, as news outlets uncovered a number of university investigations which found that astronomy professors had harassed students. The stories have generated outrage among scientists, politicians, and the public, and spurred calls for harsher punishments for harassers.

The incidents have served as a wake-up call for many in the scientific community. Both NASA and the National Science Foundation issued statements that they do not tolerate sexual harassment. And Representative Jackie Speier (D-CA) spoke about the issue on the House floor on January 12, saying she would introduce legislation to address sexual harassment in science. The events have also prompted increased action at APS, and reaffirmed the urgency of its efforts already underway.

In October, exoplanet researcher Geoff Marcy resigned from the University of California, Berkeley, after *BuzzFeed News* revealed that the university had investigated him on multiple accusations of sexual harassment and found him in violation of university policy.

Soon, more scandals followed. Caltech professor Christian Ott was placed on a year of unpaid leave for inappropriate interactions with graduate students. And a decade-old University of Arizona investigation resurfaced, detailing inappropriate behavior by astronomy educator Timothy Slater (now at the University of Wyoming).

The problem is by no means confined to the astronomy community. University of Chicago

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Edward Witten Receives Inaugural APS Medal

By Emily Conover

For the first time, APS has recognized the remarkable achievements of a single scientist — selected from across the entire field of physics — with the 2016 APS Medal for Exceptional Achievement in Research. In a ceremony held January 28 in Washington, DC, the inaugural recipient, string theorist Edward Witten of the Institute for Advanced Study in Princeton, N.J., received the prize.

The annual APS Medal is intended to "recognize contributions of the highest level that advance our knowledge and understanding of the physical universe in all its facets," and "to celebrate the human value of open and free inquiry in the pursuit of knowledge." The physicist chosen for this honor receives a medal and an award of $50,000 — making it the largest prize given by APS.

The award was established thanks to a donation from entrepreneur Jay Jones, the founder and former president of Olympic Medical Corporation.

"It is truly a wonderful occasion," said 2014 APS President Malcolm Beasley, speaking at the ceremony. "The APS can finally recognize those among us who have made the most important contributions across the entire field of physics. That was not possible before." Beasley, who helped establish the prize during his presidential term, added that doing so was "the most joyous experience of my service in the APS presidential line."

Kyle Bergener

On January 28, APS awarded its first Medal for Exceptional Achievement in Research to Edward Witten (center right), Institute for Advanced Study, Princeton. The award was funded by a donation from Jay Jones (center left) and was presented by 2016 APS President Homer Neal (left) and CEO Kate Kirby (right).

Witten received the award for "discoveries in the mathematical structure of quantum field theory that have opened new paths in all areas of quantum physics." Witten is the originator of M-theory, which united five competing string theory models. This result kicked off intense interest and rapid developments in the field, leading to a boom known as the second superstring revolution.

Summing up the importance of his work and that of colleagues in the field, Witten said, "I believe we've made lasting achievements in understanding quantum field theory better, in learning how it might be generalized to combine it with Einstein's theory of gravity, and in learning and applications to many areas of physics and mathematics, that range from algebraic geometry to condensed matter physics and heavy ion physics."

"It's marvelous to have the opportunity to work in science; I consider myself very lucky," Witten said. "For one who has the passion for physics, the chance of being a physicist is the best thing that one can imagine."

He added, "This award from the American Physical Society really means a lot to me, especially because I know that the American Physical Society is a very important voice for physics in our society and in Washington."

In remarks during the ceremony, Jones said, "I don't think your committees could have selected a more deserving or distinguished physicist, and I also think it's an extremely auspicious beginning for

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Research News From Physics

New Form of Carbon Stores Lots of Gas

By Tamela Maciel

Carbon can form diamond, nanotubes, or the nanoscale spheres called buckyballs, as well as several other structures. Now a team has produced what they call carbon honeycomb, a structure that appears to have a huge gas-storage capacity. By slightly altering a common fabrication method, the researchers created what appears to be a 3D honeycomb built from the carbon sheets known as graphene. This structure might be used as a light, energy-efficient fuel storage container for hydrogen fuel cells.

Storing and transporting hydrogen gas efficiently remains a key obstacle to its use as a renewable fuel source. So the U.S. Department of Energy has challenged scientists to develop a system that can store more than 5.5% of its total mass as hydrogen by 2020 [1]. At the moment, storage tanks at very high pressure (for hydrogen gas) or very low temperature (for liquid hydrogen) are the best commercial option, but they require a huge amount of energy to maintain. So many researchers are now focused on developing porous materials that can both trap and release hydrogen gas while consuming much less energy. In theory, carbon nanotubes and other nanostructures, with their very large surface areas, are good candidates, but in practice, access to the gas storage space in these structures is often blocked. Some researchers have proposed a new foam-like carbon structure with a higher gas storage capacity, but it has not yet been demonstrated [2].

To develop better hydrogen storage, Nina Krainyukova of the National Academy of Sciences of Ukraine and Evgeniy Zubarev of the National Technical University, both in Kharkiv, Ukraine, experimented with various ways of making carbon structures. Their most successful technique was similar to the "arc

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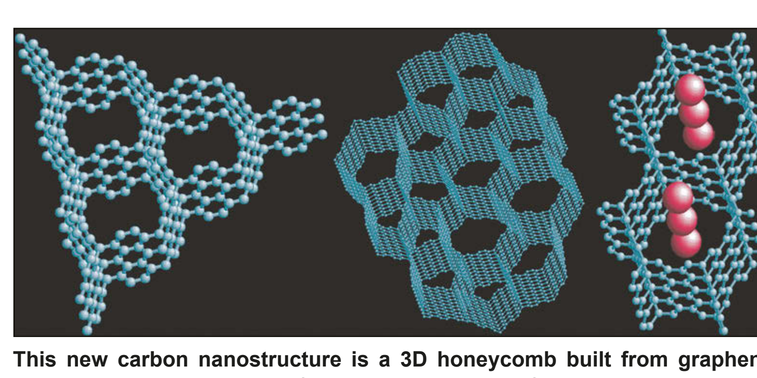

N. Krainyukova/National Academy of Sciences of Ukraine

This new carbon nanostructure is a 3D honeycomb built from graphene sheets in either periodic (left) or random (center) form. The structure can absorb large numbers of gas atoms and molecules (right).

Revised 04/11/2016

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discharge" method, where carbon fragments fly between a pair of charged carbon electrodes and land on a nearby surface to form nanostructures. But instead of two electrodes, the team heated a single carbon rod up to its sublimation point using an electric current. The hot rod produced a vapor containing much smaller carbon fragments than the arc discharge method, according to Krainyukova. These fragments then formed a thin film on a nearby surface. This film proved to be a good gas absorber, as Krainyukova reported in 2009, before she knew its atomic structure [3].

In order to identify the structure, Krainyukova and Zubarev subjected their film to a battery of tests. Electron microscope images revealed a network of hollow channels running perpendicular to the film's surface, which suggested that the material had a lattice-like structure. From electron diffraction measurements and computer modeling, the researchers determined that the bonds met at 120-degree angles. This angle is a characteristic of graphene sheets and also of sponge-like carbon fragments called schwarzites, but the measured carbon density of the film was too high to be made of schwarzites. Finally, the team again tested the gas capacity of the film, this time with carbon dioxide as well as the krypton and xenon gases tested in 2009, and they found high levels of absorption for each gas. This result eliminated the last of the previously known carbon nanostructures—bundles of nanotubes—which can only bind half as much gas as the new carbon film.

After this last test, Krainyukova says, she and Zubarev had to admit that their carbon film was different from any known structure. They modeled a series of new structures until they found one that matched all of their observations. This winning structure has a repeating pattern of flat graphene sheets bound on edge into hexagons to form a "carbon honeycomb," as the researchers call it. The open hexagonal channels in the honeycomb are key to its high absorbency, and the team says that the size of these channels could be adapted to fit many different atoms or molecules, including hydrogen gas with an estimated capacity of 8% by mass.

Boris Yakobson of Rice University in Houston, who is also developing carbon-based hydrogen storage, says that this work is a provocative discovery. If confirmed with higher resolution images, the honeycomb structure would be a "remarkable addition" to the current suite of carbon nanostructures, he says. Klavs Hansen of the University of Gothenburg in Sweden agrees. "The obvious application is, after some developments, for gas storage and possibly also molecular sieves." Farther in the future, he says, there could be still more uses beyond what today's researchers can imagine.

This article was originally published in *Physics* (physics.aps.org). The research described was published in *Physical Review Letters* (go.aps.org/1RtqUKR).

Tamela Maciel is a freelance science writer in Leicester, UK.

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This Month in Physics History

March 1844: Publication of Faraday's Letter Describing His Ice-Pail Experiment

The eminent 19th-century scientist Humphrey Davy is known for many things, including the discovery of the elements barium, strontium, sodium, potassium, calcium, and magnesium. But it has often been said that his one-time laboratory assistant, Michael Faraday, was Davy's greatest discovery. The young man went on to conduct a series of some of the most seminal experiments in electromagnetism.

Born in 1790, Faraday's father was a blacksmith, and the family lived in poverty. Young Michael received only the most rudimentary early education, but when he was 14, he was apprenticed to a local bookbinder and bookseller named George Reibau. That gave him access to scores of books, and he read voraciously for the next seven years, developing a particularly strong interest in science and the latest discoveries in electricity.

Serendipitously, as his apprenticeship was ending, a friend gave him a ticket to a lecture on electrochemistry by Davy at the Royal Institution — not a venue where the young humble-born Faraday would normally be welcomed. Faraday was entranced, and after the lecture he asked Davy for a job. There wasn't a position available, Davy gently told the young man, but shortly thereafter he sacked his assistant for brawling and hired Faraday to take the man's place.

Faraday was not considered a "gentleman" by the standards of the day. In fact, when Davy and his wife toured the continent from 1813 - 1815, Faraday was supposed to accompany them as Davy's scientific assistant — except when Davy's valet declined to go, Faraday was forced to step in, with Davy's wife insisting that he eat with the servants and travel outside the coach. He endured these indignities, and proved an able assistant, discovering two new compounds of chlorine and carbon, and successfully liquefying various gases.

In 1820, news reached England of Danish scientist Hans Christian Oersted's experiment demonstrating that an electric current in a wire can deflect a compass needle. Faraday enthusiastically dove into designing his own experiments, hoping to prove that not just electricity and magnetism, but all natural forces were somehow linked. He is best known for his demonstrations of the underlying principles behind electric motors and generators, as well as the magneto-optical effect.

But he also performed groundbreaking experiments on electrostatic charge. For instance, when he wanted to prove that the charge on a conductor resides on the exterior surface and doesn't influence anything enclosed within it, Faraday built a small room inside his laboratory and covered it with metal foil. Then he connected the foil to a high-voltage generator. He monitored the effects with an electroscope, and demonstrated that the electric charge never penetrated into the interior of the makeshift room.

Seven years later, Faraday built on that earlier work with his famous ice-pail experiment to demonstrate the effects of electrostatic induction. He insulated the metal pail from the ground by placing it on a wooden stool, and then took a page from Benjamin Franklin's experimental book by lowering a charged metal ball into the pail with a nonconducting silk thread, being careful not to let the ball touch any part of the pail.

A gold-leaf electroscope indicated the presence of a charge on the outside the pail, evidence that the ball was inducing a charge in the exterior of the pail. And if he allowed the metal ball to touch the bottom of the pail, the charges on the ball canceled the charges on the inside wall of the pail, leaving a charge on the outside wall equal to the original charge on the ball.

Faraday described these results in a letter to Richard Phillips, editor of the *Philosophical Journal*, who published the correspondence in the journal a year later in March 1844. Various versions of the experiment are still performed today for demonstration purposes, although it usually involves a hollow metal sphere instead of a pail, and a modern electrometer instead of an electroscope.

wikimedia commons

Portrait of Michael Farady painted by Thomas Phillips in 1842.

Faraday suffered a nervous breakdown in 1839, although he recovered sufficiently to continue his experiments into electromagnetism. For much of his life, he eschewed worldly honors, turning down a knighthood and twice refusing to become president of the Royal Society. During the Crimean War, he was asked to advise the British government on the production of chemical weapons; the staunchly religious Faraday refused on ethical grounds. On August 25, 1867, he died at home in Hampton Court at the age of 75.

This self-educated blackmith's son left an indelible mark on physics. The unit of electrical capacitance is named the farad in his honor. Albert Einstein purportedly included a picture of Faraday on his wall, with the likes of Isaac Newton and James Clerk Maxwell. No less a luminary than Ernest Rutherford paid tribute to his genius by declaring, "When we consider the magnitude and extent of his discoveries and their influence on the progress of science and of industry, there is no honour too great to pay to the memory of Faraday, one of the greatest scientific discoverers of all time."

Further Reading

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Washington Dispatch

POLICY UPDATE

FEDERAL BUDGET

President Obama's budget request, released on February 9, 2016, adheres to the two-year discretionary spending caps the White House and Congress had negotiated last fall. To try to circumvent those caps, the president would establish "mandatory" accounts that require action by congressional authorizers and tax writers. His proposal is unlikely to generate much enthusiasm from lawmakers who are seeking ways to reduce the upward trajectory of mandatory accounts, which include Social Security, Medicare and Medicaid. In fact, House and Senate Republican leaders have refused to allow administration officials to testify on behalf of the White House budget. That denial is almost unprecedented, and it serves notice that Congress has little interest in the presidential request.

The accompanying tables illustrate the winners and losers under both presidential scenarios. The tables use the following acronyms and designations. Department of Defence (DOD) RDT&E: Defense Research, Development, Testing and Evaluation; DOD 6.1: Basic Research; 6.2; Applied Research; 6.3: Advanced Technology Development; DOE: Department of Energy; ARPA-E: Advanced Research Projects Agency-Energy; EERE: Energy Efficiency & Renewable Energy; ASCR: Advanced Scientific Computing Research; BES: Basic Energy Sciences; BER: Biological and Environmental Research; FES: Fusion Energy Sciences; HEP: High Energy Physics.

Absent a "mandatory" spending workaround, most science spending would either decline or remain relatively flat. The Department of Energy (DOE) Office of Science, the DOE EERE account, and the DOE "ARPA-E" program would be exceptions, as would the National Institute of Standards (NIST) Scientific and Technical Research and Services (STRS) and the DOD Applied Research (6.2) programs.

Discretionary Spending Only

Agency and Sub-Account	FY 16 Enacted ($M)	FY 17 Request ($M)	% Change
DOD RDT&E	20,223	20,457	1.2
6.1	697.0	631.0	-9.5
6.2	1,668	1,773	6.3
6.3	3,144	3,191	1.5
DOE	29,603	30,240	2.2
ARPA-E	291.0	350.0	20.3
EERE	2,069	2,898	40.1
Office of Science	5,347	5,572	4.2
ASCR	621.0	663.2	6.8
BES	1,849	1,937	4.8
BER	609.0	661.9	8.7
FES	438.0	398.2	-9.1
HEP	795.0	818.0	2.9
NP	617.1	635.7	3.0
NNSA	12,526	12,884	2.9
NASA	19,285	18,282	-5.2
Science	5,589	5,303	-5.1
NIH	32,311	31,311	-3.1
NIST	964.0	1,015	5.3
STRS	690.0	730.5	5.9
CRF	119.0	95.0	-20.2
NSF	7,464	7,564	1.3
R&RA	6,034	6,079	0.7
EHR	880.0	898.9	2.1
MREFC	200.3	193.1	-3.6

Discretionary Plus Mandatory Spending

Agency and Sub-Account	FY 16 Enacted ($M)	FY 17 Request ($M)	% Change
DOD RDT&E	20,223	20,457	1.2
6.1	697.0	631.0	-9.5
6.2	1,668	1,773	6.3
6.3	3,144	3,191	1.5
DOE	29,603	30,240	2.2
ARPA-E	291.0	500.0	71.8
EERE	2,069	4,233	104.6
Office of Science	5,347	5,672	6.1
ASCR	621.0	663.2	6.8
BES	1,849	1,937	4.8
BER	609.0	661.9	8.7
FES	438.0	398.2	-9.1
HEP	795.0	818.0	2.9
NP	617.1	635.7	3.0
University Grants	0.0	100.0	
NNSA	12,526	12,884	2.9
NASA	19,285	19,025	-1.3
Science	5,589	5,601	0.2
NIH	32,311	33,136	2.6
NIST	964.0	1,015	5.3
STRS	690.0	730.5	5.9
CRF	119.0	95.0	-20.2
NSF	7,464	7,964	6.7
R&RA	6,034	6,425	6.5
EHR	880.0	952.9	8.3
MREFC	200.3	193.1	-3.6

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Disentangling the World of Science Policy

By Sophia Chen

Since 2014, a group of Harvard graduate students has taken an annual trip to Washington DC for a three-day whirlwind introduction to scientists working in government. Around ten participants, who come from a variety of science disciplines, tour federal agencies such as the Department of Defense, the National Science Foundation, and the Food and Drug Administration, and speak to Ph.D. scientists about their work.

The immediate goal for the trip, organized by Harvard's science policy graduate student group, is for the students to learn about career alternatives to academia. But their underlying motivation is to figure out their public responsibility as scientists in a changing society of new technology and global problems.

Julia Gonski first became interested in the policy side of science during her senior year in college, after she received the NSF Graduate Research Fellowship to work on a particle physics experiment at the Large Hadron Collider. Gonski, a second-year Harvard physics graduate student who went on the DC trip last year, wanted to understand how the agency chose her proposal out of a pool of over 10,000 others. "Once that curtain was pulled back, it was so interesting and important, and no one was talking about it," she says. "I wanted to look into it more."

By delving into the funding process and then taking the trip, she learned about the hidden structure that props up the ivory tower: the work of science lobbyists, Congressional staff, and numerous other government employees who advocate for and inform policy makers about academic research. "In physics in particular, as a community, we tend to believe that we're doing this fundamental research, and that the integrity of it alone will get us by," she says. This attitude, in which researchers take the taxpayer's compliance for granted, isn't sustainable, she says. "The caveat is, the second that people stop believing it's worthwhile, they're not going to fund us."

Certainly many scientists are aware of the advocacy and politics that keep the research engine oiled. But they usually develop this awareness later in their career, when they need to apply for grants. Younger scientists like Gonski have to take the initiative to learn about it.

"Maybe having a seminar on it at university is a good idea," says Franklin Carrero-Martínez, a former biology professor who worked in the Department of State through the American Association for the Advancement of Science (AAAS) Science and Technology Fellowship. He now works as a program director at NSF. "It's easy to complain about how dysfunctional the government is or how things aren't working, but if you don't educate yourself, it's even harder to change."

But academic culture treats policy work as a side interest, says Nicole Bedford, a Harvard biology graduate student who is organizing this year's trip in early April. "The reward structure is not present," she says. "The system rewards highly focused individuals, and not necessarily people with a breadth of experience. Ph.D. students are dissuaded from working in policy because it's thought of as time taken away from doing basic research. [Policy experience] could be considered a holistic part of your training." To shift the culture, Bedford suggests that university hiring committees could give candidates with science policy experience some credit for these pursuits instead of considering only their publication records.

For next month's trip, in addition to learning about the policy relevant to basic research, Bedford is also interested in how basic science gets translated into useful language for policy makers, especially concerning climate change. "There are so many interest groups

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Profiles in Versatility

The Call of the Caves

By Alaina G. Levine

For Matt Covington, the call of the caves was stronger than the pull of the cosmos. Educated as an astrophysicist with a Ph.D. from the University of California, Santa Cruz, he originally chose the subject for its job security. "I didn't want to be flipping burgers the rest of my life so maybe I should go into grad school for physics," he recalls thinking.

And yet, his love of nature was originally nurtured by access to inner space. He grew up in Arkansas, where the limestone bedrock breeds an abundance of caves, and in fact the state is internationally known by cavers and cave scientists alike for its underground laboratories. Covington had been exploring caves there since he was a child, and he kept his eyes peeled for opportunities where his craving for caves could turn into a career.

While his sights were set on the stars, he noticed something about his attitude. "I enjoyed astrophysics but wasn't passionate about it," he says. "I would do my work and then go caving." One day, as is known to happen, "it hit me," he says. "I was sitting in a seminar on galaxy formation … and I wondered if this could be used to study caves."

He stuck with his doctoral studies, wrote two NSF proposals for postdoc fellowships in cave geophysics, and both were funded. Covington used one fellowship to spend a year at the University of Minnesota Twin Cities, where he worked on issues pertaining to

Jason Gulley

Matt Covington, pictured above in a glacier cave in Svalbard, Norway, uses his physics training in exploring and understanding caves.

hydrogeology, and another to spend two years at the Karst Research Institute in Postojna, Slovenia, where he examined geomorphology. Both institutes are in regions which have fantastic cave systems. "Now I have to be careful that I don't work too hard," he jests, "because I just want to work all the time."

Covington stresses that his transition from astrophysics to speleophysics wasn't smooth. "When I started I had little knowledge of the scientific literature, but knew a lot about caves," he says. Despite this lack of formal education, his intimate familiarity with cave environments gave him something no degree could ever provide — street cred in the geology community. "It wasn't like I was some physicist totally detached from reality," who just randomly decided to ditch galaxies for stalactites and stalagmites, he notes. His cave expertise, coupled with his postdoc appointments, enabled him to compete at the same level as Ph.D. geologists for jobs. Today he is assistant professor of geosciences at the University of Arkansas, where he had received his undergraduate degree.

Ok — so what the heck does a cave physicist do? Geomorphology, hydrogeology, and mathematical models of physical processes all take a starring role in the field. "The study of landscape evolution is vital," says Covington. "There's a push to develop mechanistic models for studying landscape development, so there's good interplay

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molecular biologist Jason Lieb resigned in February after he was found to have harassed students.

"I think most women in the field would say it's a serious problem," says APS CEO Kate Kirby. "I think most women would say that they've experienced harassment, inappropriate comments, and inappropriate behaviors." Also, the leadership of some APS divisions has raised concerns about harassment with APS senior management.

APS efforts to address harassment include a code of conduct for APS meetings, approved in November 2015. The code states, in part, that all participants "will conduct themselves in a professional manner that is welcoming to all participants and free from any form of discrimination, harassment, or retaliation."

The code lays out consequences for transgressions. "Violations of this code of conduct policy should be reported to meeting organizers, APS staff, or the APS Director of Meetings. Sanctions may range from verbal warning, to ejection from the meeting without refund, to notifying appropriate authorities." The full code of conduct is available at go.aps.org/1T54Ycv

"I think it's just incredibly important that we make sure that people are able to practice physics without being bullied, harassed, or made to feel uncomfortable," Kirby says. "We have to establish — especially at our meetings — an environment where people feel safe and can benefit from participating fully."

APS senior management is now getting legal advice on what actions the Society can and should take upon accusations of harassment. "I think APS needs to be prepared to handle whatever comes," says Kirby. "I'm very concerned with setting up the appropriate due process because it is really important for a society to try to treat people fairly in such situations."

The code of conduct is just the first step in addressing harassment at APS meetings, says APS Director of Education and Diversity Ted Hodapp. "The second step is to provide training for all APS staff members and all session chairs to know what to do in case they witness or experience unprofessional behavior." Such behavior is not limited to sexual harassment, and includes other kinds of unprofessional conduct, such as yelling at speakers.

Prior to the 2016 March and April meetings, harassment training will be provided to APS senior management, certain APS Education and Diversity staff, and all APS meetings staff. The training instructs employees how to respond if an attendee at a meeting has concerns about harassment or other inappropriate behavior. Additional APS staff present at the meetings will receive basic information on what to do if an attendee approaches them with a complaint, including directing the person to APS staff that have received the harassment training. Session chairs at the meetings will receive written instructions.

Unfortunately, there's little data on sexual harassment specific to physics, says Lauren Aycock, a graduate student at Cornell and the Joint Quantum Institute at the University of Maryland. To try to get a better handle on how prevalent such issues are in the physics community, Aycock worked with APS to include questions about harassment on a survey taken by participants in the Society's recent Conference for Undergraduate Women in Physics. In preliminary, unpublished results from that survey, shared in an interview with *APS News*, Aycock found that about half of the undergraduate women stated they had witnessed inappropriate comments "often" or "sometimes." And about half said that they had personally experienced such conduct. "To me, this is saying 'This is a problem and we should address it,'" Aycock says.

The APS Committee on the Status of Women in Physics (CSWP) has formed a three-person subcommittee tasked with studying harassment issues and considering how APS should respond to reports of harassment. The subcommittee will formulate recommendations that they will bring to the full CSWP in early March, and then to APS leadership. "We're really trying to both understand the scope of the problems and understand what the possible interventions are at this point," says Patricia Rankin of the University of Colorado, Boulder, the leader of the subcommittee.

Providing a supportive, inclusive environment at APS meetings is a top priority, Rankin says. "We'll be looking at what happens in the March and April meetings." Then, by the time of the next round of meetings, in 2017, "We would expect to have something which is much more fully developed at that point," Rankin says. In the long term, the subcommittee will also tackle questions of how to investigate complaints and how to prevent harassment from occurring in the first place.

"I just don't think we can afford to lose people from physics because people are behaving inappropriately," says Rankin. "There's so much that is so exciting about physics that to me it's a tragedy if people are dissuaded from coming into physics."

WAVES continued from page 1

two observatories, located in Hanford, Washington and Livingston, Louisiana.

That observation has left scientists stunned. "My jaw dropped," says Emanuele Berti of the University of Mississippi, who was not involved in the experiment. "The significance of the detection is so high that it's extremely unlikely that this is not a binary black hole signal. ... Never would I have thought in my life that I would see a signal that clear so early."

"I'm totally beside myself," says Clifford Will of the University of Florida, Gainesville, who was not involved in the experiment. "It's tremendously exciting. I actually was shown the paper a couple of weeks ago, and I'm still excited two weeks later."

Each LIGO observatory boasts a pair of four-kilometer-long arms arranged in an L to form an enormous interferometer. In the absence of gravitational waves, the light from a laser travels the same distance along each arm, and the beams from the two arms interfere destructively when they meet at the arms' intersection, so that no light reaches a detector that monitors the beam.

But when a gravitational wave passes through the observatory, it will ever-so-slightly lengthen one arm and shorten the other, preventing the full cancellation of the two beams, letting light through to the detector and producing a signal. LIGO is designed to catch length differences a billionth the size of an atom.

LIGO's two separate observatories help to rule out spurious signals from the local environment, which can be caused by events as innocuous as a truck rumbling by, or ocean waves crashing on the shore. Gravitational wave signals should appear in both detectors, nearly simultaneously.

And that is just what happened. Both observatories recorded a signal (see graph below) consistent with predictions for a black hole merger. In such an event, two black holes rapidly spiral closer and closer together, until they meet to form a single black hole, which then undergoes "ringdown" — in analogy to a bell ringing after being struck with a hammer. According to predictions, the process should produce a telltale "chirp" signal of increasing frequency. That is exactly what LIGO saw, and the LIGO team is extremely confident that it is the real deal: They expect an event like this to appear as a false alarm only once every 203,000 years.

"It was amazing; this was a gift of nature. It was not just black holes but it was a signal we could see by eye," LIGO spokesperson Gabriela González of Louisiana State University said at a press conference in Washington, DC on February 11, noting that the signal was strong enough to stick out obviously above the noise.

Some LIGO team members say the signal initially struck them as too good to be true. And since LIGO's process includes "blind injections" — test signals planted in the data that only a few collaboration members know about — it well could have been. "I thought it had to be an injection; it was so beautiful," says John Veitch of the University of Birmingham. But collaboration leaders quickly confirmed that it was not a drill.

The researchers estimate that the black holes' masses were 36 and 29 times the mass of the Sun, and pegged them at a distance of 1.3 billion light years from Earth. When these two behemoths combined, their coalescence was so intense that it radiated away 3 solar masses worth of energy in gravitational waves, leaving behind a black hole 62 times the mass of the Sun.

"There's really no doubt that this is a real detection, a real signal," says Will. "They do a very careful job of worrying about any kind of issues that might have fooled them."

The discovery of the system and its merger is significant in itself, affirming the power of gravitational waves to unlock new secrets of the cosmos. The result shows that binary black holes can form and merge — something predicted but never before seen.

Additionally, the merging black holes are more massive than most "stellar mass" black holes, and also much smaller than the supermassive black holes found at the centers of galaxies, which can have masses billions of times that of the Sun. But there is a no-man's-land between the two groups, with the stellar mass black holes topping out around 15 or 20 times the mass of the Sun, says Berti. The result shows that more massive black holes of this size indeed exist.

"The motivation wasn't just to detect gravitational waves and go home, but the potential to create a completely new science," says Barry Barish of Caltech, a member of the LIGO collaboration and 2011 APS president. "This is a completely different way to look at the sky."

The researchers also set a bound on the mass of the graviton — the hypothetical particle that transmits the gravitational interaction — and put general relativity through its paces by performing consistency tests, which it passed handily.

LIGO detected a second, less significant event, which was also compatible with a binary black hole merger. But, "My feeling is that it's not part of the story," says Barish. "It doesn't measure to be statistically probable enough that we should talk about it." The false alarm rate for an event like this is once every 2.3 years.

The discovery came on the heels of a $200-million upgrade to the experiment, called Advanced LIGO, intended to boost its chances of finding the elusive signals. During LIGO's previous run, from 2002 to 2010, the collaboration came up empty-handed. Currently, the detector's sensitivity to binary neutron star mergers is improved over its previous incarnation by a factor of three to five, says Barish. Eventually, the sensitivity will reach a factor-of-ten improvement — increasing the rate of binary neutron star mergers LIGO can detect by a factor of 1000, by effectively allowing LIGO to peer further out in space.

Several planned gravitational wave observatories, including Advanced Virgo in Italy, will soon form a network of detectors along with LIGO, allowing physicists to more accurately pinpoint sources on the sky, and point telescopes in the direction of candidates to look for corresponding electromagnetic signals. "We can start seeing the universe and listening to it at the same time," says Chiara Mingarelli of Caltech.

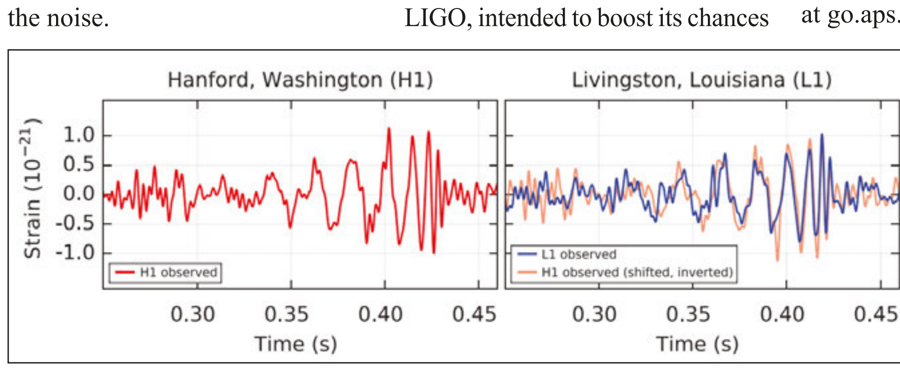
In fact, LIGO and Virgo are already working as a team and collaborating on data analysis, so members of the Virgo collaboration were also listed as authors on the paper.

Although the result is the first direct detection of gravitational waves, physicists have long been confident in their existence, persuaded by indirect evidence gleaned from long-term observation of a pulsar — a rapidly rotating neutron star that appears to pulse regularly — in a binary system. Over decades, analysis of the pulses' timing revealed a slow but steady loss of energy, at just the rate expected for the emission of gravitational waves. The 1974 discovery of this binary pulsar earned its discoverers, Russell Hulse and Joseph Taylor, the 1993 Nobel Prize in physics. For years, physicists have speculated that the first direct detection of gravitational waves will be Nobel-worthy too.

With the paper covering only a few weeks of operation, and months more of data already in the can, it might not take long for new signals to appear. "They'll find more stuff," says Virginia Trimble of the University of California, Irvine. "The next rumor, of course, is events two and three."

There's plenty to come from LIGO, said Kip Thorne of Caltech during the press conference. "It's really fantastic; we are going to have a huge richness of gravitational wave signals." As for what the new data will bring, "I think we can be rather sure that we will see big surprises," he said.

For more on the discovery read the *Physics* Viewpoint by Emanuele Berti at go.aps.org/20XHwP7 and the *Physical Review Letters* paper at go.aps.org/1o7qarw



Adapted from PRL 116, 061102 (2016).

Nearly simultaneous signals at the LIGO Observatories clinch the case for gravitational waves. Right side shows the two signals shifted and superimposed.

Education Update

Award for Improving Undergraduate Physics Education

Created by the APS Committee on Education, the award recognizes departments and programs that support best practices in education at the undergraduate level. Nominations for the award are being accepted until July 15. More information can be found at go.aps.org/14l8Qc2

Research mentor training seminar — free guide available

The Physics Research Mentor Training Seminar is a facilitation guide to an educational seminar for physics faculty, postdocs, and graduate students who are in mentorship roles. It is ideal for Research Experiences for Undergraduates programs and can be run as a weekly seminar during the summer. The guide is available in pdf format at go.aps.org/physicsmentortraining.

APS Speakers Lists features Physics Education Researchers

The APS Speakers Lists contain names, contact information, and talk titles of physicists who are willing to give talks on a variety of subjects. Advanced searches allow one to search specifically for physics education researchers. Learn more at aps.org/programs/speakers

The *PER User's Guide*: A Web Resource for Physics Educators

The *PER User's Guide* is a growing web resource designed to translate, summarize, and organize the results of physics education research (PER) in an accessible and useful way for busy educators. Learn more at: perusersguide.org

APS Membership Continues to Climb

By Emily Conover

APS membership increased for the third year in a row, the APS Membership Department has announced, following its annual count. At the beginning of 2016, APS hit a record high of 53,099 members — an increase of 1,576 members over last year. The membership boost came mostly from students and early career members.

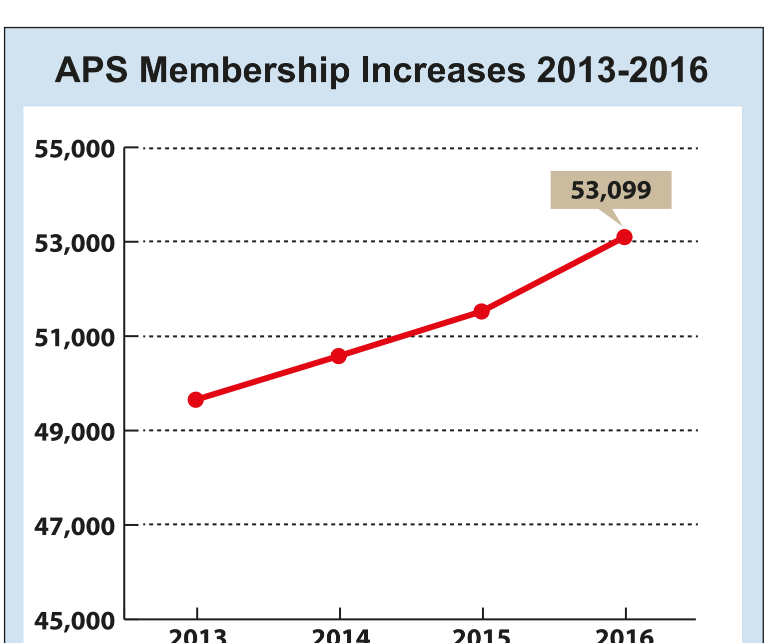
"We offer a lot at our meetings for students, and in particular undergrads, and I think we're doing a better job communicating that," says APS Director of Membership Trish Lettieri. In particular, the Conferences for Undergraduate Women in Physics (CUWiP) are a significant and relatively new source of student members. Additionally, students receive one year of free membership in APS, and students who join the Society of Physics Students can also choose to join APS as part of their membership. Much of the growth occurred in these categories. Overall, student memberships increased from 17,002 last year to 18,716 in 2016.

Early-career membership, which is offered at a reduced price, increased by 508 members this year, continuing steady gains in that category over the past few years, after the discount was extended from three to five years post-graduation.

International membership also increased. Members living outside the U.S. now make up 24% of the Society, up from 23% last year. "That's the highest it's been since I've been here," says Lettieri, who has been with APS for over two decades.

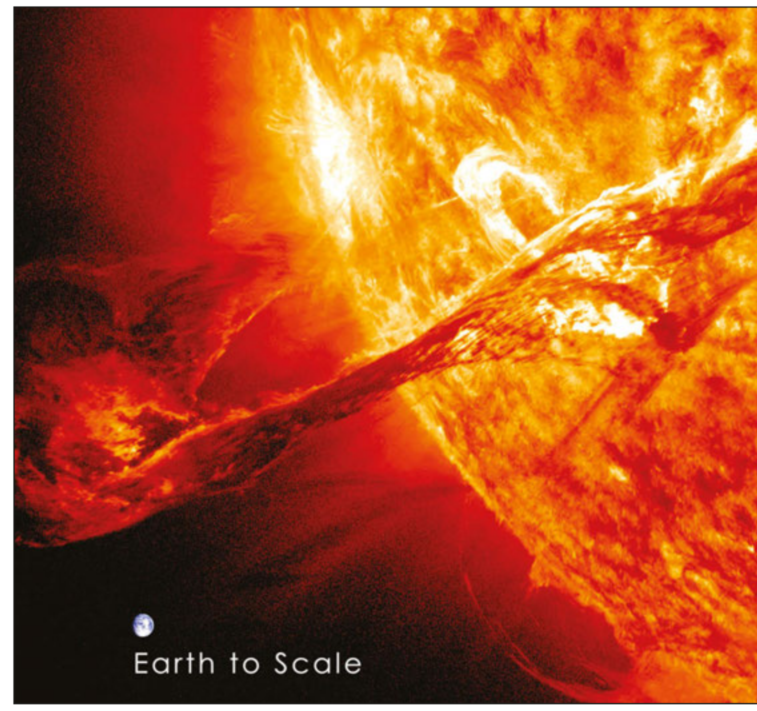
But not all membership categories have grown. "For me the concern is — and has been for a number of years — the slow decline of the regular member category," Lettieri says. Regular memberships dropped by 629 members, from 21,722 last year to 21,093 at the beginning of 2016. In coming years, Lettieri hopes that some of the early career members will move on to become regular members after their five years are up.

To maintain steady membership growth, APS is working to better serve its members, Lettieri says. "We continue to try and run programs that benefit our early career members and students. But we're also focusing on better communicating to the membership and engaging people onsite at APS meetings."



Scientists Discuss the Dangers of Space Weather

By Emily Conover



NASA

Huge solar coronal mass ejections hurl plasma into space. These cause space storms that can wreak havoc on Earth.

Auroras lit the skies as far south as Cuba on September 1, 1859. Telegraph systems across the globe malfunctioned, sparking and shocking their operators, and making transmission impossible. The cause was a massive geomagnetic storm, known as the Carrington Event after astronomer Richard Carrington, who observed an enormous solar flare preceding the events on Earth.

If a storm of equal strength occurred in today's technology-addicted world, it would have catastrophic impacts, said a panel of space weather experts at the American Association for the Advancement of Science (AAAS) Meeting in Washington, DC on February 15.

"This was by all measures a huge storm," said Daniel Baker of the University of Colorado. "If an event of that size were to occur today, the effects by most estimates would be devastating." Large regions of the globe could be plunged into darkness and hobbled with technology failures, from widespread power outages, to loss of communication systems, to GPS navigation failures, and damage to satellites.

Blasts of plasma hurled from the Sun, known as coronal mass ejections, can cause geomagnetic storms if the eruption is directed at Earth. Coronal mass ejections can fling billions of tons of material at speeds reaching millions of miles an hour, making them capable of traveling the distance to Earth in as little as half a day.

Just this kind of blast occurred in July 2012 — a powerful coronal mass ejection, which was observed by NASA's STEREO A spacecraft. Had it hit Earth, the resulting storm may have been even stronger than the Carrington event. Luckily for humanity, it missed — but by only a slim margin. "If this event had occurred just a few days earlier, as the Earth was in the line of fire," said Baker, "I've contended that we would still be picking up the pieces."

Geomagnetic storms can induce currents in power lines, wreaking havoc with the electrical grid, and potentially burning out transformers. An extreme solar storm could cause the loss of hundreds of house-sized transformers, Baker said. Such transformers are difficult and expensive to replace, and power outages could stretch out for weeks, months, or even years, Baker said, as damaged equipment is restored and the grid is brought back up. Recovery costs have been estimated to run into the trillions of dollars.

The storms can disrupt high-frequency radio communications, radar and GPS, causing headaches for industries that rely on these technologies, like airlines. In November 2015, flights in Sweden disappeared from air traffic control screens during a geomagnetic storm. "Is it possible that an event like this can happen in the U.S.? We're not so sure," said Bill Murtagh, Director for Space Weather at the White House Office of Science and Technology Policy. "We've got to be able to answer that question. ... A loss of our air traffic control over the United States for any number of hours will quickly result in impacts of hundreds of millions of dollars, and severe disruption to our economy."

Scientists are working to predict the chances of a catastrophic storm hitting Earth. Pete Riley of

WEATHER continued on page 6

International News

An International Cosmic Observatory Launches a New Field of Physics

By Maria Spiropulu

I started writing this some time before the Laser Interferometer Gravitational-wave Observatory (LIGO) discovery announcement (see article on p.1), and my main theme was the excitement and challenges of seeding new international science projects around the world. In addition, I was interested in probing existing models of international collaboration and in discussing the impact of global science engagement, both in terms of knowledge advancement and in terms of accelerated development and growth of societies worldwide. But after February 11, I decided to change my focus. I'll explain why later in the article.

The science communities across the globe have already established Brobdingnagian projects – immense in financial investment, scale, people and countries involved, and in overall complexity. In 2012 we witnessed an example of an unprecedented science effort bear fruit with the fundamental discovery of the Higgs boson at the LHC. It is important to investigate and study how such projects are envisioned, designed, built, and run on different continents, countries, planets — or outer space for that matter, with the participation of thousands of people and hundreds of nations and governments.

We started a very productive discussion at the invited sessions of the APS Forum on International Physics at the 2015 April Meeting, where we explored big science partnerships around the world with a focus on high energy physics, nuclear physics and energy, astronomy and cosmology, and last, but by no means least, gravity. The discussion will continue again this year at the Forum's sessions in the 2016 March and April meetings.

However, on February 11, a monumental discovery was announced: the observation of gravitational waves at LIGO. As a result, I felt compelled to take this great opportunity to reflect on how the unachievable, the impossible, the unthinkable, the Mars-shot in science, is actually carried out and accomplished in the context of international collaboration.

When we talk about LIGO we refer actually to two things: the LIGO Scientific Collaboration (LSC), and the LIGO Laboratory. The LIGO Laboratory is jointly managed by Caltech and MIT and operates the LIGO facilities: the twin interferometers that constitute the gravitational wave observatory at Hanford, Washington, and Livingston, Louisiana. They are funded by the U.S. National Science Foundation (NSF), and were conceived, built, and operated by Caltech and MIT.

Advanced LIGO — a major upgrade to the sensitivity of the instruments compared to the first generation LIGO detectors — began scientific operations in September 2015. Funded in large part by NSF, with contributions from the Max Planck Society in Germany, the Science and Technology Facilities Council in the UK, and the Australian Research Council, Advanced LIGO led to the discovery of gravitational waves. The mission of LIGO was always to open a new field of experimental science: that

LIGO continued on page 7

WEATHER continued from page 5

Predictive Science, a space weather research company, pegs the probability of a Carrington-strength event or worse over the next decade at around ten percent. But, he said during the AAAS session, "There are large uncertainties associated with that number, and that is at least an equally important message to communicate as the actual value itself."

The severity of storms can be ranked by an index of geomagnetic activity known as the disturbance storm time index (Dst). To make their estimate, Riley and colleagues fit the observed storm Dst data to a variety of models — including power law, log-normal, and stretched exponential distributions — to calculate the probability of an extreme storm. For the power law distribution, they found a 10 percent probability of a strong storm within the next decade, but when uncertainties are considered, this number could range from 1 to 19 percent probability, and the numbers vary with different distributions.

The dire warnings about such events convinced Washington to take notice, said Murtagh. "For someone to suggest we could have power outage for an extended period, as in months, in a large part of this nation, that changed the picture, that changed the landscape altogether."

As a result, in November 2014, the National Science and Technology Council (NSTC) established the Space Weather Operations, Research, and Mitigation (SWORM) Task Force to develop a space weather preparedness strategy.

The need to understand space weather reaches well beyond the typical science policy players (like NASA, the National Science Foundation, and the National Oceanic and Atmospheric Administration) to the Department of Homeland Security, the Federal Emergency Management Agency, and the National Security Council, among others. "It was clear to everybody that we needed a cohesive all-of-government strategy to ensure the federal government was positioned to manage these big space weather events," said Murtagh.

In October 2015, NSTC released the National Space Weather Strategy and National Space Weather Action Plan developed by SWORM. The first document lays out six goals: understand the magnitude and frequency of space weather events, fortify the country's capability to recover after geomagnetic storms, prepare for and protect against their effects, refine predictions of their potential impacts on infrastructure, improve the understanding and forecasting of space weather events, and increase international cooperation. The action plan lays out specific steps for agencies to take towards reaching these goals.

All this will cost money, of course. A recent decadal survey from the National Academies suggests that $100 million per year should be spent on space weather over the next ten years. President Obama's 2017 budget request includes $10 million for NASA's support of the space weather action plan.

"Fortunately," said Murtagh, "in space weather there's no real politics; both sides of the House and both sides of the Senate are keen to work together to do something about this issue."

WITTEN continued from page 1

an annual award for APS."

Jones became interested in physics in high school, and he studied the subject as an undergraduate at Northwestern University. But after finishing his degree, he went on to become an entrepreneur, founding Olympic Medical Corporation in 1959. The company manufactured medical equipment, specializing in devices for neonatal care. Natus Medical Incorporated purchased the company in 2006.

"I've always had a great deal of respect for science and I believe that science basically is the driving force behind human progress in civilization," Jones told *APS News*. "I think science is what really leads us forward."

Among Olympic Medical's repertoire of medical devices were tools for the treatment of jaundice in infants. Jaundice is a condition caused by a buildup of bilirubin — a normal breakdown product of red blood cells. Scientists discovered that exposure to blue light helps reduce bilirubin levels. Now, babies are placed under blue lights to treat the condition. "It's a revolution. Today it's routinely treated, but before, babies were dying from it," Jones says. "We were the principal manufacturers of what are called 'phototherapy lights' in the nurseries."

Jones says he's "not a physics buff," as he has been occupied with his business and other interests since his undergraduate days. But he retained his appreciation for the subject. "I think science and particularly physics is really of cumulative, lasting benefit," he said. Jones approached APS about setting up a program to honor basic research in physics. The APS Medal was the result.

Jones contributed $1 million to endow the prize, along with the pledge of an additional $1 million donation from the Jay and Mary Jayne Jones Charitable Remainder Trust.

Jones notes that his training in physics assisted his work with engineers employed by the company. "Every product had to be engineered, so a background in physics was very helpful to me."

CAVES continued from page 3

between geology and physics."

His research group focuses on karst terrains, which are places where dissolution of soluble rock plays a major role in the evolution of landscapes, the formation of caves, and, ultimately the routing of groundwater, he notes. When a cave system interconnects with an aquifer, it presents problems, especially if contaminants are involved. "Contaminants move rapidly without filtration," he explains, "and how and where they go is dependent upon the structure of the caves. So the essential problem is trying to figure out the structure."

The cave is made up of pores in-between and inside rocks, and the way water flows through these systems is dependent upon numerous factors, including the position of the individual cavities, the position of the cave itself in the rock, and how big the holes are, among many other elements. As a cave physicist, Covington has to take a holistic view of the entire cave system in order to map its components, and has to understand how water shapes and reshapes the cave and interacts with the cave's minerals, sediment, and microorganisms. He does this by building numerical models of fluid flow and transport, heat exchange, and chemical variations in the underground lairs. "We look at how the attributes of the cave influence the signals coming out of it," he adds.

The challenge is the complexity of the cave system. "You're never going to understand the whole thing," he admits. "Most of the work we've done is to simplify." So Covington's other focus area is related to better comprehending the processes that form caves. He explores different aspects of mature caves. "We look at the width of a stream in a cave, and seek to answer what controls that width. Can we piece together the story of a cave's development by reading the shapes of the cave passages left over time?" He examines erosion processes, and notes that dissolution of rock versus mechanical erosion of rock combined with movement of sediment can provide clues to the nature of how a cave was formed.

Mathematical models of caves are one thing, but being able to cave is quite another, and it is one of Covington's favorite elements of his career choice. Some of his most memorable experiences include exploring J2, a deep cave at the bottom of a sinkhole in southern Mexico that he helped investigate in 2004. As he describes it, the area was ripe for caves. "We were walking around in the jungle looking for holes." Another team had already identified some possibilities. "It is a slow and painstaking process" to find a cave. After identifying a possible opening, the mapping and exploring begin.

Over three years, the team carefully, and as safely as possible, traversed J2. At one point, they hit an area of the cave that was filled with water. They couldn't continue because they weren't prepared for diving, but over the next three years, the team developed new, lighter-weight diving technology and meticulously trained to be able to dive safely. When they returned to the cave in 2009, they were ready. The cave was very remote and large — in fact, they needed three days just to travel to the sump (the part of the cave that was under water). "It took an entire month just to carry the stuff we needed from the entrance of the cave to the sump to get started." Almost 30 people were involved.

His reward for all the time and hard work was priceless: After diving in and swimming under water for 10 – 15 minutes, they were the first humans to set up camp on the other side of the sump. "I was scared. I was not particularly comfortable underwater in a cave and I wondered if I had gone too quickly through my training," he shares. On the other side of the pool in the cave, he and his friend camped for four to five days. "It's an incredibly memorable feeling." Beyond the sump were large chambers big enough to walk through, more tunnels and a second sump. While his friend dove through a sump to try to find the way onward, Covington sat alone in pitch black darkness for 20 minutes. He felt totally cut off. His friend had some of the diving equipment that Covington needed to exit the cave, and the nearest other people were three days travel and an underwater tunnel away. But that is just part of being a cave scientist.

Covington could have been a geologist, but if he had the choice to travel through time and change his undergraduate major from physics to geosciences, he wouldn't budge. "The skills I have now are incredibly useful, and I wouldn't have been able to get them if I studied geology," he says. "Also, because I wasn't trained in the field I didn't come in with biases about caves. I ask different questions than my colleagues do, which allows me to make a novel contribution."

He is especially drawn to cave physics as a profession because caving "is something where an average person with an average budget can accomplish original exploration," he says. "It's really a curiosity that makes it addictive. The reason I'm a caver is the same reason I am a scientist — it's like a puzzle. It's only when you have that drive of curiosity that you can be successful [doing] either science or caving."

DISPATCH continued from page 3

WASHINGTON OFFICE ACTIVITIES

CONGRESSIONAL VISITS DAY

On January 28, 2016, 40 physicists from across the country went to Capitol Hill on Congressional Visits Day to meet with the staff of 63 offices of the U.S. Senate and House of Representatives. This group of physicists, featuring APS unit leaders and APS president-elect Laura Greene, met with congressional staff to discuss American science leadership, funding of scientific research, and STEM education. Comments from participants after the meetings provided evidence of how important conversations with policy makers can be in motivating members of Congress to prioritize science issues.

MEDIA UPDATE

In the February edition of *Capitol Hill Quarterly*, U.S. Rep. Elizabeth Esty (D-CT) writes about the intersection of scientific research and public policy. The piece notes, "…as our economy's growth increasingly relies on innovation, scientific research and discovery must drive our national policy agenda." Read the entire op-ed: go.aps.org/1QZ3gCY

Panel on Public Affairs

Review of APS Statements: Annually, the APS Panel on Public Affairs (POPA) looks back (in five-year increments) at previously approved statements. The panel reviews statements for clarity, relevance, context, endurance, and whether each still provides outreach and advocacy opportunities for the Society. In 2016, the following seven APS Statements are up for review by POPA: 06.3 Career Options for Physicists; 06.2 Advocacy for Science Education; 01.2 Assessment and Science; 91.5 Reaffirmation of Statement on Scientific Review of Research Facilities Funding; 06.1 The Use of Nuclear Weapons; 01.1 Security and Science at the Weapons Laboratories; and 96.2 Energy: The Forgotten Crisis.

Physics & the Public Subcommittee: A survey, conducted by the American Institute of Physics at POPA's request, focused on overcoming the obstacles of recruiting teachers in the physical sciences. The POPA study committee has begun to examine the data and expects to report its findings and recommendations later this year.

Energy & Environment Subcommittee: A study committee, comprising members from POPA, the American Chemical Society, and the Materials Research Society, has been evaluating the long-term challenges of helium supply and pricing. The committee presented its initial findings at POPA's first meeting of 2016 and is due to deliver a final report on the issue mid-year. The Liquid Helium Purchasing Program has expanded and will support users at a total of 19 institutions in its second year of service. In its pilot year, the program saved users 15% on average and enabled increased reliability in helium delivery. State-based science policy initiatives have also expanded. An internship centered on advancing e-cycling legislation is in place at Northern Illinois University, based on last year's pilot program at the University of Michigan.

National Security Subcommittee: The Subcommittee is considering a proposal for a study on the issues and obstacles associated with the conversion of high-enrichment uranium research reactors to low-enrichment uranium reactors.

APS members can log in and obtain a template for study proposals, along with a suggestion box for future POPA studies: go.aps.org/1QBz8DE

ANNOUNCEMENTS

Editor in Chief

APS physics

APS seeks a highly respected member of the physics community to serve as **Editor in Chief** for all APS journals. Key responsibilities include:

- ensuring the excellence and integrity of APS journal content
- effectively communicating and representing APS journals to a broad range of constituencies
- partnering with APS senior leaders, particularly the Publisher, to articulate and drive a strategic vision for the APS publishing enterprise

Nominations, together with a brief supporting statement, and applications from potential candidates should be sent to **APSEditorinChief@storbeckpimentel.com**.

See the full position description at **storbeckpimentel.com/resources/uploads/institution/APSEiCPD.pdf**

Reviews of Modern Physics

Cavity-based quantum networks with single atoms and optical photons

Andreas Reiserer and Gerhard Rempe

A vision has formed in recent years of the components necessary for a large-scale quantum network. Single trapped atoms can serve as the nodes of this network, with the links established by flying photons that are coupled to the atoms using optical resonators. This review describes progress towards the goal of multinode networks using the current generation of experiments, which have achieved unprecedented levels of atomic qubit control and light-matter coupling efficiencies.

journals.aps.org/rmp

Physics Teacher Education Coalition

PhysTEC recognizes the following institutions for graduating 5 or more well-prepared physics teachers in the past academic year. They are national leaders in addressing the severe nationwide shortage of secondary physics teachers.

The 5+ Club

Brigham Young University (17)
Illinois State University (10)
Stony Brook University (8)
Arizona State University (6)
Boston University (6)
University of Central Florida (6)
Middle Tennessee State University (5)
Rowan (5)
Towson University (5)
University of Arkansas (5)
West Chester University (5)
Western Michigan University (5)

PhysTEC is led by the American Physical Society and the American Association of Physics Teachers.

POLICY continued from page 3

with so many conflicting points of view," she says. "It's super challenging to make incredibly complex phenomena like climate science understandable without losing any of the accuracy."

Science is embedded in so many political issues — climate change, cybersecurity, and nuclear nonproliferation, to name a few — yet so many members of Congress are resistant to accepting scientific evidence, says Rush Holt, a Ph.D. physicist who served eight terms as a New Jersey congressman from 1999 to 2015 and is now CEO of AAAS. "None of them will say publicly they are anti-science, but the fact is most of them have grown up in school being told they are not scientists, and therefore they shouldn't try this at home," he says. "They become uncomfortable with science; they think they can't do it, and they shouldn't try. And [scientists] unfortunately make it harder by saying, in effect, 'Oh, the public is just going to mess this up.'"

Some policy makers seem to treat science with unique distrust. "They'll say, I'm not a scientist, I can't do science, I won't even think about this aspect of a particular issue," Holt says. "Yet they wouldn't say that about international relations. They wouldn't say, I'm not an expert on those other countries, or I'm not going to deal with the parts that deal with public opinion because I'm not an expert pollster or whatever it is. But with science, they will say this."

Ultimately, Holt says, this discomfort with science reflects a need across the country for better science training from an early age. "More than the facts, procedures, and instrumentation of science, we need to teach the essence of science, which is collecting and evaluating evidence to answer questions," he says. "Then, we need to win the trust of the people so that they are willing to accept us as honest brokers of the evidence."

But in the meantime, not all scientists need to work directly in policy to build this trust. Gonski, who serves a graduate student representative on the APS Council and has lobbied Congress on behalf of the organization, doesn't expect "everybody to want to fly down to DC a couple times a year and put in the time that we have." But she does think that scientists need to build better awareness about how their work is funded. That awareness "permeates your entire attitude about outreach," she says, and provides a personal motivation for scientists to communicate more effectively with the public.

Gonski would actually prefer to stay in academia after her Ph.D. But her budding policy experience has given her a broader perspective. "It's easy in physics to get caught up with what you're doing, and it's fun. It's a great part of being a career scientist," she says. But equally important, she says, is to take a step back to think about a scientist's relationship with the rest of the world.

The author is a freelance writer based in Tucson, Arizona.

International Research Travel Award Program

IRTAP provides funding to foster international scientific collaborations between APS members and physicists in developing countries.

Application deadline:
April 15, 2016

APS physics

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of gravitational astronomy. On September 14, 2015, LIGO obtained compelling evidence that they have done just that.

But the experimental facilities are only part of the story. LSC is responsible for extracting the science (data analysis strategies, goals, timelines, results dissemination, education and outreach, and so on) and identifying priorities for R&D and improvements of the observatory. It comprises 945 members from 15 countries (United States, United Kingdom, Germany, India, Australia, Russia, Korea, Italy, Hungary, Brazil, Spain, China, Taiwan, Canada, and Belgium). The LSC governance principles include two elements worth noting: (i) no individual or group will be denied membership on any basis except scientific merit and the willingness to participate and contribute, and (ii) member agreements describe scientific, not financial commitments.

The collaboration is poised to continue growing, as LIGO is only the first node on a powerful network of gravitational wave detectors worldwide. The network includes GE0600 in Germany, the Virgo detector in Italy, and KAGRA in Japan. Following the February 11 announcement, the Indian Cabinet, chaired by Prime Minister Modi, has granted in-principle approval to the Laser Interferometer Gravitational-wave Observatory in India, which will be the sixth node of the international gravitational wave network. This global web will not only produce fundamental knowledge about our universe — knowledge that would be otherwise difficult if not impossible to extract — but will also add further impetus to scientific research across the world. It will foster communications among the scientists themselves but also among nations and governments, funding agencies, and research institutions.

When I recently discussed the big discovery with my colleague Kip Thorne at Caltech, he swiftly mentioned that without LIGO carefully and deliberately morphing into a "big science" project, the chances that it would have achieved success would be much smaller. It was in this spirit that Caltech professor Barry Barish, a master not only of scientific judgment, but also of forming international collaborations, became involved at a critical moment in the development of the project. He proceeded (along with other heroes and talented researchers and engineers across many science disciplines internationally) to build LIGO as a highly complex, big science, international project — now demonstratively successful. Gabriela González, the LSC spokeswoman, enthusiastically presented a talk on the vision and success behind LIGO and that of the international gravitational wave observatory network in the Megascience Global Projects session at the 2016 AAAS meeting.

Science and technology are what led to our globally connected world — a world far more powerful than a set of disconnected nations. It will continue being the case that global science collaboration and worldwide projects will change our perspective of the world, impact our way of thinking and living, and produce knowledge-based cooperative societies of unprecedented capacity.

Maria Spiropulu is a professor of physics at the California Institute of Technology and is chair of the APS Forum on International Physics.

U.S.–LEBANON PROFESSORSHIP PROGRAM

The Académie des Sciences du Liban and the American Physical Society are pleased to support a professorship/lectureship program for physicists in Lebanon and the United States. The program provides support for scientists wishing to visit overseas to deliver a short course or a physics lecture series at a university in the U.S. or Lebanon.

Applications Due: MARCH 30, 2016
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APS physics

The Back Page

Is Physics Open and Accepting for LGBT People?

By Michael Falk and Elena Long

Physicists who differ from the majority by gender or sexuality too frequently face hostility and unnecessary barriers to their participation in our profession. We were recently tasked by APS CEO Kate Kirby to constitute an APS ad-hoc Committee on LGBT [1] Issues (C-LGBT) to "advise the APS on the current status of LGBT issues in physics, provide recommendations for greater inclusion, and engage physicists in laying the foundation for a more inclusive physics community." Here we share our own stories as out LGBT physicists and then discuss our work with C-LGBT.

Michael's Story

Twenty-two years ago, when I was a second-year graduate student, a letter I wrote [2] was published in *APS News*. The APS Council had approved a resolution stating that APS "will not sponsor meetings in any state or locality that discriminates or prohibits protection from discrimination… . Specifically, the Council deplores the passage … of Amendment II to the Constitution of the State of Colorado… ." Amendment II would have prohibited the adoption or enforcement of any law that would protect the civil rights of gays, lesbians, and bisexuals.

To me, as a 26-year-old graduate student who had just "come out" as gay, the APS action was highly significant. It made clear that within the body that represented my future profession there existed individuals who were willing to stand up so that I might participate fully in physics. The letter I sent was in response to letters from three physicists who did not see things in the same light. To them the statement was a matter of APS overstepping its bounds by capitulating to an "arbitrary political agenda." "Doesn't the APS owe more to physicists than to homosexuals?" one inquired, in a casual erasure of my existence.

My letter was my attempt to explain why I found it offensive "to find myself compared repeatedly to alcoholics, pedophiles and practitioners of bestiality and ritual murder" in the pages of *APS News*. I wondered, "Why is it so much to ask that my professional organization would take me into account when choosing where to place its conferences?" But most striking to me in retrospect is the last sentence in which I expressed my trepidation in writing that letter: "I hope this letter does not interfere with my aspirations in physics, or make me a target for those around me who lack the courage to try to understand me."

It is always strange to think back on one's younger self. At the time I was full of passion and anxiety for a future that was, for me, in flux in many ways. Thankfully I had landed in Santa Barbara, surrounded by a supportive advisor and fellow graduate students in a department that had just hired an out gay astrophysicist. Most notable was my office mate, Sora, who faced her own struggles trying to navigate a world that did not always take well to a woman being the smartest and most opinionated person in the room. Sora was equally gifted explaining tough physics problems as she was as a matchmaker, introducing me to my first boyfriend. When I became political, petitioning city hall for a domestic partner registry, I learned that my advisor's wife, a city councilor, was a supporter. In retrospect I cannot really ever repay the universe for the good fortune that landed me in this bucolic paradise, really almost sitcom-worthy, that integrated physics, human connection, and social integration. Even so, I worried that the world of physics beyond this bubble would not welcome me or my contributions.

Elena's Story

It was 2009 when I attended my first APS Meeting, just a year after I had passed my qualifiers and moved to a national laboratory to begin my research. I was loving the work, but concerned about what my opportunities would be if I stayed in physics. Only a few years had passed since I had a research advisor from a research experience for undergraduates program refuse to have anything to do with me after finding out that I was transgender (trans).

The lab I had just started working in had no equal employment protections for LGBT people, and there was no indication that, if I stayed in physics, I would ever be able to get medical insurance that was inclusive of trans-related health care. Moreover, I was struggling to connect with the community of physicists around me, and I was finding the straight male culture inherent in our male-dominated field stifling and isolating.

Before I had moved to the lab, I was vitally connected to lesbian, gay, bisexual, and transgender (LGBT) resources and opportunities on campus. For me, this constituted a "second life" distinct from my studies in physics, and it seemed to me that the two would always be forced to remain separate. Once I arrived at the lab, I was cut off from all of those resources.

Michael Falk

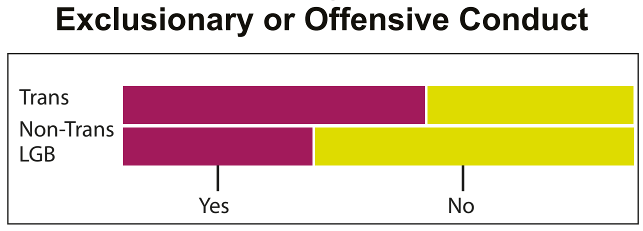
Elena Long

There was only the physics, and nowhere to voice my concerns about becoming successful as a professional physicist who happens to be trans.

I began searching for resources and tried to connect with other LGBT physicists to see if I was alone in the issues I was facing. At the time, I could find only a few online homework help forums where topics like this were broached. When someone would ask if they were the only gay physicist, they were met with multiple pages of replies telling them that it doesn't matter, and that there is no connection between being LGBT and science. A repeated message was that if anyone ever talked about being LGBT in a professional setting that it would hurt their career.

In spite of this, I naively thought that some kind of support must exist. When I attended that first APS meeting, I participated in a lunch seminar hosted by the Committee on the Status of Women in Physics. After the presentation, I asked where I might find resources for LGBT physicists. The room fell silent. Finally, after a long pause, someone quietly offered, "Huh. We never thought of that." As a young graduate student, in that moment, I dreaded that there would never be a place for me in physics.

Percent Reporting Observation of Exclusionary or Offensive Conduct



The climate survey performed by the C-LGBT revealed that a high percentage of LGBT individuals reported observing exclusionary behavior that could range from shunning to harassment. 37% of non-trans LGB individuals reported observing exclusionary behavior and 60% of trans individuals reported such observations. Reporting such observations correlated strongly with considering leaving their institution within the previous year.

Our work with APS

In preparing the recently released C-LGBT report, entitled "LGBT Climate in Physics: Building an Inclusive Community" [3], we held numerous focus group discussions with physicists, worked with the APS Membership department to include a demographic question in the most recent APS membership survey, and carried out an independent climate survey. The results were at the same time heartening and sobering.

This work culminated a process that had started many years prior, instigated to a large extent by Elena Long, the co-author of this Back Page, through her work within the APS Forum on Graduate Student Affairs and starting the independent lgbt+physicists group. The lgbt+physicists organization has focused on addressing issues for sexual and gender minoritie in physics, such as employment discrimination, professional networking and mentoring opportunities, lack of access to health care, and a lack of statistics. Its volunteer members have also created a guide, "Supporting LGBT+ Physicists and Astronomers: Best Practices for Academic Departments" [4].

As our two personal experiences illustrate, the climate for LGBT individuals in physics is highly variable, and this was reflected in the data that C-LGBT gathered. When we asked the 324 LGBT respondents about their level of comfort in their department or division the rate at which respondents noted this to be "uncomfortable" or "very uncomfortable" was significantly different for male (15%), female (25%), gender-nonconforming (30%) or transgender (30%) respondents. Being "out" at their workplace or university correlated significantly with a respondent's level of comfort. Furthermore 22% of respondents had experienced exclusionary behavior that could range from shunning to harassment, and this was significantly higher, nearly 50%, for transgender respondents. Tellingly, 40% of respondents agreed with the statement that "Employees are expected to not act too gay." 45% of respondents disagreed that "Coworkers are as likely to ask nice, interested questions about same-sex relationships as they are about heterosexual relationships." Over a third (36%) of LGBT participants considered leaving their institutions in the year prior to taking the survey.

These responses reinforced many of the accounts we heard during focus groups and in survey free-form responses regarding feelings of isolation, invisibility, and lack of supportive mentorship. The most hostile and harrowing of these were reported by transgender physicists, by those who did not conform to standard gender norms, and by those who carried multiple identities that differed from the majority, e.g. those who are female and bisexual or those who are black and gender-nonconforming.

Since the obligation to hide or minimize sexual and gender difference was a recurrent theme for those facing hostile environments, this has caused many of us on the committee to reflect on the operation of "the closet" in physics. The phrase "to be in the closet," meaning that a part of one's identity is obscured to others, has long been a descriptor of the lesbian, gay and bisexual experience. Similar issues around conformity and "stealth" related to hiding a gender transition also mark the trans experience. Since these differences are not immediately apparent, in the face of social hostility individuals can find it beneficial to hide these aspects of their identity, but at a cost. Being "in the closet" cuts one off from the kinds of support that others routinely expect from their colleagues: social connections, inclusion of important family members in gatherings, understanding in the face of family emergencies or crises, support during trying emotional times, help navigating the conflicts between career and personal motivations. For some this is the devil's bargain one makes to become a working physicist.

In physics, this pressure for LGBT scientists to remain closeted is most often communicated to them by their colleagues as disdain for the importance or relevance of the personal in the context of physics. In response to our membership survey question, posed to 2,596 APS member respondents, approximately 2.5% openly identified as LGBT. Significantly, respondents in the 18 - 25 age range were significantly more likely (16.3%) to identify as LGBT and less likely to choose not to provide this kind of information (6% vs. 14%). Clearly the issue of LGBT identity may presently be both more salient and less taboo to physics students in undergraduate and graduate physics programs than it is to their professors.

Also notable within the written comments was a small but noteworthy number (20) of strongly negative responses to the abovementioned self-identification question on the membership survey. These responses generally fell into two main categories: denying the relevance of the question or objecting to the question as offensive. Whether LGBT students and physicists find our profession a nurturing home for their development as scientists and human beings will, to a large part, depend on whether their advisors, colleagues, mentors, and employers are able to support them as whole people and have the courage to try to understand them.

Michael Falk is a professor at Johns Hopkins University who deploys computational methods to develop physical theories of non-equilibrium processes in materials. He is chairperson of the APS C-LGBT, has served as a member-at-large for the Group on Statistical and Nonlinear Physics, and was a recipient of the APS Nicholas Metropolis Award for Outstanding Doctoral Thesis Work in Computational Physics. He also leads an NSF-funded Math and Science Partnership with Baltimore City Schools, STEM Achievement in Baltimore Elementary Schools (SABES).

Elena Long is a postdoctoral research associate at the University of New Hampshire; she studies experimental hadronic physics with an emphasis on nucleonic spin structure. She is also the founder of the organization lgbt+physicists, serves on the APS C-LGBT and is the vice president of diversity and inclusion for Out in Science, Technology, Engineering, and Mathematics (oSTEM).

References

1. For the purpose of the C-LGBT report, LGBT was taken to refer to persons who self-identify as lesbian, gay, bisexual, transgender, queer, questioning, intersex, as well as other sexual and gender minorities.
2. For copies of the original correspondence, see http://go.aps.org/216SVue and http://go.aps.org/1oWoHyp
3. http://www.aps.org/programs/lgbt
4. http://lgbtphysicists.org/physics_resources.html