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Physicists Who Blog
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Promoting Physics Innovation and Entrepreneurship Education: the PIPELINE Program

By Crystal Bailey, APS Careers Program Manager

APS is proud to announce a new NSF-funded project, PIPELINE, to promote innovation and entrepreneurship education in physics at the undergraduate level. This project will combine efforts of six institutions — Loyola University Maryland, Rochester Institute of Technology, William and Mary, The George Washington University, the University of Colorado Denver, and Wright State University — to develop and disseminate new curricular and co-curricular approaches to physics innovation and entrepreneurship (PIE) education. This project will also advance our understanding of how these practices affect student and faculty attitudes towards innovation and entrepreneurship in physics.

PIPELINE will implement various PIE activities at member institutions during each academic year of the three-year grant, revising approaches (or where appropriate, "swapping" them between institutions) during each iteration, and finally documenting and disseminating the developed curriculum. PIPELINE will also develop research tools for investigating the link between PIE experiences and student and faculty attitudes about innovation and entrepreneurship; these tools can be used by physics departments at other institutions for gauging, monitoring, and improving institutional change around PIE. Throughout the project's lifespan, findings and materials will be broadly shared with the physics community at APS and AAPT meetings, in *APS News* and other publications, as well as on the new project website go.aps.org/2d7AqtL

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First Palestine Advanced Physics School

By Rachel Gaal

The Arab American University in Jenin (AAUJ) recently hosted the 5th Palestinian Conference on Modern Trends in Mathematics and Physics (PCMTMP-V), which is one of the main scientific events in Palestine. Over two hundred students from the Palestinian Territories and abroad gathered over three days to discuss advances in theoretical and applied mathematics and physics. The keynote speakers — Jonathan Ellis of King's College London and Charles Doering of the University of Michigan — gave plenary talks; Ellis spoke on the physics beyond the standard model, and Doering on the 100-year history of the mathematics behind Rayleigh-Bénard convection. Other invited speakers and attendees presented their research to round out the conference.

Students attending the Palestine Advanced Physics School at the Arab-American University in Jenin.

This year, the PCMTMP-V was accompanied by another notable event at AAUJ — in fact, the first of its kind in the Palestinian Territories. The first Palestinian Advanced Physics School preceded the conference, attracting around 30 graduate students from a number of universities in Palestine for three days of instruction. Created by a newly founded international group, Scientists for Palestine, and co-funded by CERN and the Sharing

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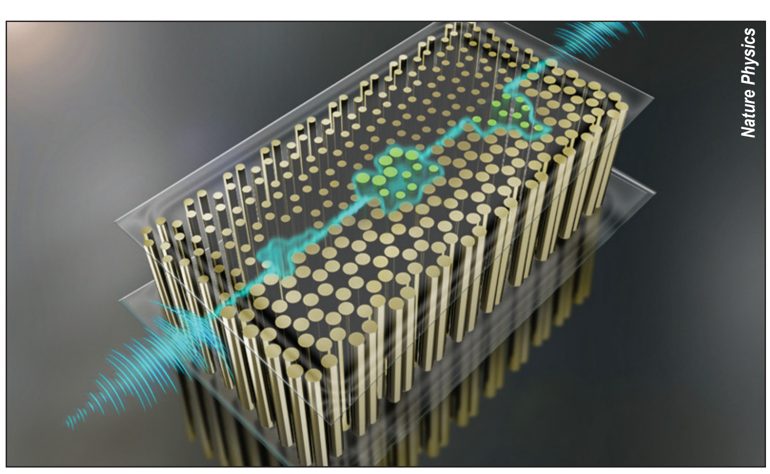
Research News: Editors' Choice

physics.aps.org

A Monthly Recap of Papers Selected by the Physics Editors

On the Edge of "Acoustic Graphene"

Researchers in China have crafted the acoustic equivalent of a topological insulator (TI) that exhibits the quantum spin Hall effect for sound. This is the hallmark of TI behavior in which waves cannot propagate through the bulk of the material but only at the material's edges. He *et al.* have constructed a newer, more robust experimental setup compared to previous studies. As described in *Nature Physics (doi:10.1038/nphys3867)*, their TI is composed of macroscopic stainless-steel rods arranged in air to mimic the honeycomb structure of graphene. Within a constant lattice structure, the radii of the rods, which are analogous to atom radii, are varied to create different regions with an interface that behaves like a TI. By launching sound waves through the material, the researchers observed that the waves propagated via the edge states along the interface. They then carried out experiments to demonstrate the topologically protected nature of such states: the acoustic waves were unaffected even when certain defects were introduced at the interface, like cavities (missing rods), lattice disorder, and bends. This acoustic TI could serve as a model system to study topological phenomena without the complications of conventional solid-state TIs.



Adjacent metal rods of two different radii create an acoustic topological insulator through which sound waves propagate without resistance caused by defects.

Proton Radius Puzzle Widens

The deuterium nucleus — made up of one proton and one neutron — appears to have the same "size problem" as the proton does. In 2010, researchers studying an exotic form of hydrogen reported an unexpectedly small value for the proton radius. Now that same group, the CREMA collaboration, has performed a similar study with exotic deuterium, in which a muon takes the place of the atom's usual electron. The larger mass of the muon means the muonic orbitals overlap with the nucleus much more than the normal electronic orbitals do. This greater overlap makes certain atomic transitions in muonic deuterium extremely sensitive to the radius of the deuterium nucleus. As reported in *Science (DOI: 10.1126/science.aaf2468)*, the collaboration used precision laser spectroscopy to determine the deuterium nuclear radius to be 2.12 femtometers, which is significantly (7.5σ) smaller than previous estimates based on spectroscopy of "nonexotic" atoms, as well as electron scattering. The cause of this size discrepancy — as well as that for the proton radius — has not yet been deciphered, but one tantalizing possibility is a new fundamental force acting between muons and protons.

Digging Out the Qubits

Although quantum computers made from qubits (short for quantum bits) are thought to be the ultimate code crackers, the ability to use and apply qubits is limited by their lifespan (that is, how long

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2016 LeRoy Apker Award Recipients

By Rachel Gaal

Two young physicists have won the 2016 APS LeRoy Apker Award for exceptional undergraduate research: Stephanie Gorczyca of the University of San Diego, and Nick Rivera of the Massachusetts Institute of Technology (MIT). Gorczyca and Rivera will receive their awards at the March Meeting 2017 in New Orleans. The APS Council approved the finalists in mid-September, following the LeRoy Apker Award Selection Meeting in July 2016.

Stephanie Gorczyca

The research carried out by Gorczyca in the Physics and Biophysics Department at the University of San Diego investigated crowding effects on the diffusion and conformation of DNA molecules. Under the supervision of Rae M. Robertson-Anderson, she manipulated sizes, shapes, and concentrations of crowding molecules in solutions embedded with ring or linear DNA. Gorczyca showed that both shapes of DNA molecules undergo topology-driven conformational changes to facilitate movement through the high-viscosity environments. The work uncovered a possible mechanism within DNA that inhibits movement in various biological processes. "Universal scaling of crowding-induced DNA mobility is coupled with topology-dependent molecular compaction and elongation" appeared in *Soft Matter*, published by the Royal Society of Chemistry. She was recently accepted into the University of California, Los Angeles and University of California, San Francisco Doctor of Dental Surgery/Ph.D. programs, where she hopes to continue her research.

Nick Rivera

Working under the supervision of Marin Soljacic, Rivera is a joint Department of Energy / MIT School of Science fellow. Currently a Ph.D. candidate in MIT's Department of Physics, he completed his undergrad research with the MIT Photonics and Modern Electromagnetics Group. He is the lead author on a recently published article in *Science* reporting on this work, "Shrinking light to allow forbidden transitions on the atomic scale," which lies at the intersection of nanophotonics and quantum electrodynamics. Rivera and his collaborators showed theoretically that spontaneous emission of photons can become the dominant transition in an excited system. By using plasmonic excitations associated with the 2D material graphene, the researchers showed that spontaneous emission can be controlled,

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Revised 10/11/2016

Members in the Media

"Debbie was a role model for me – a hero. … The talks she gave were a model of clarity. … She was so famous, but still someone you could talk to very easily."

***Ana Maria Rey**, University of Colorado Boulder and JILA, on the passing of Deborah Jin,* CU Boulder Today*, September 22, 2016.*

"A lot, lot harder. … What did come out was more impressive than I thought would be possible."

*Nobel laureate **Carl Wieman** comparing Deborah Jin's research with his work with Eric Cornell producing the first Bose-Einstein condensate,* New York Times*, September 21, 2016.*

"His deportation without any explanation is something that makes me feel ashamed for my country. … If there is no objective reason for this extreme act, the Brazilian government should revoke the act of deportation and request the French authorities to send him back to Rio."

***Ron Shellard**, director of the Brazilian Center for Physics Research (CBPF), on the deportation of physicist Adlène Hicheur,* Nature*, September 14, 2016.*

"The game is to try to match the mutation in the tumor cells to responding T cells to see if we can figure out which T cell response is caused by which mutation."

***Curtis Callan**, Princeton University, on his collaboration with cancer researchers,* Wall Street Journal*, September 25, 2016.*

"He's a really interesting case. … There are really smart people in all corners of the world."

***James Forrest**, Perimeter Institute and University of Waterloo, Ontario, on his colleague physicist Percy Paul, who grew up in the English River First Nation in northwest Saskatchewan,* thestarphoenix.com*, September 15, 2016.*

"The more I started taking courses at the university, the more I realized that I don't really like math. Computer science is boring. And everything that had to do with the little physics that they forced you to take was very interesting. So I converted completely."

***Or Hen**, Massachusetts Institute of Technology, on becoming a physicist,* dailypress.com*, September 5, 2016.*

"Scientists learn in the lab but are sometimes unprepared for the real world. Our book tells scientists how to find a job, get funding, and get your ideas published."

***Federico Rosei**, Institut National de la Recherche Scientifique, Montreal, on the death of his co-author, plasma physicist Tudor Johnston,* The Globe and Mail*, September 18, 2016.*

"It's a seductive idea to think that human impacts aren't a major driver of climate change."

***Robert Davies**, Utah State University, on policymakers avoiding the challenges of global warming,* thespectrum.com*, September 15, 2016.*

"Biologists and perhaps physicists will understand much better how the brain works. But why something that we call consciousness goes with those workings, I think that will remain mysterious. I have a much easier time imagining how we understand the Big Bang than I have imagining how we can understand consciousness… ."

***Edward Witten**,* Institute for Advanced Study, futurism.com*, August 28, 2016.*

This Month in Physics History

October 19, 1955: Discovery of the Antiproton Announced

Scientists in the early 20th century assumed that a particle's energy must always be a positive number. That changed in 1928, when Paul Dirac formulated an equation to describe the behavior of relativistic electrons in electric and magnetic fields. He suggested that antiparticles could exist as well as particles, each with the same mass as its twin, only with the sign of both of the electrical charge and the energy reversed.

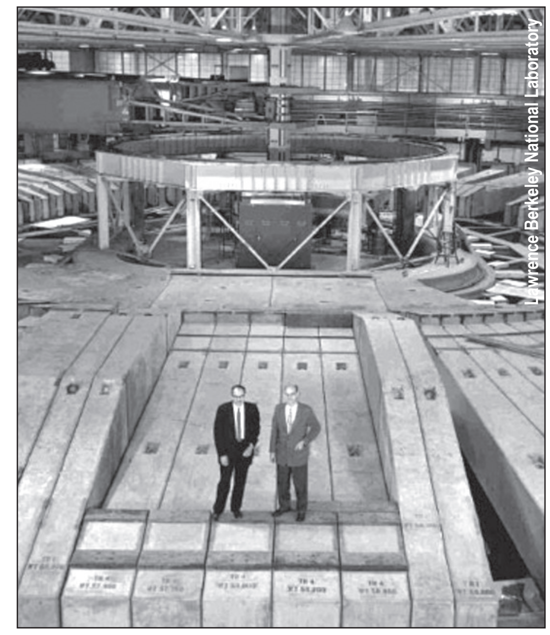
Following Dirac's work, the race was on to find some experimental means of proving the existence of antiparticles — and it took only four years. In August 1932, a young Caltech postdoc named Carl Anderson recorded an historic photograph: the track of a positively charged particle passing through a cloud chamber. It was neither a proton nor an electron traveling backwards; it was an antiparticle, later dubbed the positron. Despite initial skepticism from other physicists, his result was confirmed the following year. The discovery snagged Anderson a Nobel Prize in Physics in 1936, at the age of 31 — one of the youngest people to be so honored. (Dirac won the prize three years earlier.)

The success of Dirac's theory led physicists to conclude that it could also be applied to protons — and that meant there must be antiprotons. But the accelerators available at the time simply weren't powerful enough to create them. So at his "Rad Lab" in Berkeley, California, Ernest O. Lawrence set out to build a synchrotron machine capable of producing the 2 billion electron volts required to create proton-antiproton pairs. It was called the Bevatron, since at the time the unit acronym for a billion electron volts was BeV (now known as GeV).

There were two separate teams assigned the task of hunting for the antiproton. Edward Lofgren led one team, and Emilio Segre and Owen Chamberlain headed up the other. The Bevatron had the high voltage to produce antiprotons. The challenge would be detecting them amid the myriad other particles that would also be produced in the collisions in the ten millionth of a second between the appearance of an antiproton and its annihilation upon contact with a proton. They concluded that they needed to precisely measure two properties to make an identification based on mass and charge: momentum and velocity.

The teams opted to measure momentum using an elaborate system of magnetic quadrupole lenses. When the proton beam collided with the copper target, it would send particle fragments flying in all directions, and only those within certain momentum intervals could pass though the lens system, which deflected any negative particles through collimator apertures and blocked any positive particles.

For their velocity measurements, the physicists used scintillation counters to time how long it took particles to travel between two detectors separated by 12 meters. This would help them distinguish between pions and antiprotons, since the former would cover that distance 11 nanoseconds faster. It was still possible to get two pions mimicking an antiproton signal, however, so the physicists also brought in two detectors of Cerenkov radiation — one using a liquid fluorocarbon as a medium and the other using quartz. The first would measure the velocity of any particles traveling faster than an antiproton, while the second was designed to detect only those particles moving at exactly the predicted speed for antiprotons.



Berkeley physicists Edward McMillan and Edward Lofgren, shown here on the shielding of the Bevatron, which was used to produce antiprotons. McMillan was the co-inventor of the synchrotron.

As one last safeguard against a false detection, there was one other experiment deployed. It involved photographic emulsion stacks to pick up the telltale star-shaped bursts indicative of an annihilation event from a proton-antiproton pair.

The two teams began alternating experimental runs in August 1955, although the Bevatron broke down on September 5, right in the middle of Segre and Chamberlain's second run. Once it had been repaired, Lofgren generously gave them his scheduled beam time so they could complete their experiment. And that run proved to be the decisive one, yielding the first evidence of antiprotons.

In order to analyze all the data from thousands of particle interactions, the teams recruited human operators — such as the wives of graduate students — working with big measuring machines (dubbed "Frankensteins") to follow the particle tracks. The operators used a foot pedal to punch the data into IBM cards. Then early computers reconstructed those particle tracks to calculate the momentum and energy of each one, enabling them to identify which particles had been produced. Finally, the emulsion-stack images were reviewed to verify any annihilation events.

All told, Segre and Chamblerlain's experiment

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Letters to the editor are welcomed from the membership. Letters must be signed and should include an address and daytime telephone number. APS reserves the right to select and to edit for length and clarity. All correspondence regarding *APS News* should be directed to: Editor, APS News, One Physics Ellipse, College Park, MD 20740-3844, Email: letters@aps.org.

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Washington Dispatch

From the APS Office of Public Affairs

POLICY UPDATE
ISSUE: CONGRESSIONAL ACTIONS

With the clock ticking down on the start of the new fiscal year and Election Day, it came as no surprise that November 8 campaign priorities won out over October 1 budget obligations. Congress left town without passing the required set of 12 appropriations bills needed to keep the government operating beyond September 30. Instead, as in almost every year during the last two decades, lawmakers resorted to a continuing resolution that would put federal programs on autopilot and extend existing activities through at least December of this year.

Even passage of that stopgap measure proved politically challenging.

Senate Republicans demanded that the $1.1 billion in emergency funding for the Zika virus be offset with cuts to other programs, and that Planned Parenthood of Puerto Rico be barred from using any of the funds. Democrats objected, and the impasse temporarily threatened a government shutdown.

Sen. Ted Cruz (R-Tex.) insisted on adding a provision to the short-term spending bill that would prevent the White House from transferring oversight of world-wide-web domain name registrations to a Los-Angeles-based multinational private organization known as the Internet Corporation for Assigned Names and Numbers.

Finally, Democratic language to raise the Export-Import Bank loan limit above $10 million ran into a buzz saw of conservative opposition in the Senate. What should have been a well-paved path to an early exit from the Capitol turned into an acre of quicksand.

And those were only the obstacles in the Senate. Across the way, the far-right GOP House Freedom Caucus, the nemesis of the Republican leadership, threatened to hold up passage of any continuing resolution that would allow a “lame-duck” session (i.e., one that meets after the November general elections) of Congress to write a spending bill for fiscal year 2017. They insisted on a resolution that would either carry through the middle of March or cover the full fiscal year.

Desperate to avoid a government shutdown, legislators finally agreed to a December 9 termination date. The internecine battles will likely resume then, unless lawmakers decide that the holidays are more important than partisan jousting and either pass combined appropriations bills (one or several) or extend the continuing resolution until sometime into the new calendar year.

Members of Congress who authorize programs in each chamber arguably made somewhat better although still limited progress. The Senate passed bipartisan bills authorizing science activities housed in the National Institute of Standards and Technology, the National Science Foundation, and the Department of Energy, while the House managed only to pass an Energy authorization bill almost entirely along partisan lines. It remains for House and Senate Energy conferees to try to resolve their differences in conference, which will be a challenging task given the hyper-partisanship in the House.

A House rule — in effect for the last four years — that requires authorizations above current spending levels to be offset with cuts from other programs has made it extremely difficult for lawmakers to take a long-range outlook. The Senate Energy bill, for example, authorizes Office of Science expenditures only one year ahead. In essence, the House rule has made authorizers almost superfluous, except for policy considerations. But there is little chance the rule will be eliminated unless the House changes hands.

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detected 60 antiprotons. The team announced this momentous discovery at a press conference on October 19, 1955, publishing the paper in *Physical Review Letters* on November 1 — just eight days after it had been submitted. Naturally the discovery made national headlines, although a reporter at the local *Berkeley Gazette* declared it a “grim new find,” misunderstanding the nature of matter/antimatter annihilation. Apparently he believed if a person came into contact with an antiproton, that person would explode.

Both Chamberlain and Segre were awarded the 1959 Nobel Prize in Physics for their discovery. As for the Bevatron, it would continue operating for the next 40 years, reinventing itself in 1971 as an injector for heavy ions. The beam officially shut off in 1993 and the structure was finally demolished in 2011.

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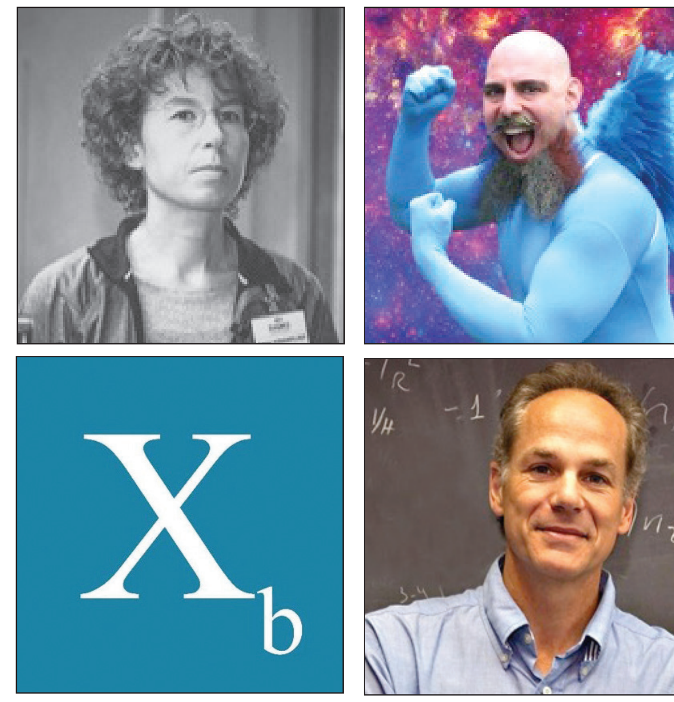
Virtual Think Tanks: Physicists Who Blog

By Rachel Gaal

Physicists typically showcase their research by preparing a journal article or giving a lecture. Blogging about discoveries is not part of the job description, but some physicists choose to dive into this endeavor to answer questions, stimulate creative thought, or to simply have their followers learn what science is all about.

Several APS members are among those physicists who actively blog, and some of their blogs are hosted by mainstream outlets like *Forbes*, *Medium*, and National Public Radio (NPR). No matter the topic, blogging gives science enthusiasts an inside look at what makes these physicists tick, showcasing what are essentially their informal “think tanks.”



Clockwise from upper left: Sabine Hossenfelder of *Backreaction*; Ethan Siegel of *Starts With a Bang*; Marcelo Gleiser of *13.7*; and the anonymous blogger of the *Physics ArXiv* blog.

Marcelo Gleiser: *13.7 - Cosmos & Culture: Commentary on Science and Society*

Named after the estimated age of the universe, 13.7 billion years, and quite possibly a reference to the fine-structure constant, *13.7 – Cosmos & Culture* is NPR’s only opinion blog, focused on sparking conversations at the intersections of science and culture. Co-founder Marcelo Gleiser, a cosmologist, treats *13.7* as a constructive platform to talk about spirituality, human culture, and everyday science.

Specializing in astrobiology, cosmology, and nonlinear physics, Gleiser teaches at Dartmouth College, where he is a professor of physics and astronomy. As the director of the Institute for Cross-Disciplinary Engagement at Dartmouth, Gleiser believes the general public should actively discuss scientific discoveries to promote awareness and cultural understanding.

Besides his collection of philosophical science books and his appearances in science documentaries, Gleiser has a constant presence on *13.7*, where he regularly contributes his thoughts on a number of topics. NPR launched *13.7* in 2009, featuring Gleiser, along with astrophysicist Adam Frank, who also is a regular contributor.

Many of *13.7*’s commentaries are geared toward how our culture perceives attributes of science — like our existence in three spatial dimensions — but some delve into religious topics, current hot topics in science (including scrutiny of new physics beyond the Higgs boson), and deep-think dialogues, including the possible end of knowledge itself. No matter the topic, Gleiser and other contributors keep readers on their toes, urging them to discover unseen connections and to consider the culmination of science through different philosophical viewpoints. His first blog post, titled *Science For A New Millennium,* discussed the invention of science itself, connecting its history to “the same curiosity that has moved our collective imagination for thousands of years.” Expressing his excitement for the launch of *13.7*, Gleiser stresses the importance of the blog, claiming it to be a “wonderful opportunity” to be a part of and to share in the ongoing conversation with readers around the world.

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International News

The European Scientific Advice Mechanism Puts Science at the Heart of Policy

By Rolf-Dieter Heuer

In January 2014, the European Commission President-elect, Jean-Claude Juncker, triggered outrage among Europe’s scientific community when he chose not to renew the role of Chief Scientific Advisor to the Commission. At the time, I remained cautiously optimistic and urged the community to wait and see what Mr. Juncker would propose instead: I could not believe that he would simply rip science out of policy making. My optimism proved to be well founded, since one year into his mandate, in November 2015, the Commission launched the Scientific Advice Mechanism (SAM).

The SAM is, in my opinion, a much more robust method of providing scientific advice than placing the entire responsibility on the shoulders of one individual. When Mr. Juncker did away with the role of Chief Scientific Advisor, it was against a backdrop of sometimes-vitriolic attacks on the incumbent, Anne Glover, a vocal proponent of genetically modified organisms (GMOs). In such an environment, it became impossible to have a rational public debate on the subject, and whatever we may feel about GMOs, they deserve a rational, evidence-based debate in the policy arena. By moving away from reliance on a single advisor to a mechanism that allows for a much broader, structured consultation among the scientific community, the kind of debate needed becomes not only possible but inevitable.

Rolf-Dieter Heuer

So what is the SAM? To answer that question, it’s first necessary to understand how science is organized in Europe. Much science in Europe is conducted at the national level, with national communities represented by national academies and learned societies. In addition, there are international bodies, such as the European Physical Society. The European Commission has its own research capacity in the form of the Joint Research Centre (JRC), which carries out research relevant to policy making. Recent JRC reports cover subjects from the robustness of natural ecosystems in the face of climate change to the safety of inks used in tattoos (the latter reflecting the growing popularity of tattoos among the young).

The SAM draws on all this expertise, working through a high-level group of seven scientific advisors supported by a strong secretariat in Brussels. I have the privilege of being one of the seven by virtue of my longer-than-I-care-to-admit career in particle physics and the management of big science. Rather than working alone, I share the responsibility with a molecular biologist, a sociologist, a materials scientist, a meteorologist, a mathematician, and our chairperson, a microbiologist. Together, we see things from all angles, and we have access to a vast range of expertise.

The way it works is via a two-way flow of information. We are asked by the Commission to provide scientific advice for policy

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Motivation for this project stems from the fact that 90 percent of physics students, including half of all Ph.D. recipients, find employment outside of traditional faculty positions — yet there are very few experiences incorporated into the standard undergraduate physics degree which explicitly help to prepare students for these career eventualities. Examples include relating physics content to its real-world applications, building students' communication skills, or familiarizing students with basic business concepts, both of which are important for successful private sector careers. It has been shown that [1] physics programs which provide engaged learning environments focused on future career development have higher retention rates and improved student experiences, and that future employability is an especially important factor for students from underrepresented groups when choosing a major [2, 3]. Therefore, a program that incorporates workforce-relevant training into the curriculum could lead to better enrollment, retention, and diversity of new majors, as well as generating more workforce-confident graduates.

At the same time, by its very nature physics research prepares physicists to be generalists. Most of the world's greatest game-changing technologies (e.g. the transistor, the laser, medical devices, and the fiber optic cable) have originated in the minds of physicists, who are able to draw upon a deep understanding of the physical world to create new, out-of-the-box solutions which in turn lead to new technologies. Widespread incorporation of technology-focused experiential learning spaces in physics departments will leverage students' versatility, curiosity, and creativity, and allow them to apply that deep knowledge to addressing important human needs.

Despite the many advantages of incorporating more workforce-relevant activities into the physics curriculum, there are a variety of challenges to widespread adoption of PIE practices. These include (1) a lack of faculty awareness of actual employment outcomes for physics graduates, and therefore limited understanding of the need for experiences relevant to a non-academic career path; (2) discomfort with incorporating entrepreneurial content because it seems foreign to those with purely academic backgrounds; and (3) a lack of institutional buy-in, such that adding a new course, track or facility seems too ambitious for many departments. PIPELINE hopes to address these challenges by involving physics faculty who have already built successful entrepreneurship programs (e.g., at Case Western and Carthage College), so that the development of PIPELINE materials and practices are guided by well established innovation and entrepreneurship expertise. Also, the project will develop approaches that are diverse in terms of overall resource and time commitment required to implement, so that future adopters can identify and use models that best fit their own resources and needs.

But perhaps the greatest obstacle to widespread adoption of these practices is the sense that PIE adoption is tantamount to undermining physics as a "pure science," seeking to transform it into a "vocational" field. However, these approaches are intended to build upon, rather than replace, "traditional" physics education in that they can be easily integrated into existing courses or added as co-curricular activities. To be effective teachers and mentors, most academic physicists must learn something about "entrepreneurial" subjects like project management, resource management, funding, and intellectual property. By integrating PIE material into the physics discipline, we would not only be supporting the vast majority of our students destined for the private sector, but also the small percentage who will become permanent academic physicists as well.

By supporting the widespread adoption of practices which explicitly promote innovation, career confidence, and career preparedness among physics majors, PIPELINE has the potential to improve student learning and career outcomes, and to elevate the profile of private sector and entrepreneurial paths as legitimate career trajectories for physics faculty and students. These changes will not only positively impact physics as a discipline, but indeed the entire STEM workforce. Physics faculty who are interested in learning more about PIPELINE can visit the project webpage, go.aps.org/2daD11M/, for information about member institutions, links to join the PIPELINE mailing list, and announcements about upcoming PIPELINE sessions and conferences. Additional questions can be directed to Crystal Bailey (bailey@aps.org).

[1] 1.R. Hilborn, R. Howes, and K. Drane, "Strategic Programs for Innovations in Undergraduate Physics: Project Report," The American Association of Physics Teachers, College Park, MD, January 2003.2.

[2] S. J. Basu, "How Students Design and Enact Physics Lessons: Five Immigrant Caribbean Youth and the Cultivation of Student Voice." *Journal of Research in Science Teaching*, vol. 45, no. 8, pp. 881 – 899,2008.3.

[3] S. J. Basu, A. C. Barton, N. Clairmont, D. Locke, "Developing a framework for critical science agency through case study in a conceptual physics context." *Cultural Studies of Science Education*, vol. 4, no. 2,pp. 345 – 371, 2008.

Atomic Physicist Loses Battle with Cancer at Age 47

Deborah S. Jin, adjunct professor of physics at the University of Colorado Boulder, and a Fellow at JILA (a joint institute of the National Institute of Standards and Technology and the University of Colorado), died on September 15, 2016.

Considered by her colleagues to be a pioneer in ultracold atom and molecule research, Jin had received numerous awards, including a MacArthur Fellowship, the APS Maria Goeppert-Mayer Award, the APS I. I. Rabi Prize, and the Isaac Newton Medal of the Institute of Physics. She was a Fellow of the APS and a member of U.S. National Academy of Sciences.

"To those of us who have had the privilege to know Debbie Jin as an amazing and accomplished scientific colleague and friend, this news is absolutely devastating," said APS CEO Kate Kirby. "Her passing leaves a gaping hole in our physics community and in our hearts."

Jin received her A.B. from Princeton in 1990 and her Ph.D. in physics from the University of Chicago in 1995. She was involved in the early work at JILA in ultracold atom research and Bose-Einstein condensates with Eric Cornell and Carl Wieman. She turned to the study of ultracold fermionic gases and in 2003 her group made the first fermionic condensate.

"Debbie, quite simply, changed cold atom physics in wonderful and lasting ways whose importance cannot be overstated," her NIST colleague and Nobel laureate William Phillips wrote in an email. "Her pioneering of degenerate Fermi gases, paired Fermi condensates, the observation of the BCS-BEC crossover, and so much more, enriched the field and all of us."


JILA

Deborah Jin

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Sabine "Bee" Hossenfelder: *Backreaction*

Hosting a pool of questions and vignettes, Sabine Hossenfelder's personal blog *Backreaction* offers original thoughts and ideas based upon her experience as a theoretical physicist. Known through her blogger pseudonym "Bee," she isn't afraid to speak her mind, candidly stinging others in her writing; Hossenfelder uses *Backreaction* as a gateway to allow followers to know her philosophical side, rather than solely her track record within academia and research.

Currently a research fellow at the Frankfurt Institute for Advanced Studies in Frankfurt, Germany, Hossenfelder aims to uncover new physics beyond the standard model — the current theory of fundamental particles and forces — and find new evidence of quantum gravity. After receiving her Ph.D. in theoretical physics, Hossenfelder conducted research as a fellow at many institutions, including the University of Arizona and the University of California, Santa Barbara. She frequently publishes on topics like black holes and quantum gravity, while also writing as a freelancer for major publications and other science blogs.

Created in 2006, many of her posts reflect her interest in the sociology of science, like the similarities of quark-gluon plasmas and bananas, or the consensus definition of the big bang. Others simply address news within the physics community, or try to explain complex subject matter. In line with the personal flavor of *Backreaction*, Hossenfelder occasionally offers unadulterated opinions. Her posts often include tags like "rant," "humor," or "random."

Recently discussing the "nightmare scenario" of the Large Hadron Collider (LHC), following the demise of the 750 GeV "diphoton" bump, Hossenfelder expresses her worry that scientists will "fail to learn from failure." Asserting that particle physicists "are playing today by the same rules as in 1973," around the time the Standard Model was created, she feels no shame in challenging her followers' opinions, stirring up both support and controversy over the future of particle physics in the comments of her posts.

Ethan R. Siegel: *Starts With A Bang*

"The Universe is out there, waiting for you to discover it." The tagline for this popular blog, authored and edited by astronomer Ethan R. Siegel, embodies the idea of scientific discovery and the fascination that goes along with the story of the universe. While Siegel himself writes much of the content, he hosts a number of physicists and science writers on his blog, including Sabine Hossenfelder from *Backreaction*, Jillian Scudder, author of the Q&A platform *Astroquizzical*, and Paul Halpern, author of multiple science books and articles.

Siegel has become a sizable presence in scientific communications: At the beginning of his career in academia and research, he moved toward the educational side of science, writing as a columnist for NASA's *The Space Place*, and recently publishing a book geared toward budding astronomers — *Beyond the Galaxy: How Humanity Looked Beyond Our Milky Way and Discovered the Entire Universe*.

Created in 2008, *Starts With A Bang* was hosted on *ScienceBlogs*, until the mainstream outlet *Forbes* picked it up in 2016. Siegel's stories capture a variety of audiences with his passionate approach, and he won the 2010 Physics Blog Award from the Institute of Physics, and a Charm Quark writing award winner from *3 Quarks Daily*.

In the blog's monthly podcasts for followers, he feasts on topics like dark energy, interstellar travel, and whether there is life on Mars. Written posts embrace physics and astronomy themes (like why some galaxies appear "dustier" on one half than the other), and encourage followers to get involved in discussion. The featured "Ask Ethan" posts — recently, for instance, answering the question of where exactly the big bang occurred — showcase inquiries from fans around the world. Stunning cosmic pictures flood the homepage, further drawing in a curious audience.

@KentuckyFC – *The Physics ArXiv Blog*

Concealed behind the fast-food-themed twitter handle @KentuckyFC, *The Physics arXiv Blog* is an independent science news outlet covering the latest and greatest papers submitted through the open-access preprint server, arXiv (although the blog is independent). arXiv.org is hosted by Cornell University, and contains thousands of submitted mathematics, physics, and technology research papers, with monthly submissions reaching over 8,000.

Because of arXiv's popularity, @KentuckyFC's prime goal is to sort through weekly submissions and write brief pieces for the general public on papers that appear in the preprint server. Started in 2007 on the *The Physics ArXiv* blog, the coverage was picked up by mainstream media and regarded highly — particularly by *Wired.com*, which called it "the web's best physics blog" in 2008. Only a few years passed before *Technology Review*, published by the Massachusetts Institute of Technology, picked up the blog in 2009 and transitioned its content to more technology- and computer science-focused posts. While The *Physics arXiv Blog* still exists on *Medium*, most posts are featured on *Emerging Technology from the arXiv*, which is part of *Technology Review*.

For instance, prototype WiFi-enabled contact lenses seem impossible to decipher if one is not familiar with biomedicine or computing science. *Emerging Technology from the arXiv* takes a crack at explaining this technology to the layperson, taking into account the strange feats that go into these technologies, (like converting Bluetooth frequency to WiFi frequency). Chock-full of intriguing submissions, like the future of real estate on the moon, or the strange correlation between major aircraft accidents and humans' morbid interest in their details, the contents of @KentuckyFC's posts always include a straight break-down of what you need to know from these papers.

No matter the subject, the secret formula for a successful science blog seems to hinge on triggering the imagination. Discussing where science has been and where it's headed, an effective blog draws in readers of all backgrounds — eager to learn the thoughts behind the people immersed in the daily life of a scientific researcher. For more physics blog sites, see the online version of this article at aps.org/apsnews

Profiles in Versatility

Q&A with Jürgen Kluge

By Alaina G. Levine

Each year, a group of Nobel Laureates in physics and chemistry meets with about 400 early career scientists and engineers from over 80 nations. This conference is known as the Lindau Meetings, and *APS News* had the opportunity to talk with Jürgen Kluge, the new Chairman of the Foundation Lindau Nobel Laureates Meetings.

Kluge, who has been associated with the Meetings since the early 2000s, worked for McKinsey & Co. for 25 years, where he concentrated his efforts in the automotive, mechanical engineering, electronics, utilities, and telecommunications industries. He has served on numerous boards of directors for international companies, and currently is a senior advisor at Bank of America Merrill Lynch. His Ph.D. is in experimental physics, and he is an honorary professor of mechanical engineering at Technische Universität Darmstadt in Germany. (This interview has been edited for length and clarity.)

Jürgen Kluge

AGL: Why did you become involved in the Lindau Meetings?

JK: I became involved by Wolfgang Schurer, my good friend and predecessor, basically 10 - 15 years ago. The meeting had problems: financial, organizational, and so forth. Wolfgang had to fix it and he asked me if I could help. I helped recruit a few sponsors, for example Siemens, who is still a good friend of the meeting, and a few others, like the Mars Corporation. With Wolfgang's efforts and my little help, it turned around and became stable and much better and now it is what it is.

AGL: What has been and will be the legacy of Lindau?

JK: It's called the Lindau Nobel Laureates Meeting but it should rather be called the young scientists meeting. Priority number one is the young scientists, and frankly that's why the Nobel Laureates come here. They come here to meet the young scientists, to help them, mentor them, coach them, talk to them, and exchange ideas. They are excited by them because they see their mirror image and it makes them really happy. The second thing is here they meet the other Laureates. It's like seeing family and friends.

AGL: Why is networking such an important aspect of this conference? Why does it underscore everything you do?

JK: Because networking is probably the most value added activity you can do in a week. Inviting one young student, it costs us X but the value created scales with X squared. We have 30,000-35,000 alumni from the last 66 meetings and we will get them on the database and try to get them involved on a regular basis. These are the best and the brightest. So why not leverage that?

AGL: What advice do you have for the early career scientists who attend Lindau, in regards to interacting with the Nobel Laureates?

JK: They shouldn't be shy. The Nobel Laureates aren't shy. They are amazingly normal people (laughs). In a sense they are super good and they know they are super good. They cruise with weightless speed. I like it relaxed. The Nobel Laureates like it relaxed. So the young people shouldn't be shy. They approach them, they take photos. Selfies are the thing of the day and they don't mind. They even sign copies of books. And they are approached for advice. That's what it's all about.

AGL: How has the Lindau conference changed over the years, as science and technology has advanced in different directions?

JK: Standstill is not an option; we have to make it contemporary, without sacrificing the quality and eternal values. But the main purpose is not changing. Young scientists and Nobel Laureates 50 years ago and in 50 years will be the same. So that's enduring. To engage the sponsors, we invented something called "the innovation forum" as a pre-meeting. This time we had 30 CEOs and CTOs, for example from Siemens and Novartis, and 12 Nobel Laureates, and Vint Cerf [one of the originators of the internet who was at Lindau in an exchange with the Heidelberg Laureate Forum]. We had discussions about quantum computing and artificial intelligence and self-driving cars. The topics have to be current.

AGL: What else are you interested in?

JK: I drive race cars from time to time, which teaches you discipline, otherwise you hurt yourself. I also do charity. 10 years ago I helped found Little Scientists' House (now supported by the Siemens foundation) to support natural science experiments in kindergartens. We wanted to do something covering the whole country in Germany and now we are in 28,000 kindergartens, doing natural science experiments in classes. My dream is when I am really old and I'm going to die, there will be a Nobel Prize Laureate and he will be asked "Where was your first contact with science?" and he will say in the Little Scientists' House.

AGL: How did your work at McKinsey prepare you for your role with Lindau?

JK: In consulting, the approach I took was always a scientific approach. First you see a problem, then you need a coordinate system to describe it. That's the act of creativity and where you need experience, to find a coordinate system that's suitable for the problem you have. [As a physicist], I look at problems in that structured way.

AGL: That's why I think physicists are particularly well-suited for …

JK: Every problem! Exactly. We are so lucky in Germany with Angela Merkel that in times of crisis, we have a trained [physical chemist]. A skill that I have is to explain difficult things in a simple way that normal people understand; to quote Einstein, as simple as possible, but no simpler.

AGL: At this conference what were you especially excited about? Were there certain Laureates you wanted to meet?

JK: Steven Chu is always a delight. I met the guy who wanted to hire me (as a postdoc), Ted Hänsch; he's a super guy. He's so pragmatic and he's kind of a businessman. I like him. But I like all of them.

AGL: Going forward, what can we expect next year?

JK: It's just a superbly organized, beautiful meeting in a superb setting, carried by the goodwill of nearly everyone here. So I would be a fool to make dramatic changes. I will make small changes. The Innovation Forum will be renewed and even better. It will be even more global. We now have 83 or so nationalities. We will go for even more people from all over the world. We are very engaged with Africa. And we usually sign Memoranda of Understanding, and this time, we signed MOUs with Pakistan, China, South Africa, and the American University in Beirut.

AGL: Anything else you'd like to share about Lindau?

JK: There's an old saying: If you want people to say that you are funny, don't tell them you're funny, tell them the joke. With Lindau, I hope you can sense and embrace the spirit and I hope it radiates for itself. It's a piece of art in a sense. All small pieces have to fall in place for the mood to be created here.

The author expresses appreciation to the organizers of the Lindau Nobel Laureates Meetings for a partial travel fellowship to attend.

APS Historic Sites: Oak Ridge National Laboratory

APS honored ORNL's Holifield Radioactive Ion Beam Facility as a Historic Physics Site with a plaque on July 25, 2016. The Holifield Radioactive Ion Beam Facility and its predecessors, the Oak Ridge Isochronous Cyclotron (ORIC) and the Holifield Heavy Ion Research Facility, supported five decades of nuclear physics and astrophysics research at ORNL. At the plaque ceremony, from left to right: Alan Tatum (ORNL), Jim Ball (ORNL), Johnny Moore (ORNL), Paul Halpern (Chair of APS HIstoric Sites Committee, University of the Sciences), Alfredo Galindo-Uribarri (ORNL), Laura Greene (APS President-Elect, Florida State University), Mark Riley (Florida State University), and Jim Beene (ORNL).

Lindau: The Day I Got the Nobel Prize

By Alaina G. Levine

So I was minding my business at a conference in Bavaria this summer when something rather bizarre occurred. I got the Nobel Prize in Physics.

Allow me to explain. For the last three score and six years, the tiny hamlet of Lindau, Germany has played host to the world's most dense aggregation of brainpower. The Lindau Nobel Laureates Meetings take place here annually, in which multitudes of Nobel Laureates and hundreds of hungry young scientists from over 80 countries in a particular field flood onto this island town to do what they do best: talk about science with scientists.

I first attended this conference four years ago, the last time it focused on physics. That was a mind-blowing adventure, because never had I been around so many Laureates in one place. But being that it was summer of 2012, there was also another pinch-me moment that took place that year: the Higgs Boson was announced.

So having had a taste of Lindau, I knew what to expect this year: brilliance, brilliance, creativity, and brilliance. There are formal lectures given by the laureates in the morning, and then master classes and semi-private meetings that take place between the Laureates and the students in the afternoons. As a journalist, I can only attend the "public" events, so as much as I would have liked to send a drone in to check out what atomic physicist and former U.S. Secretary of Energy Steven Chu was saying to the kids, I maintained decorum and relied on the occasional Snapchat from carefully sourced insiders.

At this year's meeting, I spent the week interviewing various laureates, including Brian Schmidt, Dan Shechtman, and Bill Phillips, all gracious and enthusiastic. I attended lectures by Roy Glauber, who walked us down memory lane of the days with Feynman and Oppenheimer, and went to press conferences concerning migration in science, women in science, and

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Klaus von Klitzing sharing his physics Nobel prize with Alaina Levine

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— as opposed to policy advice for science — on a range of specific questions. At the moment, we are looking at cybersecurity and CO_2 emissions from light commercial vehicles. Before delivering our advice, we will consult any relevant research being carried out at the JRC, and interrogate Europe's national and international academies and learned societies on the scientific evidence they are able to provide. As an example of the day-to-day work we do, at an upcoming workshop in Vilnius, I will be the rapporteur on secure digital identities for a single digital market in Europe, which will provide valuable input to the cybersecurity question.

As well as responding to specific requests from the Commission, we will also provide advice on subjects that our combined experience and expertise allow us to identify as important potential meeting points for science and policy over the long term. We're currently examining a variety of interesting topics.

Scientific research is one of the greatest successes of the European project. Over the years, the European Commission's Framework programmes have catalyzed cross-border research in Europe, leading to the establishment of a genuine research area across the continent. This was the reason for my cautious optimism back in 2014, and I'm very pleased that my instinct proved to be correct.

In establishing the SAM, Mr. Juncker has taken the provision of independent scientific advice to the next level, acknowledging that science is essential to policy making. Science is everywhere. It permeates every aspect of modern life, and it is to science that we must turn when we address the major societal issues facing the world and shaping our future. Issues such as climate, energy, food, and water are challenging the way we inhabit and share this planet. They all present major hurdles to overcome, and none can be resolved by policy alone. To find a sustainable solution for each of them requires science. And for policy makers to steer the right course, they need access to clear, level-headed advice on subjects that frequently elicit an emotional response. The SAM provides the mechanism for that to happen.

I am thoroughly enjoying my first year of service on the SAM's group of seven. It's still early days for us, and to paraphrase our chairperson speaking at our last meeting during this year's EuroScience Open Forum conference, the SAM is still a child just learning to walk. Nevertheless, I think we're learning fast, and the longer I serve, the more convinced I am that Mr. Juncker and the Commission have done both Europe and science a great service by establishing such a well thought-out, well structured and robust mechanism for delivering independent scientific advice to policy making.

Rolf-Dieter Heuer is president of the German Physical Society and is the former director-general of CERN.

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Knowledge Foundation, the school provided master's-degree-level students with activities and overview lectures led by internationally recognized experts, shedding light on recent research developments and opportunities within modern physics.

The various lectures covered topics in prominent research, ranging from symmetry breaking to modern particle physics, as well as recent research at the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME). Presented with a plethora of subjects, the students were exposed to both familiar and new areas of research, promoting possible collaboration in the future. CERN recently signed an agreement with the Palestinian Territories that will let Palestinian researchers join the ATLAS experiment. Those involved hope to get more scientists in the lab by fostering scientific collaboration and better relations in the region, which the school effectively accomplished.

"The school was a great success," wrote David Marsh of the University of Cambridge, in an email to *APS News*. He served as one of the international organizers of the school, along with Nabil Iqbal (University of Amsterdam), Mario Martone (University of Cincinnati), Andy O'Bannon (University of Southampton), and Kate Shaw (The Abdus Salam International Centre for Theoretical Physics).

"We organizers and the lecturers were very happy with the outcome of the school, [and] the international reception from fellow scientists [is] overwhelmingly positive. [This] has been a great encouragement to us all to continue our work with supporting the development of science in Palestine," Marsh noted.

The students in attendance felt likewise — through immersion in problem-solving sessions and applied particle physics tutorials, the school offered them opportunities that would normally not be part of their regular university curricula.

A number of female physics students traveled to AAUJ to attend the advanced physics school.

The Facebook page of Scientists for Palestine featured brief statements of select students to raise awareness of the successful and inaugural event.

"Being at the first Palestinian Advanced Physics School was a wonderful experience," comments Waad Awad, a student working on her master's degree in physics at Birzeit University and attendee of the school. "We feel lucky to have a chance to improve our physics knowledge … [meet] scientists from all over the world … and now we know about [potential opportunities and] training at SESAME or CERN!"

Falastine Abu Saif, also an attendee of the school, and a physics master's degree student at An-Najah National University, emphasizes her take on the school's impact: "It is great to hear lectures directly from world experts and connect with them, and it's the most helpful way to get involved. … [Palestine has] plenty of potential, and very smart people. We just need more support and encouragement," she said in her interview.

While the students and organizers alike benefited from both excursions, some students were unable to participate due to travel restrictions imposed by the Israeli occupation of Palestine. Students from Gaza were not granted permission to travel to the meetings, which prevented one student from attending the school, and also prevented two scientists from giving their talks at PCMTMP-V. All three individuals are from the Islamic University of Gaza and requested they not be identified.

"Access to higher education is a human right, and it is deeply regrettable that this right is not respected by the ongoing Israeli occupation," stated Marsh in an email. A statement by Scientists for Palestine, released at the end of July 2016, asserted the organization's position is to ensure equality of human rights despite the restrictions.

"Despite the hardships caused by the occupation, science in Palestine continues to grow and strengthen its international connections. Scientists for Palestine will be proud to continue to support this development," the statement said. To overcome the imposed travel restrictions, Scientists for Palestine broadcast the school's program to the Islamic University in Gaza.

When contacted, the Israeli government refused to comment on the matter.

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WASHINGTON OFFICE ACTIVITIES

ADVOCACY

At the 2016 APS April Meeting and the Division of Atomic, Molecular and Optical Physics meeting, 652 attendees contacted Congress about the priorities of the physics community, prime among them sustained science funding. At the Physics Teacher Education Coalition (PhysTEC) site leader meeting on July 17, 2016 in Sacramento, APS Government Relations Specialist Greg Mack held a workshop focused on advocacy for state funding of PhysTEC sites via the Every Student Succeeds Act, which became federal law in December 2015, replacing the Bush era "No Child Left Behind" act.

As a benefit to APS members and others in the physics community, visits by APS Washington office staff to Wisconsin, Ohio, and Tennessee in the second half of the year have highlighted the importance of advocacy for physics. If you'd like us to visit your home state and provide resources for grassroots advocacy, contact Greg Mack at mack@aps.org.

MEDIA UPDATE

APS Director of Public Affairs Michael S. Lubell published an op-ed in *The Hill* on September 9 highlighting the destructive impact of congressional budgetary dysfunction on science. Read the piece at go.aps.org/2daDZer

Piali De, co-founder and CEO of Senscio Systems, authored a guest editorial September 2 in the *Vermillion Plain Talk* in South Dakota on the link between scientific research and innovation. Read the editorial at go.aps.org/2daEBRx

APS member Mina Hanna, a software consultant at Synopsys, published an op-ed in *The Houston Chronicle* on August 23, arguing that science should not be politicized, as it benefits all Americans. Check out the op-ed at go.aps.org/2daEx4b

Have something important to say? APS Members have a resource in Press Secretary, Tawanda Johnson. Contact her with your story at tjohnson@aps.org.

APS PANEL ON PUBLIC AFFAIRS ACTIVITY

APS, in partnership with the American Chemical Society (ACS) and Materials Research Society (MRS), recently launched a first-of-its-kind website, connecting researchers who use liquid helium with vendors of equipment that reduces helium consumption. The website is conserve-helium.org

APS is hosting the website in response to recommendations included in the recently released Panel on Public Affairs report, "*Responding to the U.S. Research Community's Liquid Helium Crisis: An Action Plan to Preserve U.S. Innovation*." The report is available at go.aps.org/2daGI7w

The report, produced in collaboration with ACS & MRS, outlines the importance of liquid helium to the U.S. research enterprise and highlights the issues currently confronting researchers in the face of increasing prices and unreliable supply. It offers a series of actionable recommendations that could have a transformative effect on the ability to maintain a ready availability of helium. The website should prove beneficial to researchers considering solutions to the liquid helium dilemma.

Website visitors can quickly learn whether investing in new equipment, which either dramatically reduces or eliminates their helium use, might make economic sense for them. The website provides contact information for multiple vendors that specialize in systems that recycle helium and/or are cryogen-free. The website also enables researchers to submit contact information and have vendors reach out to them directly. Additionally, the website includes information on various helium conservation technologies. For more information, visit conserve-helium.org

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extending the spectrum of optical emitters.

Gorczyca and Rivera will each receive an award stipend of $5000, and their departments will receive an additional $5000 each to support undergraduate research.

Learn more about the LeRoy Apker Awards at go.aps.org/17NMsc2

ANNOUNCEMENTS

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artificial intelligence. I ate dinner with the delegation of students from the States, which was one of the largest contingents there. I sat in on panel discussions relating to particle physics and education. I learned about leadership from a physicist's perspective during a breakfast sponsored by McKinsey & Co. and featuring Schmidt, who this year was named vice-chancellor (essentially the president) of Australian National University.

Lindau is filled with what I can only describe as odd experiences, or essentially "classic" Lindau moments. A moment like when Phillips, who loves when students ask him questions about physics, was mobbed behind a piano at the evening poster session. As I watched I noticed that the more animated and happy Phillips became, the more the students' confidence blossomed and the more they engaged him. This also led to more pupils being drawn into the vortex, unable to escape the excitement of the experience of talking with a Nobel laureate next to a musical instrument.

Another classic Lindau moment occurred on the first evening I was chatting with a physics Nobel Laureate (in this case, who shall remain nameless) who shared that he sadly would have to leave the conference early due to another engagement taking place in the celebrity world of physics. Specifically, Stephen Hawking was having his 75th birthday party on an exotic island on Earth that week and the laureate was on his way to the celebration.

And then there was the special moment when I sat down with Klaus Von Klitzing. I interviewed him on 27 June, which was also coincidentally his birthday. So I wished the physicist a happy birthday. Now, Von Klitzing is an interesting chap for many reasons. As he revealed to me in the conversation, he is the only Nobel Laureate who has ever applied to attend Lindau as a youngster and was turned down. "As a young student, I applied and I wasn't accepted," he recounts with a chuckle. "So I decided to get the Nobel Prize, because then you are invited every year."

I asked Von Klitzing what his advice was for getting a Nobel Prize. It turns out that he had a few tricks up his sleeve. One was that he had already worked into his speech some tips for actually landing the coveted prize.

But then something magical happened. And this is what I mean by a classic Lindau moment. Because this has never happened to me before, and in particular, it has never happened to me at a science conference. Von Klitzing just casually reached into his jacket pocket and handed me his Nobel medal. I suddenly realized I was looking down in my own hands and holding a Nobel Prize in Physics. It was shiny. It was heavy. Parts of it were faded and worn. I asked why that was and Von Klitzing explained that he takes the medal with him to every Lindau and is happy to share it with the young kids that attend. Many are very eager to hold it themselves and to take snaps with him and it.

I realized that in my life this moment will probably never happen again. Yes, I might run into Von Klitzing in some airport en route to Lindau again, fingers crossed, and he could hand it to me to hold while he checks his boarding pass, but there is no certainty. The Nobel Prize will always be both in my possession and not. So I had to act quickly to measure, quantify, and secure this moment in time and space with a photograph. And because Von Klitzing is such a classy guy, he was more than happy to take a picture with me and it, the Nobel Prize in Physics that I had just received.

So you see, fairy tales do come true at Lindau. You can meet and greet and learn from Nobel Laureates left and right. You can discuss your true love, science, with others from around the world who are just as passionate about it. You can gain insight and advice to take your scientific endeavors into novel and innovative directions. And sometimes, when the stars and Laureates align, you can also get the Nobel Prize.

The author expresses appreciation to the organizers of the Lindau Nobel Laureates Meetings for a partial travel fellowship to attend.

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they remain coherent). Known to be on the order of a few microseconds, a qubit's lifetime is reduced by interactions with materials in the experimental setup. To combat this, qubits are usually kept as far away from other materials as possible to decrease the loss of dielectric loss and decoherence. Chu *et al.* investigated ways to alter the geometry of materials and interfaces that contribute to loss of coherence, and describe in *Applied Physics Letters (DOI: 10.1063/1.4962327)* a procedure using micromachining to "dig out" an aluminum qubit. This involves removing the silicon substrate under the qubit with an ion etch, leaving it suspended over the remaining silicon in a vacuum. This methodology resulted in decreased dielectric loss on silicon and longer lifetimes of qubits than nonsuspended ones — around 60 microseconds, a factor of 10 larger than most aluminum qubits on silicon. This greater lifetime is comparable to the coherence times of qubits on sapphire, a high-quality but expensive substrate with properties that minimize dielectric loss in superconducting qubits.

Seeing What's There by Looking Elsewhere

Two research groups have now shown that the counterintuitive technique of "ghost imaging" is not restricted to infrared and visible wavelengths, but works with x-rays too. Conventional imaging methods capture an image of an object by recording, in a multipixel detector, the intensity and color of light that reflects from, passes through, or is emitted by an object. Ghost imaging is different. It forms an image of the object by recording correlations in the intensities of two light beams, an "object beam" that strikes the object and a "reference beam" that does not. The technique builds up images by combining information from a single-pixel detector probing the object beam and a 2D detector probing the reference beam. Crucially, in this form of imaging, the object doesn't have to receive a high dose of radiation because the object beam can be weak if the reference beam is strong. The two new studies, both published in *Physical Review Letters*, one by Yu *et al.* (DOI: 10.1103/PhysRevLett.117.113901) and the other by Pellicia *et al.* (DOI: 10.1103/PhysRevLett.117.113902) now extend this imaging capability to the x-ray regime. This wavelength domain is widely used in medical imaging, so the approach could pave the way to reducing the damage incurred by radiation exposure in such imaging. (For more, see the Viewpoint "Ghost imaging with x rays" by Dilano Saldin at physics.aps.org/articles/v9/103)

The Back Page

Why Does the Universe Exist?

By Sean Carroll

Sidney Morgenbesser, a much-beloved professor of philosophy at Columbia University, renowned for his aphoristic wisdom, was once asked, "Why is there something, rather than nothing?"

"If there were nothing," Morgenbesser immediately replied, "you'd still be complaining."

Let's start with the relatively straightforward, science-oriented question: could the universe exist all by itself, or does it need something to bring it into existence?

As Galileo taught us, one of the foundational features of modern physics is that objects can move, and tend to do so, without any need for an external cause or mover. Roughly speaking, the same goes for the universe. The scientific question to ask isn't "What caused the universe?" or "What keeps the universe going?" All we want to know is "Is the existence of the universe compatible with unbroken laws of nature, or do we need to look beyond those laws in order to account for it?"

"The scientific question to ask isn't "What caused the universe?" or 'What keeps the universe going?' All we want to know is 'Is the existence of the universe compatible with unbroken laws of nature, or do we need to look beyond those laws in order to account for it?'"

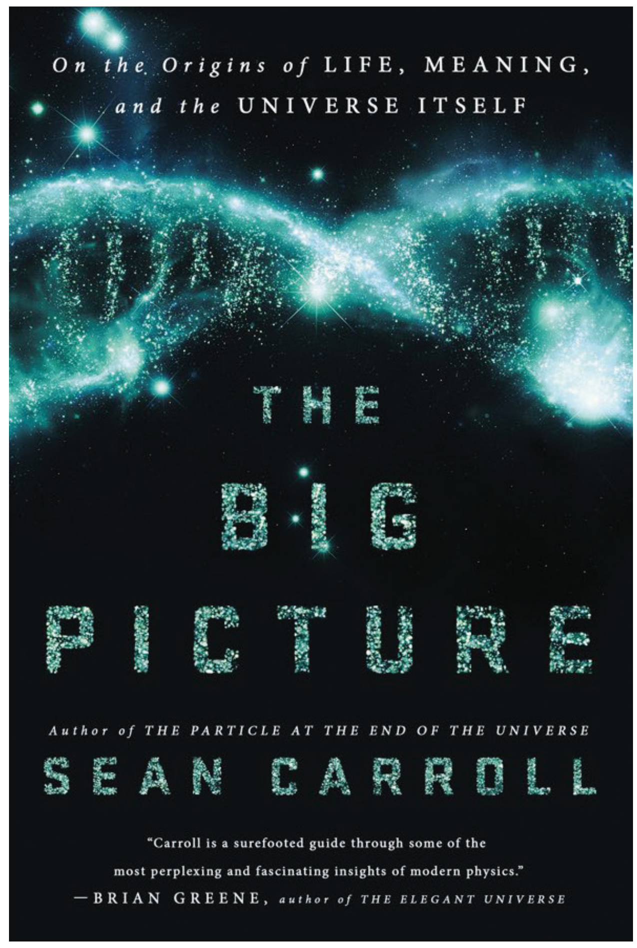
This question is complicated by the fact that we don't know what the ultimate laws of nature actually are. Consider an issue that is inextricably tied to why the universe exists: has it existed forever, or did it come into existence at some particular moment, presumably the Big Bang?

Nobody knows. If we were Pierre-Simon Laplace, who believed in the classical physics of Newton and scoffed at the idea that God would ever interfere in the workings of nature, the answer would be easy: the universe exists forever. Space and time are fixed and absolute, and it doesn't really matter what happens to the stuff that is moving around inside space. Time stretches from the infinite past to the infinite future. Of course you are always welcome to consider other theories, but in unmodified Newtonian physics the universe has no beginning.

Then in 1915 along comes Einstein and his theory of general relativity. Space and time are subsumed into a four-dimensional spacetime, and spacetime is not absolute — it is dynamic, stretching and twisting in response to matter and energy. Not long thereafter, we learned that the universe is expanding, which led to the prediction of a Big Bang singularity in the past. In classical general relativity, the Big Bang is the very first moment in the history of the universe. It is the beginning of time.

Then in the 1920s we stumbled across quantum mechanics. The "state of the universe" in quantum mechanics isn't simply a particular configuration of spacetime and matter. The quantum state is a superposition of many different classical possibilities. This completely changes the rules of the game. In classical general relativity, the Big Bang is the beginning of spacetime; in quantum general relativity — whatever that may be, since nobody has a complete formulation of such a theory as yet — we don't know whether the universe has a beginning or not.

There are two possibilities: one where the universe is



eternal, one where it had a beginning. That's because the Schroedinger equation of quantum mechanics turns out to have two very different kinds of solutions, corresponding to two different kinds of universes.

One possibility is that time is fundamental, and the universe changes as time passes. In that case, the Schroedinger equation is unequivocal: time is infinite. If the universe truly evolves, it always has been evolving and always will evolve. There is no starting and stopping. There may have been a moment that looks like our Big Bang, but it would have only been a temporary phase, and there would be more universe that was there even before the event.

The other possibility is that time is not truly fundamental, but rather emergent. Then, the universe can have a beginning. The Schroedinger equation has solutions describing universes that don't evolve at all: they just sit there, unchanging.

"The 'state of the universe' in quantum mechanics isn't simply a particular configuration of spacetime and matter. The quantum state is a superposition of many different classical possibilities. This completely changes the rules of the game."

You might think that's simply a mathematical curiosity, irrelevant to our actual world. After all, it seems pretty obvious that time does exist, and that it's passing all around us. In a classical world, you'd be right. Time either passes or it doesn't; since time seems to pass in our world, the possibility of a timeless universe isn't very physically relevant.

Quantum mechanics is different. It describes the universe as a superposition of various classical possibilities. It's like we take different ways a classical world could be and stack them on top of each other to create a quantum world. Imagine that we take a very specific set of ways the world could be: configurations of an ordinary classical universe, but at different moments in time. The whole universe at 12:00, the whole universe at 12:01, the whole universe at 12:02, and so on — but at moments that are much closer together than a minute apart. Take those configurations and superimpose them to create a quantum universe.

That's a universe that is not evolving in time — the quantum state itself simply is, unchanging and forever. But in any one part of the state, it looks like one moment of time in a universe that is evolving. Every element in the quantum superposition looks like a classical universe that came from somewhere, and is going somewhere else. If there were people in that universe, at every part of the superposition they would all think that time was passing, exactly as we actually do think. That's the sense in which time can be emergent in quantum mechanics. Quantum mechanics allows us to consider universes that are fundamentally timeless, but in which time emerges at a coarse-grained level of description.

And if that's true, then there's no problem at all with there being a first moment in time. The whole idea of "time" is just an approximation anyway.

"Quantum mechanics allows us to consider universes that are fundamentally timeless, but in which time emerges at a coarse-grained level of description. …And if that's true, then there's no problem at all with there being a first moment in time. The whole idea of "time" is just an approximation anyway."

I'm not making this up — this kind of scenario is exactly what was contemplated by physicists Stephen Hawking and James Hartle back in the early 1980s, when they helped pioneer the subject of "quantum cosmology." They showed how to construct a quantum state of the universe in which time isn't truly fundamental, and in which the Big Bang represents the beginning of time as we know it. Hawking went on to write *A Brief History of Time*, and become the most famous scientist of the modern age.

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