July/August 2022 • Vol. 31, No.7
aps.org/apsnews

APS NEWS

APS physics

A PUBLICATION OF THE AMERICAN PHYSICAL SOCIETY

RESEARCH

Searching for New Molecules with Quantum Computers

Could the budding technology see a breakthrough application in chemistry?

BY SOPHIA CHEN

Many predict that quantum computers will have their "first killer app" in chemistry. CREDIT: BARTEK WRÓBLEWSKI/FLICKR

In 2019, researchers at Google claimed that their quantum computer, a 53-qubit processor named Sycamore, beat a supercomputer at a commercially useless mathematical task. Since then, other researchers have challenged Google's claim, but it was the first of several so-called "quantum advantage" experiments, heralding the arrival of functioning quantum computers.

But the question remains: Can the nascent technology do anything useful? One testing ground lies in chemistry, where many quantum computing advocates predict the technology will have its "first killer app." At this year's APS March Meeting in Chicago, researchers from both academia and industry—including Google, IBM, and smaller startups—dove into quantum computing's applications in chemistry.

"There's a lot of cool stuff going on and a lot of reasons to be excited," says Katherine Klymko of Lawrence Berkeley National Laboratory.

QUANTUM CONTINUED ON PAGE 5

MEETINGS

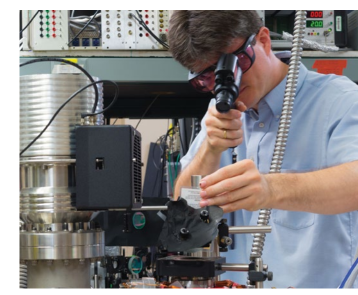
What Was the Climate Like 1,000 Years Ago? Ask Argon-39.

At the Annual APS DAMOP Meeting, scientists showcased advances in atom trace trap analysis.

BY TESS JOOSSE

High on the Tibetan plateau and deep within Antarctica, tiny clues about the past are trapped. Noble gas isotopes like krypton-81 and argon-39 lay frozen in this ancient ice, and swirl in ocean currents or groundwater aquifers, after cycling out of the Earth's atmosphere many years ago.

These isotopes are "nature's clocks in the environment," Yan-qing Chu, a graduate student at the University of Science and Technology of China (USTC), said at the APS Division of Atomic, Molecular and Optical Physics (DAMOP) Meeting in June. They're uniformly distributed in the Earth's atmosphere, and their noble status shields them from chemical alterations over time. As a result, these isotopes, dubbed "tracers," can tell us a lot about what the climate was like when they were cycled



Atom trapping at the Argonne National Laboratory. CREDIT: ARGONNE NATIONAL LABORATORY/FLICKR

out of the atmosphere—if we can detect them.

And detecting them isn't easy. "Think about a kilogram of ice," says Wei Jiang, a physicist at USTC. In it, there are only "about 2,000 krypton-81 atoms," he says, a

ARGON-39 CONTINUED ON PAGE 7

PEOPLE

Interview with Denis Bartolo, New Lead Editor of *Physical Review X*

BY TARYN MACKINNEY

Denis Bartolo, Lead Editor of PRX CREDIT: DENIS BARTOLO

In May, Denis Bartolo, Professor of Physics at ENS de Lyon in France, was named the Lead Editor of *Physical Review X* (PRX). Established in 2011, PRX is an open-access, multidisciplinary journal that publishes breakthrough or paradigm-shifting research.

In June, *APS News* Editor Taryn MacKinney spoke with Dr. Bartolo about his background, research, and experience with PRX. This interview has been edited for brevity and clarity.

What first got you into physics?

My father was an engineer, and he used to work at a company that

BARTOLO CONTINUED ON PAGE 3

MEETINGS

Lighting Tiny Movie Sets with the World's Most Intense X-Rays

Scientists at the APS DAMOP Meeting discussed the future of X-ray free electron lasers.

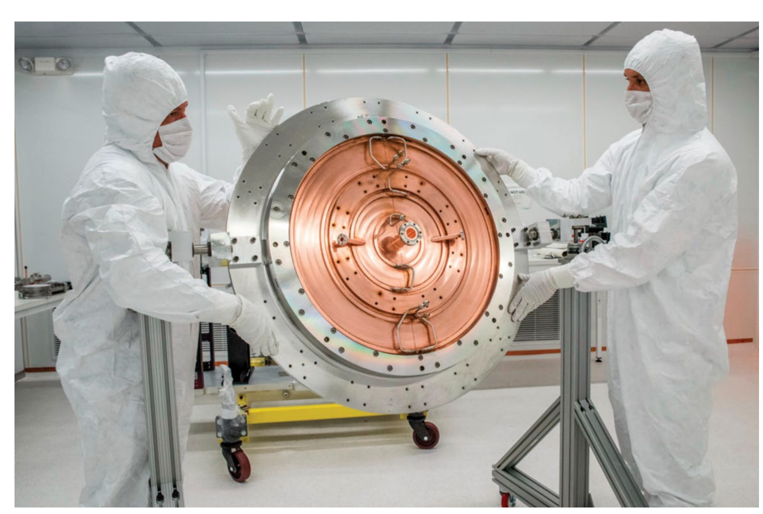
BY SOPHIA CHEN

In 2009, the Linac Coherent Light Source turned on its laser to beam the most intense X-ray light the world had ever seen. By wiggling electrons between a 130-meter stretch of magnets, the machine—which sits near Stanford's campus in California—produces X-rays in fleeting pulses, each quadrillionths of a second long. A single pulse can create light that's 100 times more intense than the light you'd get if all the sunlight hitting Earth were focused onto a thumbnail.

LCLS was the first of what are called X-ray free electron lasers, or XFELs. Other countries have since built XFELs of similar ilk: in Japan in 2012, in South Korea in 2016, and in Germany in 2017. All of them, like LCLS, are kilometers-long in size and cost around a billion dollars to build.

When scientists gathered in Orlando at this year's week-long meeting of the Division of Atomic, Molecular, and Optical Physics (DAMOP), hosted by the American Physical Society, research at XFELs had plenty of time in the limelight.

With big lasers come big ambitions: Researchers are using XFELs to better understand single molecule behavior and chemical reactions, which could shape fields



The LCLS-II—an upgrade to the LCLS, the world's first hard X-ray free-electron laser—under construction in California. Here, scientists work with a part of the LCLS-II electron gun. CREDIT: MARILYN CHUNG/BERKELEY LAB; RETRIEVED FROM SLAC/FLICKR

ranging from physics to materials science and biology.

Because they can penetrate dense materials, these high-intensity X-rays can see inside—and even alter—the microscopic structure of objects opaque to optical light. For example, researchers have used bright XFEL pulses to create and investigate plasmas, with the aim of better understanding planets and stars.

The short wavelength of X-rays also allows for high-resolution imaging. The X-rays' short pulses work like an extremely fast camera shutter: They trigger chemical reactions and then take "snapshots" of electrons darting around molecules, creating what scientists call "molecular movies." Some researchers have used this technique to study photosynthesis at the atomic level.

The movies contain more than just visual information. Thorsten Weber of Lawrence Berkeley National Laboratory studies reaction microscopy, a technique

X-RAYS CONTINUED ON PAGE 4

PEOPLE

John Schiffer, 1930-2022

Nuclear physicist who guided his field dies at 91

BY DANIEL GARISTO

John Schiffer at his desk at the University of Chicago in 1987

CREDIT: PHOTO BY KEITH SWINDEN/COURTESY UNIVERSITY OF CHICAGO HANNA HOLBORN GRAY SPECIAL COLLECTIONS RESEARCH CENTER

John Schiffer, an experimental nuclear physicist who steered the course of nuclear physics for over half a century, died June 6 in Illinois.

Over his seven-decade career, Schiffer won a variety of accolades, including the 1976 Bonner Prize in nuclear physics for " significant contributions to numerous aspects of nuclear structure," and "his unusual influence in helping to maintain and spread high standards for precision and clarity." Schiffer was an associate editor for Reviews of Modern Physics and a Fellow of both APS and the National Academy of Sciences.

Throughout his career, Schiffer investigated nuclear structure, specifically single-particle states, where one nucleon is displaced to a different nuclear shell. He was also a scrupulous debunker of tenuous claims, and a big-picture organizer of nuclear physics. "He would really set the standards for the future—what are the open issues, and how do we address them?" said Jerry Nolen, a colleague at Argonne National Lab.

John Paul Schiffer was born November 22, 1930, in Budapest, Hungary, to Ernö and Elizabeth Schiffer, both physicians. As a Jewish family, they were targeted during the Nazi occupation, but survived thanks in part to the Swedish diplomat Raoul Wallenberg, who saved thousands of Hungarian Jews during the Holocaust. In 1947, Schiffer emigrated to the US, where he lived with his aunt and uncle before attending Oberlin and pursuing physics.

After graduating in just three years, Schiffer went to Yale, where he was introduced to nuclear physics and got his first job: painting the new cyclotron blue. Finishing again in three years, Schiffer moved on to what is now Rice University in Houston. In 1959, he discovered that an isotope of iron had a powerful Mössbauer effect—it absorbed and reemitted high energy photons without recoil, pushing the effect from a novelty to a useful tool in the lab.

In 1960, Schiffer married Marianne Tsuk, a fellow emigree from Hungary. Four years later, while Marianne was writing her thesis on x-ray crystallography, the couple had their first child, Celia—John did most of the typing because "the noise made the baby kick." Their second, Peter, was born three years later. As a female scientist in the 1960s, Marianne faced pressure to quit. But in his autobiography, Schiffer wrote that he "always took it for granted that [Marianne] should pursue a career."

At Argonne, and later the University of Chicago, Schiffer hit his stride, performing experiments on nuclear structure. Transfer reactions, in which a projectile fired at a target nucleus caused an exchange of nucleons, would become a mainstay for the rest of his career. From reactions like these, Schiffer saw things others missed.

"He would plot and plot and plot, and then sit back and chew his glasses," said Ben Kay, a colleague at Argonne. "He would do this in talks, and everyone knew that the brain was churning." For Schiffer, data was sacrosanct: it needed to be clearly presented and acces-

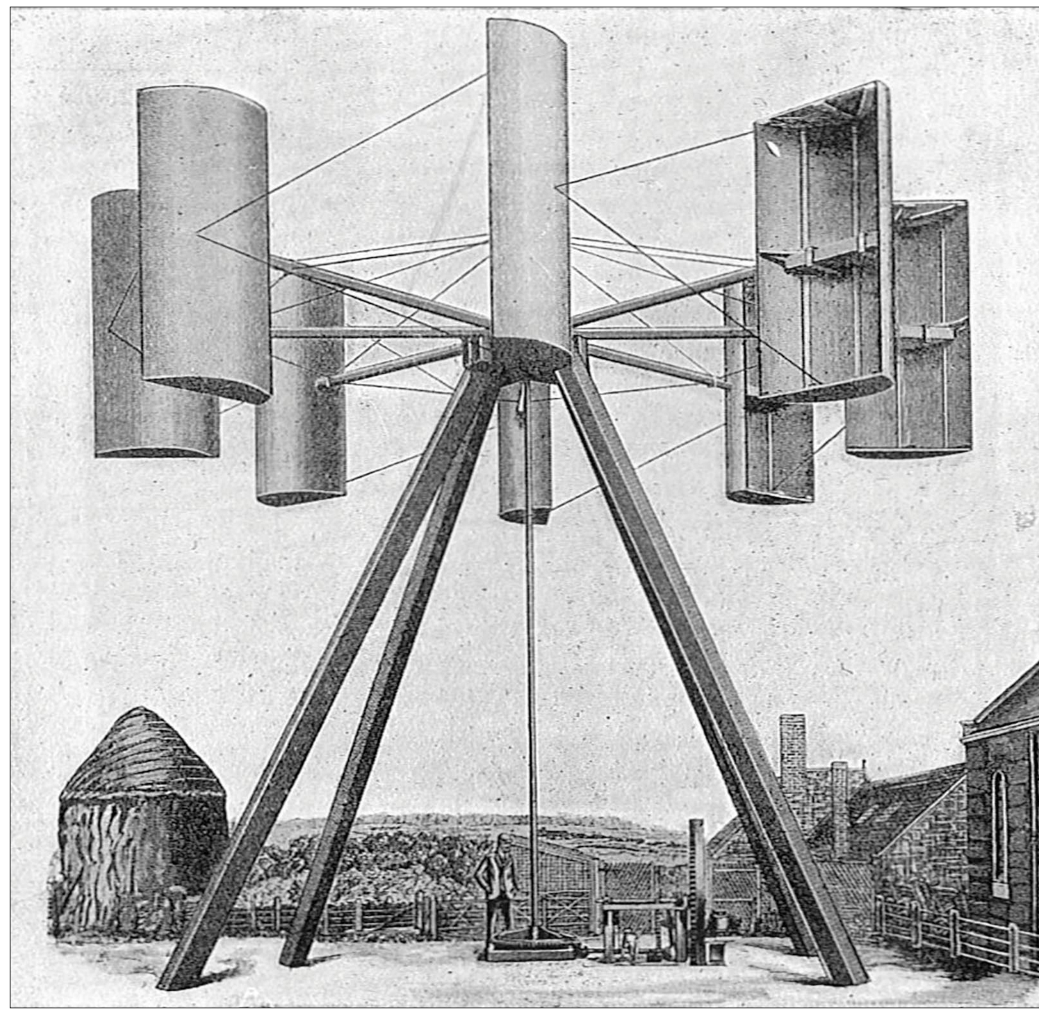
SCHIFFER CONTINUED ON PAGE 6

THIS MONTH IN

Physics History

July 1887: James Blyth Harnesses the Wind for Electricity

BY DANIEL GARISTO



James Blyth's 1891 design for a wind turbine. The wind, Blyth said, "is to be had everywhere."

CREDIT: RANKIN KENNEDY'S 1912 EDITION OF 1905 BOOK THE BOOK OF MODERN ENGINES AND POWER GENERATORS, VOL. I, LONDON: CAXTON, PP. FIG. 35

Nearly a century before anyone thought seriously about wind-powered electricity, a Scotsman named James Blyth built the world's first wind turbine in his front yard. "When a good breeze was blowing, I stored as much in half a day as gave me light for four evenings," he wrote.

It was July 1887, and Blyth—an electrical engineer living in Marykirk, a town in north-eastern Scotland—used the turbine to power his holiday home. He even offered to light Marykirk's main street with the excess power, but the villagers, who believed electricity was the work of the devil, rebuffed him.

"[Blyth] was obviously too far forward-thinking for the local villagers, who probably thought he was a wizard," said Trevor Price, a senior lecturer of environmental and mechanical engineering at the University of South Wales who wrote a short biography of Blyth.

Unlike his contemporary pioneers of wind energy, the American engineer Charles Brush and Danish inventor Poul la Cour, Blyth is less well-remembered—with nary a monument to his name—despite his pride of place as the first person to harness the wind for electricity.

James Blyth was born April 4, 1839, to Catherine and John Blyth, who ran an inn in Marykirk (auspiciously, the house Blyth was born in had a windmill in its garden). He earned a degree at Edinburgh University and then, like many educated Scotsmen of his day, became a teacher. He married, and he and his wife, Jesse Taylor, had seven children; two died young.

The family settled down in Glasgow, where Blyth took up a teaching position at what is now Strathclyde University. There, Blyth rubbed shoulders with the intellectuals who would likely inspire him to build the wind turbine.

Scotland was an industrial and scientific power then, home to the world's largest chemical

BLYTH CONTINUED ON PAGE 7

APS NEWS

Series II, Vol. 31, No. 7
July/August 2022
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APS News (ISSN: 1058-8132) is published monthly, except for a combined July-August issue, 11 times per year, by the American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, (301) 209-3200. It contains news of the Society and of its Divisions, Topical Groups, Sections, and Forums; advance information on meetings of the Society; and reports to the Society by its committees and task forces, as well as opinions.

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.

Subscriptions: *APS News* is an on-membership publication delivered by Periodical Mail Postage Paid at College Park, MD and at additional mailing offices.

For address changes, please send both the old and new addresses, and, if possible, include a mailing label from a recent issue. Changes can be emailed to membership@aps.org. **Postmaster:** Send address changes to *APS News*, Membership Department, American Physical Society, One Physics Ellipse, College Park, MD 20740-3844.

Coden: ANWSEN ISSN: 1058-8132

APS COMMUNITY

Researchers Find Home in Division of Physics of Beams and Look Ahead to August Meeting in New Mexico

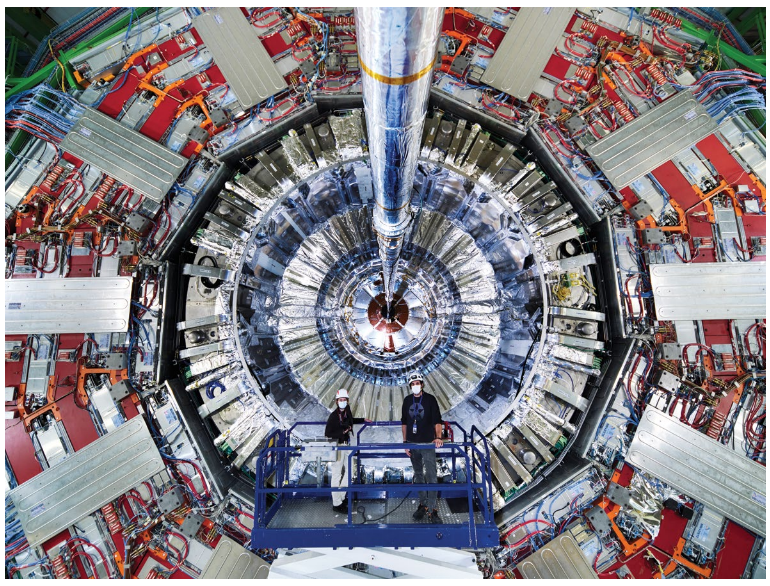
BY ABIGAIL DOVE

Established in 1985, the Division of Physics of Beams (DPB) is a hub for more than 1,000 physicists interested in beams, their nature and behavior, and the instruments necessary to make and use them.

Beams—discrete streams of photons or particles—are essential to technologies like electron microscopes, spectrometers, and X-rays. The most powerful beams are used in particle accelerators, which use electromagnetic fields to propel and smash together charged particles. The largest particle accelerator is the CERN's Large Hadron Collider, whose 17-mile-long tunnel is buried 570 feet beneath the city of Geneva, Switzerland.

Beam research is diverse. On the instrumentation side, beam physicists seek to update and refine existing particle accelerators and design future ones that are smaller and cheaper and build, and that incorporate the most cutting-edge science. Beams themselves are also a window into complex physics, like non-linear effects and collective phenomena.

Given this range, DPB membership is highly interdisciplinary. Scientists hail not only from high-energy, nuclear, medical, and plasma physics, but also from fields like engineering.



Particle accelerators like the Large Hadron Collider (LHC), buried nearly 600 feet below the streets of Geneva, are central to beam physics. The LHC's CMS detector, shown here, takes "snapshots" of particles as they smash together.
CREDIT: SAMUEL JOSEPH HERTZOG (CERN)

DPB helps organize several conferences on particle accelerators. One, the North American Particle Accelerator Conference (NAPAC), is scheduled for August 7–12 in Albuquerque, New Mexico. Held every three years, NAPAC meetings typically draw around 400 people from across the US and Canada.

Marlene Turner, a research scientist at Berkeley's Lab Laser Accelerator Center, is DPB's Early Career Member-at-Large. She characterized the conference as an opportunity to engage with other beam physicists, perhaps over coffee.

"In such a large field, no one can be an expert in everything. Building a network of who knows what— especially after having met

DPB CONTINUED ON PAGE 6

HISTORY

Morgan State University, SURF, Bevatron Celebrated as APS Historic Sites

BY TAWANDA W. JOHNSON

For physicist Sylvester James Gates, Jr., Morgan State University in Baltimore is a special place: It's the birthplace of the National Society of Black Physicists (NSBP).

Gates—the Clark Leadership Chair in Science at the University of Maryland, Past APS President, and Past NSBP President—attended his first NSBP meeting during the early 1980s in Philadelphia.

"It was the first time I had been in a meeting with a significant number of African-American physicists, talking about doing physics, discussing physics education, and expressing the excitement of being in the field," he said.

NSBP was formed on April 28, 1977, after some prominent physicists, including Nobel Prize winner, William Shockley, claimed that people of African heritage were intellectually incapable of succeeding in a logic and mathematically-enable field like physics.

"African-American APS members petitioned the organization's leadership for a statement denouncing this," he said, but no such statement was forthcoming.

Black physicists realized the need to advocate for themselves—and so began NSBP, which started as an annual meeting and grew from there. Ronald E. Mickens, Distinguished Fuller E. Callaway Professor of Physics at Clark Atlanta University, played a leading role in

Dr. Willie Rockward, Chair of the Physics Department at Morgan State University, during a celebration after the university was named an APS Historic Site.

moving the group forward. Walter Massey and James Davenport served as the organization's first president and secretary-treasurer, respectively. Membership in the NSBP has always been open to all who support its goals.

Morgan State seemed the natural home for NSBP; the university has a rapidly growing physics department and is close to other prominent historically Black colleges and universities.

Recently, Morgan State was named an APS Historic Site, an honor that recognizes NSBP's importance to the history of physics. A plaque noting the honor will be hung in the university's Physics Department.

"I was totally surprised and amazed," said Willie Rockward, who serves as Physics Chair at Morgan State and is a past NSBP President. "To have APS and our entire physics community recognize this important moment in our history is much appreciated and respected."

Mya Merritt, a junior engineering physics major at Morgan State, said NSBP was integral to her decision to pursue a STEM career.

HISTORIC CONTINUED ON PAGE 5

BARTOLO CONTINUED FROM PAGE 1

supplied equipment to research institutes, like CERN. I would hear him talking about science over dinner, so when I was a very young kid, I was interested in physics.

Until I became a young adult. During my 20s, my passion was clubbing. *(laughs)* But clubbing in Paris is expensive. If I wanted to keep on clubbing that much, I would need to make a lot of money. I was contemplating working in consulting or finance.

But you're not working in finance or consulting, of course. What changed?

I got an internship in New Jersey, researching polymers for additives for shampoos and the products you use to clean toilets. Not super sexy. I convinced my supervisor to let me do an experiment with a specific instrument at Lehigh University. He sent me there for three days. I was taking long shifts—sometimes 12 hours.

During the nights, I was bored as hell, because I had to wait for the instrument to make measurements. And in those hours, I discovered something *really* great: the internet. I spent entire nights browsing the home pages of physicists. I realized that clubbing was cool, but physics was my passion.

What are your research interests right now?

The first is soft condensed matter physics, and within that, synthetic active matter. We're making and studying materials whose building blocks are self-propelled units. We're basically trying to make fluids and solids out of motorized robots. What are the collective dynamics of these microscopic flocks of robots? What are the types of new materials they form?

I'm also working on *actual* flocks—animal groups and groups of pedestrians. We're trying to explain the dynamics of these groups as we would explain the dynamics of condensed matter.

Let's talk about *Physical Review X*. How did you learn about the journal?

A colleague of mine told me he was submitting his research to a journal called PRX. I didn't know what it was at the time. He told me it was an open journal that was relatively new.

But PRX quickly became part of my routine around bibliographic research. In my daily routine, I would come to the lab, and I would usually drink a cup of decaf coffee—

Decaf?

Yes, that's terrible. Just write "coffee"—I could lose my citizenship. *(laughs)* I would get my big mug of decaf, and then I would browse a bunch of journals. I would usually spend about 30 minutes seeing what's new in the journals. And very rapidly, I started checking PRX.

What stood out to you about PRX?

What the managing editors have done is remarkable. In 10 years, they brought this journal to an extremely high level in terms of scientific quality—the quality of research is so consistent. And they created a very clear editorial line: Papers that are published in this journal need to make a difference. Not a splash, but a difference. Significant advances in the field. Whether the advance is sexy, and can be summarized in an easy elevator pitch, doesn't matter. What matters is the quality of the science and its impact on the community.

I liked that clear editorial line, and I liked that the format was less restrictive. As soon as I was able to publish research in the caliber of this journal, PRX became one of my primary choices.

What did you like about the journal's format?

Usually, high-impact journals have strong format restrictions. You have to really summarize an idea. But not all ideas can fit in four or five pages or 2,000 words, especially if you want to combine theory, experiments, and numerical simulations.

What's great about PRX is that you can summarize the core idea of your research in the paper, and then you can publish longer appendices that are also formally reviewed. You have the room you need to give the details. With PRX, you have core ideas *and* technical details, both written at the same level of quality.

In the announcement of your appointment, you wrote that your team would "strive to make PRX an example of strong ethics and high integrity." In the context of this journal, what do strong ethics and high integrity mean to you?

APS and PRX are not running a business; we're providing a service to the community. We want to deliver the same service to all physicists, from all fields, regardless of their origin, religion, gender, ethnicity. This is a basic requirement for integrity.

And we also want to be a journal where we listen to authors and referees—where we have a dialogue. We only publish a couple hundred papers a year, and because of that small number, we can interact directly with authors and reviewers. We can offer counsel, we can correct our mistakes, and we can make sure we're making the right decisions for the benefit of the community. I think that's a unique edge that PRX has.

Let's say I'm a physicist who would love to publish my research findings in PRX, but I've never submitted to PRX before, and I'm uncertain. What advice would you give me?

First of all, if you're nervous, stop drinking coffee and switch to decaf. *(laughs)*

If you have a doubt, contact us. If you don't know whether you should, for example, write two papers or one, or combine your theories and experiments to make a stronger case, just contact the editors. They're incredibly committed, talented people. I'm so impressed with their breadth of scientific knowledge. They handle hundreds of papers every year; they probably know more physics than anyone else. So if you have doubts, ask for advice.

Taryn MacKinney is the Editor of APS News.

X-RAYS CONTINUED FROM PAGE 1

in "its teenage years," Weber says. He uses the technique to "film" a movie of a molecule breaking apart while simultaneously measuring the angles and kinetic energies of the ejected particles. XFELs also make it possible to study ions and electrons in a reaction at the same time, says Weber. Before XFELs, scientists studied electron behavior and ion behavior separately, as ions are over a thousand times heavier than electrons.

During a presentation at the APS DAMOP Meeting, Weber outlined one of the challenges of using XFELs for molecular movies: time. To make a movie, a researcher fires an X-ray pulse at the molecule of interest, triggering a chemical reaction. Then, a second pulse illuminates the molecule for imaging. But current XFELs only produce pulses up to thousands of times per second. This might sound fast, but the researcher must trigger the reaction *millions* of times, so it can take days to make a movie. With so many researchers worldwide competing for time to use these machines, that pace is a challenge.

But what if the X-ray that spurs the chemical reaction, and the X-ray that illuminates it, could be fired in the same pulse? Weber presented a method for keeping time in this case, to track when motion takes place. The technique would cut down on the time a researcher needs at the laser to make a movie.

Now, Weber is working to combine the X-ray light with an ultraviolet laser. In this setup, researchers would first shine lower-energy UV light at a molecule before imaging it with X-rays. The initial UV illumination would more closely mimic how sunlight interacts with organisms, while the X-rays would provide high imaging resolution.

Linda Young of Argonne National Laboratory presented work at the APS DAMOP Meeting related to studying and controlling the X-ray pulses themselves. The XFEL produces a spiky, noisy spectrum that researchers must measure before experiments. However, this measurement is difficult, because it typically requires the researcher to divert the X-rays with solid beamsplitters that do not tolerate high intensities well. In a recent study, her team devised a way to measure the spectrum with a beamsplitter made of neon gas using a technique called ghost imaging.

Young's team has also used the XFEL facility in Germany to study the interactions between X-rays and neon gas. When an X-ray pulse strikes neon, it emits light, and this light in turn changes the spectrum of the X-ray pulse. This outgoing spectrum reveals information about the electronic structure of the neon atoms. While neon has a simple structure, Young says these studies will help them investigate more complex molecules in the future. She also plans to study the effects of the X-ray-and-neon interaction on the pulse's shape over time.

As XFELs are just over a decade old, researchers like Weber and Young are still figuring out all the ways to use them—and they'll soon have a new toy to look forward to. Construction of the LCLS-II, an upgrade to the LCLS, is scheduled for completion by the end of the year. This new XFEL will be capable of producing up to a million pulses per second, compared to the 120-per-second pulses of its predecessor.

For researchers, having more machines will make a big difference. "It gives us the opportunity to really systematically go after the understanding needed for our dream experiments," says Young.

Sophia Chen is a writer based in Columbus, Ohio.

A Particle is Born: Making the Higgs Famous

Science communicators had a field day with the 2012 Higgs discovery

BY MICHAEL SCHIRBER

The Higgs discovery, announced on July 4, 2012, was a major happening in science but also in science communication. Rarely has so much effort been made to engage the public over a fundamental physics topic. Front-page headlines, best-selling books, public lectures, TV interviews, and feature-length films all tried to explain the Higgs boson—a particle whose claim to fame is its association with the generation of mass. Ten years later, the Higgs may not be a household name, but the intense limelight on this fundamental entity did offer communicators an opportunity to tell a larger story about the scientific enterprise.

"The Higgs boson is the capstone of the standard model of particle physics," says physicist Sean Carroll from the California Institute of Technology, who wrote about the Higgs in his 2012 book The Particle at the End of the Universe. He's also helped to popularize the Higgs by giving public lectures, writing blogs, and making TV appearances. He believes the discovery was a "watershed moment," as it showed that physicists were clearly on the right track with their understanding of the fundamental workings of the Universe. "That kind of accomplishment should not go unrecognized," Carroll says.

The Higgs discovery was covered by newspapers around the world.
CREDIT: CERN

So how have science communicators tried to make the Higgs boson famous? One of the earliest attempts was by the Nobel prize winner Leon Lederman, who wrote the 1993 popular science book The God Particle. In it, Lederman described the Higgs as the crucial but elusive piece to our understanding of the structure of matter. "[The book] was spectacularly successful in that you literally cannot have a conversation with a person on the street about the Higgs without someone talking about the God particle," Carroll says. But many physicists regret the connection that was made between the Higgs and religion. "There's a lot of work to be done in undoing the damage," Carroll says.

Another early attempt at capturing the public's imagination came with the cocktail party analogy, which earned David Miller

HIGGS CONTINUED ON PAGE 6

FYI: SCIENCE POLICY NEWS FROM AIP

US Moves to Curb Science Ties with Russia Over Ukraine Invasion

FYI SCIENCE POLICY NEWS FROM AIP

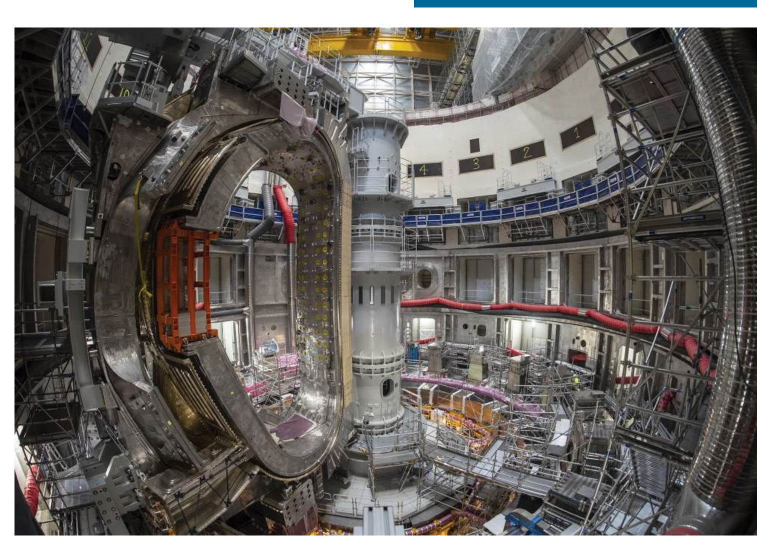
BY MITCH AMBROSE

The White House announced on June 11 that the US will "wind down" research collaborations with Russia in response to its invasion of Ukraine. The policy applies to federally funded projects involving research institutions and individuals affiliated with the Russian government, although it permits non-government organizations in the US to decide for themselves whether to cut ties.

Though the White House was quick to implement sweeping economic sanctions and export controls on Russia in the wake of the invasion on February 24, it had, up until the June announcement, been silent on sanctioning the scientific community. By contrast, many European countries moved quickly to restrict science collaborations.

The White House policy arrived just before a summit of science ministers from the G7 countries—US, UK, France, Germany, Italy, Japan, and Canada. The ministers declared their commitment to restricting research collaborations involving the Russian government, while leaving the door open for individual scientists.

"In the spirit of science diplomacy, we will continue the dialogue between civil societies, including exchanges with Russian scientists and students to the furthest extent possible, especially through the promotion of individual academic and student mobility," they wrote in a statement.



The ITER magnetic fusion device, under construction in France, photographed in June 2022. The White House seeks to cut ties with Russian science, but for some international projects, it lacks authority: Russia is one of ITER's founding members. CREDIT: ITER ORGANIZATION, HTTP://WWW.ITER.ORG/

The White House policy generally prohibits new federally funded partnerships, but it allows those begun before the start of the invasion to be completed. Partnerships required by binding international agreements will also continue.

For some projects, the US has no choice but to continue partnership. The ITER fusion facility, under construction in France, is an example; Russia is a founding member of ITER. "There is no provision for expulsion of a member state from the ITER project," a White House spokesperson said.

The Department of Energy has not yet commented on whether Russian scientists will be permitted to participate in projects involving its user facilities, such as its X-ray and neutron sources, which are generally open to scientists from around the world. According to DOE, 220 scientists from Russian institutions used DOE facilities in the fiscal year before the pandemic.

In Europe, CERN—the world's largest particle physics facility—has said it will prevent scientists affiliated with Russian institutions from working at the facility, though the decision will not take effect

FYI CONTINUED ON PAGE 7

QUANTUM CONTINUED FROM PAGE 1

Researchers are most interested in quantum computing's potential to improve simulations, a key tool in chemistry. Chemists have used computers to simulate molecules and chemical reactions for years, but these "classical" computers have limits. That's because each extra real-world factor you add to a simulation—another electron bouncing around a molecule, say—slows down the computer to prohibit simulations of molecules with more than 20 electrons. To get around this, chemists simplify these factors, which makes the simulations less accurate.

Quantum computing could change this. Molecules obey quantum mechanical equations, like qubits do (a qubit is the quantum counterpart to a 1-or-0 "bit" in normal computing). For example, in some algorithms, a qubit corresponds to a single electron orbital. As a result, researchers think it will be easier to simulate complex molecules on quantum computers, as they should be less bogged down with each added electron compared to classical computers. For instance, if researchers can simulate how electrons move around a molecule, they'll gain insight into its properties, like its electrical conductivity or its likelihood of bonding with another molecule.

In short, Richard Feynman's 1981 words apply to quantum chemistry: "Nature isn't classical, dammit, and if you want to make a simulation of nature, you'd better make it quantum mechanical."

Currently, researchers can test their molecular simulations only on the imperfect quantum computers we have today. Known as Noisy Intermediate-Scale Quantum Computers, or NISQ ("nisk"), these machines cannot fix their own errors. Existing NISQ computers consist of tens of qubits, while machines in development will have hundreds. (Many think it could take a decade or more to build a computer that can fix its own errors, called a "fault-tolerant" quantum computer.)

Challenges with NISQ computers abound. Their qubits hold on to information for limited time, which constrains the number of computations they can do in a row. It's also difficult to make qubits interact precisely, so researchers try to avoid operations involving qubits that are far apart, says Robert Parrish of the quantum computing startup QC Ware.

These challenges mean that a central part of developing algorithms is tailoring them to NISQ-era hardware, with all its limits—and researchers have gotten creative. Many use an algorithm developed in 2013 called the Variational Quantum Eigensolver (VQE) as a framework to build their own algorithms. In VQE, a quantum computer and a classical computer work together to calculate the ground state energy of a molecule.

For example, Klymko, from the Berkeley Lab, presented research at the March Meeting on how to break up a complicated molecule into several VQE calculations manageable for the quantum computers that exist today.

It's not just VQE that involves both quantum and classical computers: All quantum chemistry algorithms use both, Parrish says. Classical computers will always be better for certain calculations, like solving integrals, while quantum computers perform special tasks.

Researchers think it will be easier to simulate complex molecules on quantum computers, as they should be less bogged down with each added electron compared to classical computers.

Other research presented at the March Meeting drew from classical computational chemistry, including work by Birgitta Whaley of the University of California-Berkeley. Decades ago, chemists developed a method to approximate a molecular wave function, which describes the allowed locations of electrons within a molecule. Using this method, Whaley's team devised a quantum algorithm to calculate molecular energies, which they demonstrated by simulating the ground and excited states of a simple molecule made of four hydrogen atoms.

Although quantum algorithms have not outperformed classical ones yet, they're attracting commercial interest. For example, some pharmaceutical companies think quantum computing could accelerate drug discovery. At the March Meeting, Michael Streif of German pharmaceutical company Boehringer Ingelheim presented work on the feasibility of simulating a drug molecule binding to a protein associated with lung cancer.

"We simulated a full experiment where most of the molecule is described classically, and only the hard part is described quantum mechanically," says Parrish of QC Ware, which collaborated with Streif on the work. They performed the simulation entirely on classical hardware, which in turn simulated a small quantum computer.

Parrish's company performs consulting for commercial clients who seek to incorporate quantum computing into their businesses, and those clients are drawn to QC Ware because of its scientific rigor, Parrish says. He says that in-person meetings at conferences and academic publications are "crucial" for demonstrating that rigor.

Industry involvement has also created better-paying jobs for early-career quantum researchers. "It's actually become way harder for [academic institutions] to hire people, because a lot of people are going to companies instead of doing a postdoc," says Klymko. She hopes that the competition between academia and industry for talent will drive up salaries for academics.

In the meantime, researchers are looking ahead to new projects. Using her team's new algorithms, Whaley plans to simulate metal-containing molecules inaccessible to classical computers. QC Ware has paired with Covestro, a German polymer company, to investigate whether quantum computing can help them design more environmentally friendly materials. Klymko plans to continue refining VQE-based algorithms for calculating molecular energies.

The bottleneck, she says, is the hardware.

Sophia Chen is a writer based in Columbus, Ohio.

HISTORIC CONTINUED FROM PAGE 3

"I attended an NSBP conference in 2021 as a high school student when I was looking at colleges and was indecisive as to what major I should pursue," she said. "I learned a lot during the conference and gained an interest in physics."

Two other places also recently celebrated their designations as APS Historic Sites: the Sanford Underground Research Facility (SURF) in South Dakota and the Bevatron at Lawrence Berkeley National Laboratory in California.

Buried nearly a mile underground, SURF is the deepest underground research laboratory in the United States—and the place where, in 1965, Ray Davis, a chemist from Brookhaven National Laboratory, discovered that the sun shines because of nuclear fusion. Initially, some scientists were skeptical of the discovery, as Davis's experiment detected only about a third of the number of neutrinos predicted by theorists. But he persevered, and in 2002, was awarded a share of the Nobel Prize for Physics.

In a news release, Mike Headley, executive director of the South Dakota Science and Technology Authority, which manages SURF, said: "[Ray Davis's] legacy lives on in experiments around the world and in our efforts to educate the next generation of scientists and engineers."

APS also recognized the Bevatron as a historic site. For nearly 40 years, it reigned as one of the world's largest and highest-energy particle accelerators, designed to speed up protons to billions of electron volts. In 1954, physicists Emilio Segre and Owen Chamberlain, of the Berkeley Lab and University of California, Berkeley, used the facility to confirm the existence of antimatter by producing anti-protons.

"The Bevatron site designation is a symbol of what teams of people from many fields of science, engineering and operations can do when they work together across disciplinary boundaries to solve a problem—in this case unlocking the mysteries of the atom," said Berkeley Lab Director Mike Witherell, in a news release following the APS historic site ceremony.

Tawanda W. Johnson is APS Senior Public Relations Manager.

APS COMMUNITY

APS Legacy Circle Profile: Cherrill Spencer

BY DAVID BARNSTONE

When the APS Committee on the Status of Women in Physics (CSWP) was founded in 1972, fewer than 10% of bachelor's degrees and about 2% of PhDs were awarded to women in physics. The committee caught the attention of Cherrill Spencer, an Oxford-trained particle physicist who came to the United States in 1974 for postdoctoral research at the Stanford Linear Accelerator Center.

Cherril Spencer

"For most of my working life as a physicist, I was the only woman in the class, in the experimental group, in the lecture hall, in the department," recalls Spencer, who, after a brief stint in industry, returned to SLAC where she designed magnets for particle accelerators. "I finally had some female engineer colleagues in other SLAC departments from 1999 to 2014."

In 1999, Spencer decided to include APS as a beneficiary of her estate. As a member of the APS Legacy Circle, which recognizes donors who support the physics community through planned giving, her donation will continue her lifelong work to increase the participation of women in physics.

Born and raised in the UK, Spencer earned her bachelor's degree from the University of London in 1969 and her doctorate from the University of Oxford in 1972. During graduate school, she had the opportunity to conduct research at the European Center for Nuclear Research (CERN) in Geneva.

"That was an interesting initiation—night shift on strange apparatus that my lectures at Oxford had not touched on, surrounded by French-speaking men," Spencer wrote in an article for *Linacre News*, her graduate college's alumni magazine. She was later chosen to present the team's results at a major CERN colloquium, ultimately leading to a Royal Society European Fellowship that launched her career as one of few women in physics at the time.

Spencer supports and advocates for a variety of causes, from environmental protection to international peace. When her busy schedule kept her from volunteering her time, philanthropy was an effective alternative.

"I have crafted my current philanthropy to support the causes that I care about and the institutions that have brought me pleasure, such as orchestras and museums, and I have created my legacy donations to carry on that support," she said.

For more information about the Legacy Circle, please visit https://plannedgiving.aps.org/ or contact Kevin Kase at 301-209-3224 or kase@aps.org.

David Barnstone is APS Head of Public Relations.

DPB CONTINUED FROM PAGE 3

them in-person—makes it much easier to reach out with questions in the future," she explained.

The conference location is also a draw. NAPAC will be held in the center of Albuquerque's historic Old Town, so attendees can also explore New Mexico's famous Spanish, Mexican, and Native American cuisine. Nestled between the Sandia Mountains and the Rio Grande River, the city is a hub for hiking, kayaking, and—thanks to predictable wind patterns and stunning scenery—hot air ballooning.

The plenary sessions will cover the future of free-electron laser technology, applications of particle accelerators, and the search for axions and dark matter. Turner also highlighted a new addition to the NAPAC agenda: a contest in which graduate students and postdocs summarize their research in a two- or three-minute video. Winners get a cash prize, and their videos will play during a prime-time conference session. "The aim is to give more exposure to young researchers doing high-quality work," she explained. "This kind of publicity is good not only for career development, but also for the field in general."

Indeed, supporting students and early career scientists in beam physics, who comprise 20% of DPB's ranks, is a key goal for the DPB Executive Committee. "We need young people coming in to build the future of particle accelerators," Turner said. "Collaborations in beam physics can involve thousands of people. It takes a strong and motivated base to make things happen and move the field forward."

> "Collaborations in beam physics can involve thousands of people," Turner says. "It takes a strong and motivated base to make things happen."

DPB is also offering young researchers travel grants to attend, as well as prizes and awards, including for best dissertation and best paper, to recognize excellent work in the field.

Visit the DPB website at https://engage.aps.org/dpb to learn more.

Abigail Dove is a freelance writer in Stockholm, Sweden.

HIGGS CONTINUED FROM PAGE 4

of the University College London a bottle of champagne from the UK science minister in 1993. Miller likened the Higgs field—a space-filling energy out of which the Higgs boson arises—to a bustling crowd of partygoers. When a celebrity tries to walk through the room, the crowd presses toward them, slowing their progress. In a similar way, the Higgs field can be drawn toward a particle, slowing its progress and giving it mass. The Higgs is more drawn, for example, to the top quark than to the up quark, hence the top is more massive than the up.

These types of metaphors offer a basic appreciation of the physics behind the Higgs boson and its field. But getting people to take the time to learn about the Higgs requires a more human approach, says Mark Levinson—director of the 2013 film Particle Fever. "If you really want to get the message out, if you want to engage a bigger audience, it needs to be personalized," he says. His award-winning film—which ran in theaters across the globe and was distributed on Netflix—recounts the efforts at CERN in Switzerland leading up to the Higgs discovery, with Levinson's cameras following a handful of theorists and experimentalists during their day-to-day activities. "It is interesting to show why people pursue these incredibly abstract ideas," he says.

When Levinson started shooting in 2008, he was not focused on the Higgs boson, as physicists had warned him that a discovery might take too long to materialize. But once promising signs showed up at CERN's Large Hadron Collider (LHC), Levinson and his editor Walter Murch retooled their film's narrative to give a leading role to the Higgs. They even created a graphic with the Higgs in the center—a representation that the physics community has come to embrace, Levinson says (Fig. 1). The movie's big climactic scene is when LHC scientists revealed their data to a packed auditorium that included a visibly moved Peter Higgs, who began working in the 1960s—along with other theorists—on his namesake particle. Seeing an 80-year-old physicist tear up over a vindication of his life's work, "that's a great story," Levinson says.

The 2012 announcement was a media hit as well, with over 12,000 news reports on the Higgs boson, according to James Gillies, who was head of CERN's communication group when the discovery was announced (Fig. 2). Like Levinson, Gillies believes the Higgs was an easy sell to the public because the human effort surrounding the discovery was so immense. "We cast fundamental science as the latest step in humankind's journey of exploration," he says.

Gillies admits that it can be difficult to assess whether the Higgs excitement had a lasting impact on the public's appreciation of fundamental science. Very little data has been collected on changes in scientific understanding following a big discovery. "But there's no doubt in my mind that CERN, LHC, and Higgs are quite common currency these days," Gillies says. "My experience has taught me that people are more curious about basic research than we tend to think."

Levinson agrees. "Many people have said, I really didn't understand it, but I loved the film." The science, he says, is rather complicated, but the story about scientists and their passion is something that audiences can identify with. "The Higgs is fundamental to the physics theory, but it's bigger than that," Levinson says. "It's more about our quest to understand the way the Universe works."

"There's no shortage of enthusiasm among the public to learn about the Higgs boson," Carroll says. He thinks science communicators can always do better, "but I think the Higgs boson is something where we did take advantage of the excitement to teach people a little bit of physics." For his part, Carroll used the discovery to explain some of the quantum field theory that lies at the basis of the Higgs boson prediction. "We might as well leverage our big, happy discoveries to better acquaint the public with how science works and what scientists are finding."

Michael Schirber is a Corresponding Editor for Physics Magazine based in Lyon, France.

This article—reprinted from Physics Magazine—is part of a series that celebrates the 10th anniversary of the Higgs boson discovery.

SCHIFFER CONTINUED FROM PAGE 2

sible to others, deserved its pride of place in a paper, and shouldn't be overshadowed by speculation.

Though Schiffer discovered anomalies—he and Nolen found a strange 10-percent discrepancy between the nuclear energies of calcium and scandium that to this day baffles nuclear physicists—he was perhaps best known for debunking extraordinary claims. When another physicist claimed to find fractional charges on niobium spheres, Schiffer performed multiple experiments to corroborate it—peering at oil droplets, collecting dust from an electric fence—but found nothing. Other debunkings included strange results in positron data, an overly energetic neutrino, and explosive hafnium. "As a measure of the respect John's work had in the field, when the Argonne group did one of these experiments, in large part, then the community said it was settled," said Don Geesaman, an Argonne colleague.

When he was 78, Schiffer and Kay developed a new method for analyzing neutrinoless double beta decays, which if observed would confirm that neutrinos are their own antiparticles. Particle physicists had struggled with an uncertain, wildly variable range of nuclear matrix elements—but Schiffer realized it was possible to pin down the range using old techniques from transfer reactions to compare two nuclei. He continued publishing new research until months before his death.

Throughout his career, Schiffer was methodical. "There would be astonishing preparation, down to every hour of what we're going to do in this experiment, what spectrometer settings you'd have, what targets you'd use," Kay said.

This organizational tendency extended beyond his own research: For half a century, Schiffer helped the nuclear physics community plan its future, pushing for creative new experiments. "This is the first long range plan we ever had to go through where John wasn't a key player," Nolen said.

> "[Schiffer] would plot and plot and plot, and then sit back and chew his glasses," said Ben Kay, a colleague at Argonne. "He would do this in talks, and everyone knew that the brain was churning."

Schiffer was also committed to mentoring younger physicists. Geesaman recalled his Stony Brook advisor saying, "I went and sat at Rudy Peierls' knee in Birmingham. Go to Argonne, and sit at John Schiffer's knee and learn how to be a physicist." Schiffer was in constant contact with his postdoctoral students and left daily "see me" notes, and then emails, which Kay reports piled up into the thousands.

"He cared deeply about mentoring and helping younger physicists," said Peter Schiffer, his son, and a condensed matter physicist. An acknowledgment in Peter's own 1992 paper on superfluid helium-3 attests to a father's interest: "We also thank JP Schiffer for valuable insights on the interaction of radiation with matter."

Schiffer treated close colleagues like family, too. "The community of physicists was very much our network of close friends—essentially extended family," Celia Schiffer said. An international group of physicists gathered with the Schiffers for picnics and holidays.

Beyond physics, Schiffer loved nature. "Some people go to church; John went on walks," Nolen said. Every Sunday for years, the Schiffers visited the nearby Morton Arboretum, and every summer went hiking in the Colorado Rockies.

As an immigrant and Holocaust survivor, Schiffer was passionate about the freedom to explore nature as a scientist. "Being a scientist and working on research brought him tremendous satisfaction and joy, and he was grateful for the opportunities that the career path had given him," Peter said.

Daniel Garisto is a writer based in Bellport, New York.

ARGON-39 CONTINUED FROM PAGE1

quantity that shakes out to a tiny isotopic abundance of 9e-13—akin to finding one particular grain of sand on the beach. Argon-39's abundance is even smaller, at 8e-16. To detect those atoms, you need a system sensitive enough to count them one by one.

A method called atom trap trace analysis, or ATTA, is up for the challenge. ATTA uses lasers tuned to an isotope-specific frequency to excite and catch these atoms in ice or water samples. Those atoms fluoresce and can be counted, allowing researchers to date the samples using the known half-lives of isotopes like argon-39 and krypton-81.

It's no fool's errand. As it turns out, argon-39 allows researchers to peek through an essential window of geological time, one that has no other pinpointed dating method. "There is really nothing else in this age range," says Werner Aeschbach, an environmental physicist at Heidelberg University. Argon-39's half-life clocks in at 268 years, meaning it can date samples that are between 50 and 1,600 years old (krypton-81 can date older samples from between 30,000 and 1,300,000 years ago). This 50- to 1,600-year period matches neatly with the cycle of global ocean currents, which move water around the world like a giant conveyor belt, pushed along by wind and deep-water mixing. It might take one "parcel" of water 1,000 years or so to make it all the way around the conveyor belt, putting argon-39 in the sweet spot for dating seawater. "It's a Goldilocks isotope," says Zheng-Tian Lu, a physicist at USTC.

Studying the age of seawater, and thus tracking ocean currents over time, can help researchers better understand how the ocean mixes and moves, and even predict how the ocean will store atmospheric carbon dioxide. And dating glacial ice could help scientists reconstruct the climate over the past 1,500 years.

Argon-39 and krypton-81 are also useful for dating groundwater, an important step for studying the availability and suitability of these water sources for human use. Knowing how long it takes for freshwater sources like aquifers to refill, for instance, can help researchers understand and anticipate water needs. Researchers at Argonne National Laboratory recently used ATTA to trap and date krypton-81 in groundwater samples from Florida. They found that old seawater infiltration in the region's largest aquifer persists to this day—a potential concern as sea levels continue to rise and salinize the water source.

Scientists are just beginning to harness the power of argon-39 dating, Jiang says, as it is newer and trickier than krypton-81 dating. Its diminutive environmental abundance presents technical challenges, and researchers are typically starting with small quantities of sample to begin with (there's only so much ice that earth scientists can—or want to—drill out of the environment). Adding to the challenges, glaciers are swiftly melting because of global climate change, says Aeschbach, so researchers are on a race against time to sample and date many glaciers before they shrink or disappear in the coming decades.

New refinements to ATTA techniques could help. At the APS DAMOP Meeting in June, Chu presented recent work from USTC's Laser Laboratory for Trace Analysis and Precision Measurements. The group has increased the trap's precision for argon-39, lowering the requisite measuring time and boosting the system's hourly count rate to 10 atoms per hour (a group at Heidelberg University had previously reached a count rate of 5 atoms per hour, and the USTC team's goal is to achieve 100 atoms per hour, Lu says). With collaborators including colleagues at the Chinese Academy of Sciences, the group also created a pre-enrichment system that enriches for the isotope of interest, argon-39, by reducing the quantity of dominant isotope argon-40 in a sample by two orders of magnitude.

> "Oceanographers have been waiting for this for decades," Chu says.

The fine-tuning will allow researchers to get through more samples faster and survey larger swathes of the ocean, Chu said at the APS DAMOP Meeting. "Large scale survey is now possible," she said. "Oceanographers have been waiting for this for decades."

Tess Joosse is a science journalist based in Madison, Wisconsin.

Letter to the Editor: First Woman to Race in the Indy 500

"I enjoyed Dan Pisano's article on physics-related careers in motorsports. Relatedly, one of our past BS-Physics graduates from the University of Michigan, Janet Guthrie, was awarded an honorary doctorate at a commencement ceremony last year, sponsored by the UM Physics Department. Guthrie was a pioneering Indy/Nascar/SCCA woman race car driver. Drag racing has also become much more diverse, with many more minorities and women as top drivers, and the field is more technical than many realize."

– Frederick Becchetti (Michigan)

Janet Guthrie, the first woman to compete in the Indianapolis 500 and Daytona 500. CREDIT: JANETGUTHRIE.COM

Editor's note: Janet Guthrie indeed made history: In 1977, she became the first woman race car driver to qualify for and start in the Daytona 500 and Indianapolis 500. She earned her bachelor's degree in physics and worked as an aerospace engineer. Breaking gender norms—and using physics—on and off the racetrack!

FYI CONTINUED FROM PAGE 4

until December 2024. Russia is not a CERN member state but is among the countries that uses the facility most, with more than 1,000 Russian scientists currently involved in the lab's experimental program.

That CERN did not immediately expel these scientists reflects the tension between the push to isolate Russia and the legacy of the lab, which remained a venue for dialogue with Soviet scientists throughout the Cold War. Moreover, many Russian scientists criticized the invasion, including a group at CERN.

In its announcement, the White House noted that, since the Russian government criminalized dissent, it has become harder for Russian scientists to speak out against the war, and it pledged support to scientists who seek to leave Russia. President Biden also requested that Congress create a fast-track visa for Russian citizens with advanced degrees in STEM fields, but Congress omitted the proposal from final legislation on the Ukraine war, for unclear reasons.

Mitch Ambrose is Director of FYI. Published by the American Institute of Physics since 1989, FYI is a trusted source of science policy news. Sign up for free FYI emails at aip.org/fyi.

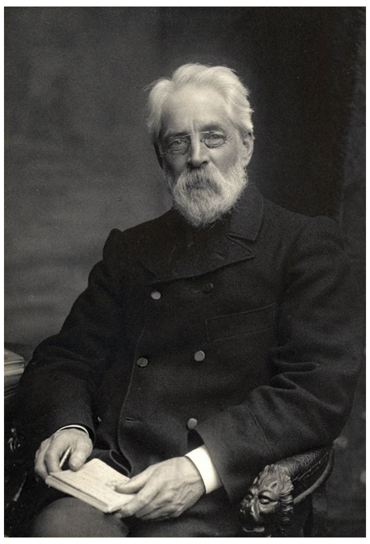
BLYTH CONTINUED FROM PAGE 2

laboratory, and a major source of coal. "At the time, there was an explosion of interest in electricity," Price said. "There were a lot of scientists, engineers, technologists, as we might call them, these days, working on batteries."

Price speculates that the physicist William Thomson—better known as Lord Kelvin—could have been an inspiration for Blyth. In 1881, Thomson gave a speech on using a windmill to charge a new type of battery, recently created by the French engineer Camille Alphonse Fauré.

Thomson pointed out that only a quarter of British merchant vessels used steam—the rest still used sails. "Even in the present day of steam ascendancy, old-fashioned Wind still supplies a large part of all the energy used by man," he wrote. Given that coal had a finite supply, Thomson speculated that "wind will do man's mechanical work on land" as well, including the production of light. With some educated guesswork, Thomson suggested that one of Fauré's batteries—charged by a windmill for five or six hours—could produce 60 "candle hours" of light. Still, Thomson lamented that the cost of building windmills would render the energy source economically unfeasible, at least until "inventions not yet made."

It's not known whether Blyth met or corresponded with Thomson, though they ran in similar Scottish academic circles, but in later papers



James Blyth, c. 1900
CREDIT: ARCHIVES AND SPECIAL COLLECTIONS AT THE UNIVERSITY OF STRATHCLYDE; PHOTO BY JOHN FERGUS

Blyth cited Thomson's 1881 report. And in Blyth's 1888 report on the first wind turbine, he noted that he had in common "with many other persons" the sense that the "power of wind was not taken advantage of for the purpose of generating and storing electrical energy."

Blyth's first wind turbine resembled a traditional English windmill. At its center, a wooden stem towered 33 feet high, anchoring four canvas sails, each eight feet long and three feet wide. As the sails spun in the wind, they turned a long vertical shaft, transmitting power into a 10-foot-wide flywheel and, eventually, 12 of Fauré's batteries.

After his success, Blyth developed a different design, essentially turning the turbine on its side. By strapping bisected barrels onto long wooden arms, he was able to create a turbine much more resistant to high winds, which caused trouble for the traditional windmill. Blyth patented his design in 1891, and in 1895, one was built at an asylum to be an emergency generator.

But with abundant coal and oil, wind turbines proved a hard sell. Blyth died after a seizure in 1906, and in 1914, his Marykirk windmill was taken apart. It wasn't until after World War II that wind turbine usage began to grow, using technology from airplanes for improved turbine blades.

Wind power today remains a fraction of the total electricity production in most places—roughly 10 percent in the United States. But wind energy made up nearly half of all new power added in 2020, and falling energy prices have made wind cheaper than nearly any other energy source.

"The wind is proverbially free, and is to be had everywhere," Blyth wrote. He dreamed of a future where each house would be lit by a wind turbine—a vision, Price says, that put him 50 or 100 years ahead of his time. Today's soaring, 300-foot-tall turbines would not fit atop individual houses, but they could certainly power them.

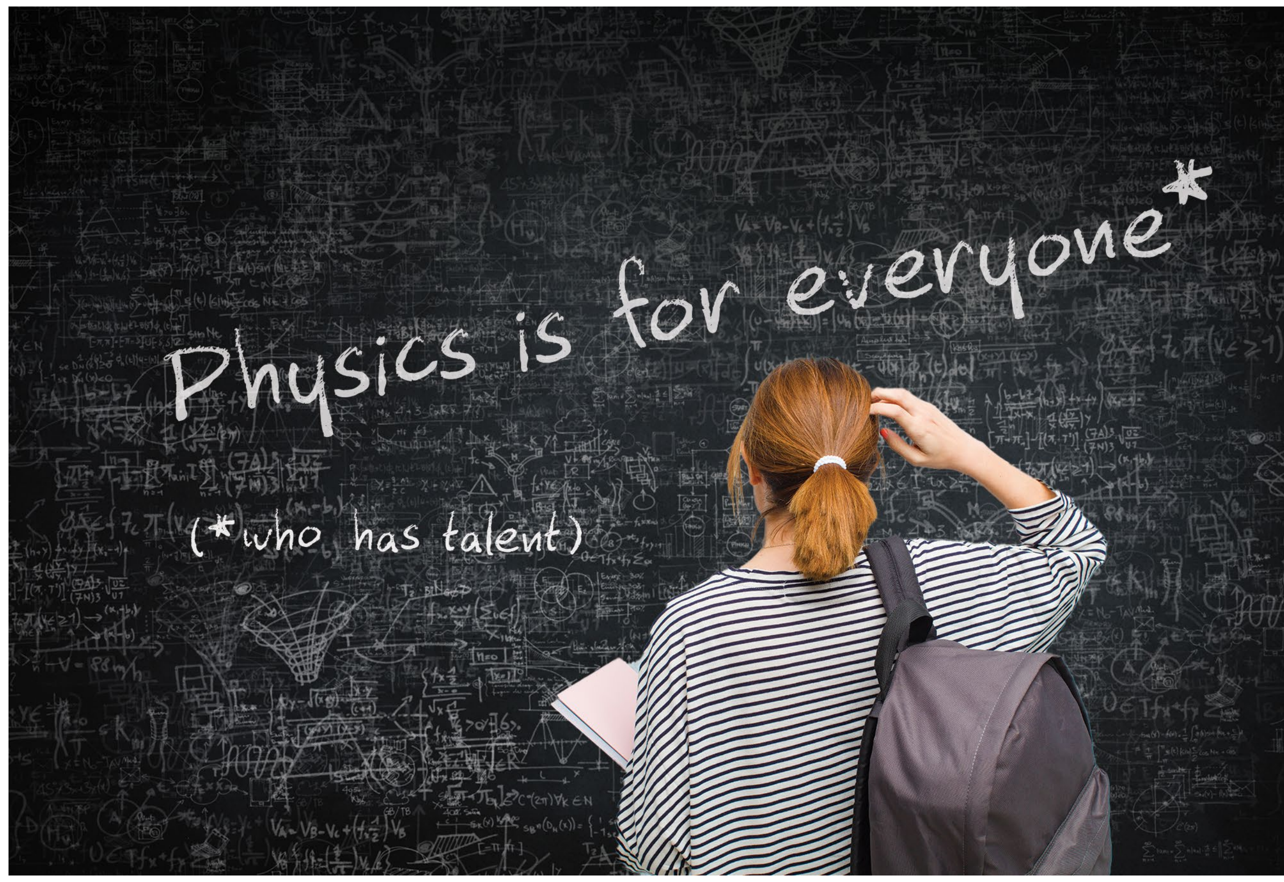
Daniel Garisto is a writer based in Bellport, New York.

THE BACK PAGE

What We Miss When We Focus on Physics "Talent"

BY DONNELL WALTON AND CARL WIEMAN

In this article, physicists Donnell Walton and Carl Wieman respond to Howard Georgi's opinion piece from the June 2022 issue of APS News, which argued that professors, to combat physics' lack of diversity, must think more expansively about physics talent. You can read Georgi's article at go.aps.org/georgicows.



In discussions about physicists and aspiring physicists, "talent" is a frequent metric. But there's one factor to which this gives short shrift: the importance of academic preparation in the leveling of the playing field.

Currently in the US, most K-12 students do not have access to the level of math and science preparedness afforded to students from wealthier families. When all these students land in the same introductory physics courses, those fortunate enough to have received excellent preparation are far more likely to be successful.

This is where professors make a mistake: They assume that students vary in their success because of talent instead of preparedness.

As physicists who study, and work to improve, diversity in physics, we have seen how widespread this assumption is, and how seriously it hurts efforts to bring historically marginalized groups into the field.

This mistake is an example of a well-known phenomenon in psychology called "fundamental attribution error—the tendency to assume that a person's behavior stems from internal factors (e.g., innate talent), while overlooking external factors that could be more important (e.g., preparedness).

This error rears its head in physics all the time. When Wieman's team surveyed university teachers about the main reason some of their students were struggling, 37% listed student deficiencies like "not working hard enough," "poor study skills," or "not motivated to learn." In reality, the primary reason for these students' difficulties is inadequate teaching—first experienced in their K-12 education, and then compounded in college. Good college teaching would be appropriate to their background and would use the most effective methods—by surveying the students' incoming preparedness, for example, and replacing lecture-based teaching with group projects and close guidance from the teacher—so that students can do well even if they had inadequate high school teaching.

The implications of this attribution error are profound. It means that looking for "talented" individuals, even using broader measures of talent, mixes up cause and effect. All our standard measures of talent primarily assess the quality of education a person has received.

Looking for "talented" individuals, even using broader measures of talent, mixes up cause and effect. All our standard measures of talent primarily assess the quality of education a person has received.

Rather than improving how we look for talent, we need to improve how we create and develop talent. We need to assume that most college students have the potential to be successful in physics, and that what is lacking is an educational system that meets them where they are and develops them into skilled physicists.

As an example of mixing up talent and educational privilege, Howard Georgi—in his piece in the June issue of *APS News*—mentions Ed Witten as an example of extraordinary physics talent. While we agree that Witten's contributions to physics have been exceptional, his education was equally exceptional. His father, a theoretical physicist, taught him calculus at age 11. He attended an elite private K-12 school renowned for its educational quality, and then progressed through a series of elite private universities.

Contrast that with the background of a more typical student, who we'll call Julia. Julia's parents, who did not go to college, work multiple jobs to pay rent and keep food on the table. Julia spends much of her time caring for her younger siblings and earning money for the family. Despite this, she does well in high school and even signs up for a physics course—but because of her public school's shrinking budget, there is no dedicated physics teacher. The class is taught by an underprepared substitute teacher, who does his best but admits he does not know physics. Julia struggles to teach herself. Still, she excels in most of her classes; she applies to, and is accepted into, a selective university, hopeful for a career in science. But despite working much harder than her wealthier classmates with stronger academic backgrounds, Julia struggles in her introductory physics and chemistry courses and ultimately abandons her career aspirations in science.

This is not a far-fetched example. Wieman's research group learned of such students when they sought to understand why a significant proportion of Stanford students did badly in introductory physics. Wieman's team found that, by simply measuring students' level of pre-college preparation, they could predict students' grades in introductory physics at Stanford and less selective universities. In fact, these measures were extremely good predictors of who would do very poorly and very well in these courses—tickets out of or into a STEM career. Moreover, most of the students scoring low on measures of preparation were students of color and/or the first in their families to attend college, and most were women. When Wieman's team interviewed these students about their high school education, stories like those of our hypothetical student, Julia—with poor or nonexistent high school physics instruction—were all too common.

While we applaud concern with improving diversity in physics, we believe that an emphasis on finding and encouraging talent, while downplaying the importance of teaching, is misguided. Only when we recognize the enormous importance of good education for becoming a successful physicist—and only when we recognize that universities are failing to provide a good education to many students who lack educational privilege—will we dramatically improve diversity in our field.

Dr. Donnell Walton

Dr. Carl Wieman

Dr. Donnell Walton is director of the Corning West Technology Center–Silicon Valley. Dr. Carl Wieman is a Professor of Physics and a Professor in the Graduate School of Education at Stanford University.