APS News

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How Do You Study Quantum Materials That Don't Yet Exist? Ask AI.

An interview with physicist Trevor David Rhone, 2022 recipient of the Joseph A. Johnson III Award, who tackles materials science with artificial intelligence.

BY SOPHIA CHEN

Each human technological era is defined by its materials: the Stone Age, the Bronze Age, or today's Silicon Age, if you will. Physicist Trevor David Rhone thinks we are approaching a Quantum Age.

To make the materials necessary to construct quantum computers, sensors, and more, Rhone is exploring a technique beyond mining and refining. He trains artificial intelligence models to explore the properties of yet-unmade materials. In fact, he's developing AI that, when given a desired application, will tell you how to design a new material, "much like you might ask Alexa today for a recipe to bake a cake," said Rhone, an assistant professor at Rensselaer Polytechnic Institute.

Rhone is the 2022 recipient of the Joseph A. Johnson III Award from the American Institute of Physics and the National Society of Black Physicists, for "scientific ingenuity and powerful mentorship and service." He credits his success in

Trevor David Rhone *Credit: Jen Pazour*

part to father, the famed Jamaican playwright Trevor Rhone, and his mother, Camella, who led Jamaica's equivalent to the U.S. National Institute of Standards and Technology. "She sparked my interest in science in general, and curiosity about the world," Rhone said.

Rhone spoke to *APS News* about his path to and in physics.

This interview has been edited for length and clarity.

You're from Kingston, Jamaica. What was it like growing up there?

I lived in Kingston until I left for college. I came from a middle class family, and life in Jamaica was very comfortable. I went to a Jesuit high school called Campion College, one of the better schools in the country. My parents more or

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New Technique Generates Non-Flickering Flames at Normal Gravity and Atmospheric Pressure

Flickering flames are more unstable. Researchers have come up with a novel way to keep them still.

BY KENDRA REDMOND

Dancing flames — in a fireplace, say — create a cozy ambiance, but flickering can impede a steady burn. That might be no big deal for the casual candle fan, but suppressing flickering could mean cleaner and more energy-efficient engines and furnaces, or help contain fires in spacecraft, where they can quickly grow out of control.

Now, scientists have generated nonflickering flames with a new method — varying the distance between two flames.

A flame flickers when its characteristic shape is distorted by the flow of the surrounding air or other gases. When buoyant diffusion flames are close together, like in a cluster of candles or gas burners, their flows interact, or "couple," causing coordinated flickering — and less efficient burning.

There are two main ways to suppress this synchronized flickering:

decrease the ambient pressure, or reduce the buoyancy of the flames, either with microgravity or by lowering the fuel mass burning rate. But in research published Jan. 23 in *Physical Review Applied*, a team at Toyohashi University of Technology in Japan, led by Yuji Nakamura, introduced a method that doesn't use either.

The team previously studied how two flames, on side-by-side gas

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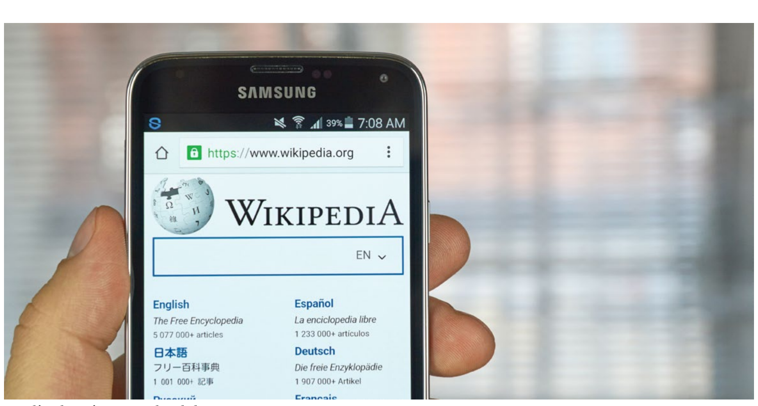
Wikipedia Has a Problem That Physicists Can Help Solve

APS's Wiki Scientist Program trains scientists to bridge the site's gender and race gap. Physicist Alexander Moreno is going even further.

BY LIZ BOATMAN



Credit: dennizn - stock.adobe.com

Wikipedia is a behemoth. As one of the world's most visited websites, the free, volunteer-written online encyclopedia has 60 million pages, 2 billion monthly users, and nearly 130,000 editors who have contributed in the last month.

It also has a problem.

Women and members of certain racial and ethnic groups are underrepresented in Wikipedia articles, including in science — a challenge that has plagued the platform since its launch two decades ago. For example, as of January 2023, just 19% of English Wikipedia's biographies were about women.

To help change this, the American Physical Society partnered with the nonprofit Wiki Edu in 2019 to launch the Wiki Scientist Program, which has now trained 84 people — including a Nobel Prize laureate —

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Now a Nuclear Physicist at Los Alamos, APS Bridge Program Grad Says Nuclear Security is His Calling

"[My mom] was my savior," says Jesus Perello. "She said, 'Listen, you did not go this far just to quit.'"

BY LIZ BOATMAN

Jesus Perello Izaguirre's favorite childhood memories are the gatherings his family held every Christmas in his hometown of El Progreso, Honduras. On Christmas Eve, eighty-some relatives would open presents together at the stroke of midnight, a tradition for many Hispanic families.

Life became harder after his father died, Perello says. For years, Perello's grandmother, already in New York City, had insisted it was time to relocate. In 2000, his mother made the difficult decision to move the family to the United States. Perello was 9 years old.

The move would set him on a path toward a doctorate in experimental nuclear physics, earned through the APS Bridge Program — which helps underrepresented students of color pursue PhDs — and ultimately a career in the field.

By middle school, Perello knew that math and science were his strongest subjects. He'd always loved science; as a boy in Honduras, he scoured his family's encyclopedia to learn about white dwarfs and black holes. And although most of his family worked in law and politics, he says, he was brimming with questions about the universe. Seventh-grade science was "where I would really pay attention, really focus," says Perello.

By high school, Perello's family had settled in Miami, whose vibrant Hispanic population made the city feel more like home than New York had. He joined the football team as

Jesus Perello, who earned his doctorate in physics from Florida State University in 2021, is now a physicist at Los Alamos National Lab. *Credit: Jesus Perello*

a starting offensive lineman. During his senior year, he took his first physics class. "I loved it," he says.

He loved it so much, in fact, that he asked his teacher to tutor him — not to catch up, but to learn college-level physics. Several days a week, prior to donning shoulder pads for football practice, Perello headed to a classroom to learn vector calculus and practice problems in classical mechanics.

After high school, Perello earned an associate degree in science at Miami Dade College. "I really enjoyed not just the observational side of physics, but the theory," he recalls. He decided to enroll at Florida International University (FIU), where he worked toward a bachelor's degree in physics.

"I was really attracted to nuclear physics," he says. "I wanted to understand the universe better, and the only way to do that was to go to school."

In 2014, the summer after his junior year, Perello got a taste of the field doing undergraduate research at Michigan State University. That summer, at the National Superconducting Cyclotron Laboratory (now FRIB), Perello became fascinated by the strong force, the fundamental force that binds subatomic particles.

At FIU, Perello worked with his McNair Scholars advisor to tackle the GRE and navigate graduate school applications. Together, they

Perello continued on page 6

Meenakshi Narain, 1964-2023

Particle physicist who was a 'force of nature' dies at 58.

BY DANIEL GARISTO

Meenakshi Narain, an experimental particle physicist who helped discover the top quark and pushed her field to be more diverse, died Jan. 1 in Providence, RI. She was 58.

She began accruing accolades early on, with one of Fermilab's prestigious Wilson Fellowships. At the end of her life, she was the physics chair at Brown University, a member of the Particle Physics Project Prioritization Panel (P5) and the Department of Energy's advisory committee, and a co-convener of the Energy Frontier during the Snowmass process. Narain was elected an APS Fellow in 2007.

In tributes, many described Narain as a "force of nature," citing her tenacity and will. "She's one of the most courageous people I know," says Tulika Bose, an experimental particle physicist at the University of Madison, Wisconsin. "I think her biggest legacy — of course, she did fantastic physics — but I think it's the way she has influenced people over the years."

Meenakshi Narain — Meena, to friends and family — was born in Gorakhpur, India, to Prem Narain Srivastav and Kusum Srivastav. "Her desire was to do very well in physics and go to America and do good research from the very beginning," says Brajesh Choudhary, a particle physicist at Delhi University and close friend. After receiving degrees from Gorakhpur University and the Indian Institute of Technology Kanpur, she matriculated to Stony Brook University in New York.

There, she worked on upsilon physics in a tight-knit team under Juliet-Lee Franzini. She also met a fellow student, Ulrich Heintz, and in 1988 the two were married with three weddings — in India with her family, in Germany with his, and in the U.S. to get a certificate. "In Germany, you have to go to City Hall two weeks before the wedding and post so that people can object, and that time constraint didn't work," Heintz explains wryly.

Narain made her way to Fermilab, where she and Heintz worked on the D-zero collaboration, then in hot pursuit of the top quark. As a postdoc, Narain was mentored by Boaz Klima, one of the top quark conveners. "I appointed her to be in charge of one of the key channels there, the dileptons," Klima says. "She did a fantastic job. Not only the dedication, but the precision. She would not take any shortcuts." The dilepton channel, in which both W bosons decayed to leptons, would prove crucial.

In February 1995, D-zero's top quark group had strong evidence for the eponymous particle and were preparing a long paper. But on Friday, Feb. 17, they learned that their competitor, the Collider Detector at Fermilab (CDF), was set to publish. Spurred, Narain and her colleagues wrote through the night and had a draft ready on Saturday. The next week, CDF and D-zero sent their papers to *Physical Review Letters* together, jointly announcing the discovery of the top quark. "One of the spokespeople of D-zero wrote to me: 'I don't think we would have been able to do the top discovery without Meenakshi quite like we did it. And I'm sorry, I never really told her that,'" Heintz says.

> In 2020, Narain was diagnosed with cancer as she began working on the Snowmass process to plan the next decades of particle physics. "She dedicated herself to it," Heintz says.

Despite her success, Narain was at times frustrated by her treatment. Her suggestions were often ignored until a male colleague chimed in. There was no maternity leave at the time, so Narain frequently brought her newborn son to work. According to Heintz, the experience at Fermilab helped lead her to fight for wom-

Narain continued on page 5

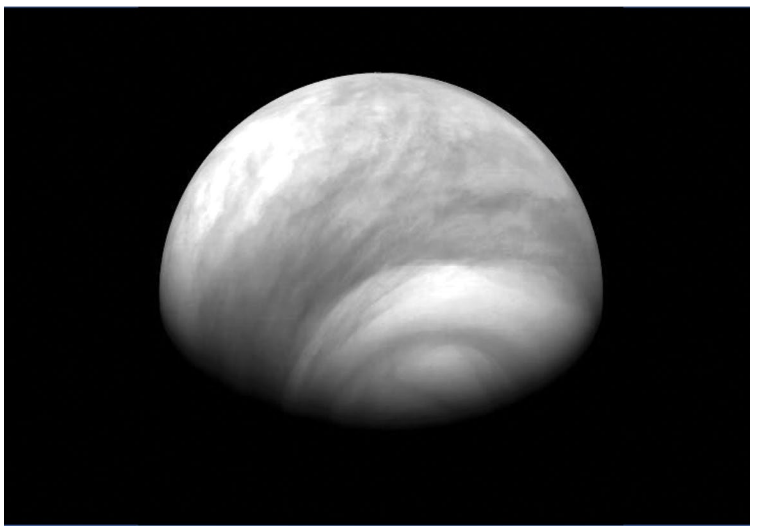
Meenakshi Narain examines possible top quark events at Fermilab's DZero experiment in 1995. *Credit: Reidar Hahn / Fermilab*

THIS MONTH IN PHYSICS HISTORY

March 1966: The First Human-Made Object Makes Impact With Another Planet

Venera 3, a spacecraft launched by the Soviet Union, crashes into Venus on March 1, 1966.

BY TESS JOOSSE



Venus, shrouded in clouds. *Credit: ESA/MPS/DLR/IDA*

Though named for a goddess of beauty, the planet Venus is, by Earthly standards, an odious place. Above a craggy volcanic terrain, clouds of sulfuric acid swirl, trapping noxious carbon dioxide like a greenhouse. The heavy atmosphere exerts 92 times more pressure than Earth's, and the temperature can reach a blistering 475 degrees Celsius (about 900 Fahrenheit).

On March 1, 1966, a spherical landing capsule crashed down on the Venusian crust and encountered these infernal conditions. Part of a spacecraft named Venera 3 ("Venera" is Russian for "Venus"), the uncrewed probe was launched by the Soviet Union in November 1965 — one in a long line of attempts to reach and study the planet. The probe's communication system failed in February, so it couldn't transmit data back to Earth. But when it hit Venus, near the shadow where night was turning into day, it became the first human-made object to touch the surface of another planet.

Venus, the second planet from the Sun and the second brightest object in the night sky, has long captivated humanity. But astronomers in the early 1900s "found Venus a really frustrating object," because its dense cloud layer obscured its surface, says space writer Brian Harvey in *Russian Planetary Exploration: History, Development, Legacy and Prospects*. Some scientists thought the planet, nearly the same size as Earth, could host life on its land or in its clouds. And in the public imagination, "Venus was a dripping wet, steaming, swampy, carboniferous planet," Harvey writes.

After the launch of Sputnik in 1957, Sergei Korolev, the chief designer of the Soviet space program, began planning a barrage of missions to the Moon, Venus, and Mars. "The level of activity ... in this period was frenzied," writes James Harford in the biography Korolev: *How One Man Masterminded the Soviet Drive to Beat America to the Moon*. The United States rushed to get its own probes to other worlds. The Space Race was in full swing.

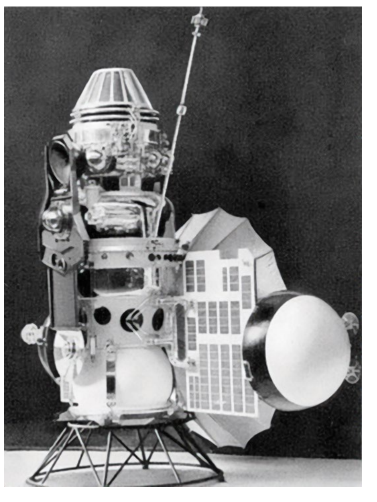
Korolev's team aimed to send up at least one probe during every available launch window (about every 19 months for Venus and 24 months for Mars). To meet such an ambitious goal, they designed a new type of spacecraft, denoted "MV" for Mars-Venus, which was standardized for ease of production but could be customized with different instruments based on the needs of each mission. Engineers also created a new version of the R-7 rocket, the world's first intercontinental ballistic missile, that could launch large payloads to the planets.

Early efforts weren't fruitful. The first Venus probe, sent in February 1961, fell back down to Earth 22 days after launch, and a second, which blasted off in the same window, lost radio contact after traveling for 10 days. Three more Soviet Venus missions, planned for launch in 1962, stalled, as did one from the U.S. — though on Dec. 14, 1962, the Americans pulled off a victory when their Mariner II probe flew past Venus and gathered data on its scorching temperatures, becoming the first ever successful interplanetary mission.

Amid these woes, Soviet engineers retooled the MV's thermal regulation system and outfitted its lander to better endure the stresses of descending onto Venus. This new probe was shaped somewhat like a baby's bottle, cylindrical with a tapered top, and was attached to a spherical landing capsule. A sheet of solar panels was affixed to its flank. In all, the craft weighed around 960 kilograms (more than 2,100 pounds), or about as heavy as a giraffe.

Two MVs were prepared for the fall 1965 launch window: Venera 2, which would fly by Venus, and Venera 3, which would land. Researchers stocked Venera 3 with scientific instruments, including ion traps, spectrometers, a cosmic ray sensor, and a magnetometer. Strapped to its side was the spherical landing probe that would drop down to Venus by parachute, packed with devices to measure the temperature, pressure, density, and chemical composition of the atmosphere. Another curious object was loaded on board: a metallic emblem, made of titanium and thermoresistant enamel and emblazoned with the U.S.S.R. state seal. This symbol was to be deposited on the surface of the planet; many Soviet space probes carried them during this era.

Venera 2 launched on Nov. 12. It flew within 24,000 kilometers (almost 15,000 miles) of the planet on Feb. 27, 1966, then lost contact with Earth before it could communicate any data. Venera 3 was fired off on Nov. 16. On March 1, 1966, after 105 days of traveling through the solar system, it entered Venus's atmosphere. But by this time all communication with the craft had been lost; a later post-mortem found that its solar panels and several internal components had overheated. Still, calculations of Venera 3's trajectory led scientists to believe that it crashed down on Venus that day.



Venera 3, the first human object to strike the surface of another planet. *Credit: NASA/NSSDCA*

No data could be collected, but with the U.S.S.R. and U.S. battling for Space Race milestones, some Soviet scientists still considered the mission a success. Control system designer Boris Chertok, Korolev's number two in the Soviet space program, lists the outcome of Venera 3 as "Mission accomplished" in his 1999 memoir *Rockets and People: Hot Days of the Cold War*. "Venera 3 deliv-

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You Think You Want a Summer Internship in Physics. Now What?

During the 2023 APS Conferences for Undergraduate Women in Physics, panelists shared tips on searching for summer opportunities.

BY LIZ BOATMAN

As an undergraduate majoring in physics, what you do with your summers, especially after your sophomore and junior years, can be important if you're planning to pursue graduate school or a career in the field. To help students, several of this year's Conferences for Undergraduate Women in Physics (CUWiP) offered workshops on exploring summer internships.

CUWiP — held annually — aims to increase the number of undergraduate women in physics, who currently earn 1 in 4 bachelor's degrees in the field. Through workshops, plenary sessions, and networking events, CUWiP provides undergraduate women with the tools and community they need to succeed in physics.

This January, around 1,800 undergraduate women gathered at 15 regional locations across the U.S. and Canada to attend CUWiP. APS has been CUWiP's institutional home since 2012, providing support for a growing number of conference sites; the 2023 CUWiP was one of the largest ever, and for many students, career and internship guidance was a key offering.

At the 2023 CUWiP at Argonne National Laboratory in Illinois, student attendees were coached on summer internships by five panelists, including Lindsay Buettner, university student program lead at Argonne; Kelly Garcia, doctoral student in engineering physics at University of Wisconsin-Madison; and Savannah Gowen, doctoral student in physics at the University of Chicago. Their advice is summarized below.

How do I choose between an internship and a regular job?

"I think sometimes students feel like if they're in a regular job, they're doing something wrong," says Buettner, but even "a regular job helps students build basic job skills — communication, time management, problem solving, leadership" — which makes working as a cashier or lifeguard, for example, a good starting point.

For more specialized skills, internships have an advantage. "Internships are really where you're going to build the technical skills related to your field," says Buettner.

Garcia adds, "If you're applying to grad school, you definitely want to have at least one internship experience" to give your application the best shot at success.

Gowen notes another advantage of internships: If you're a student from a small college, you can choose an opportunity that will give you a sense for what it's like

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Undergraduate attendees at the 2019 CUWiP at Northwestern University. Credit: APS Physics

Flames continued from page 1

burners, interacted. As they and others observed, when flames are close — separated by less than a critical distance (a function of burner size) — they flicker in sync, called "in-phase." When they're separated by more than a critical distance but still close enough to interact, the flames flicker in turn, called "anti-phase."

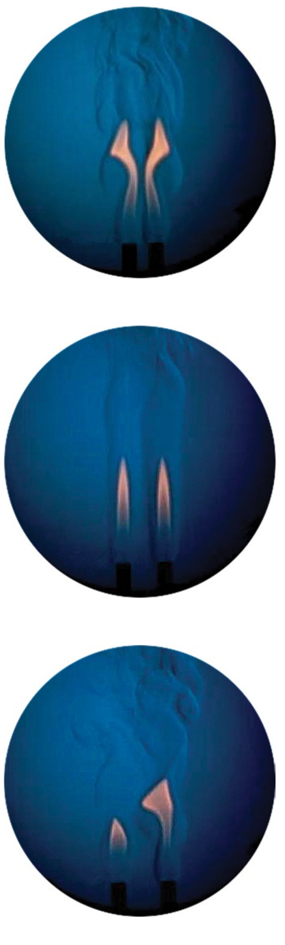
But the most interesting behavior occurs right at that critical distance, says coauthor Xiaoyu Ju. There, flames can flicker in-phase or anti-phase. If a phase flip occurs, it doesn't happen right away: Before a flip, the team always observed "a time delay," Ju explains, and "the flickering of the flames tended to cease at such moments." The team noticed a similar delay when two flames were ignited at that critical distance.

The researchers wondered: If they dragged out that delay, could they keep the flames from flickering for longer?

To find out, the team modified its setup so that one burner could move along a horizontal track. Then the researchers studied the flame interactions over different distances and burner velocities. They found that, under certain conditions, the flames were in a kind of purgatory — what the researchers call a "to be coupled but not yet coupled" state. They had induced an extended nonflickering state.

Key to achieving this was finding the Goldilocks velocity of the moving burner. If the burner moved too slowly, the flames coupled; if it moved too quickly, the flames decoupled. To induce the not-quite-coupled state, the burner velocity needed to keep pace with the fluid flow's response to the changing distance, Ju says.

Under certain conditions, the flames were in a kind of purgatory — what the researchers call a "to be coupled but not yet coupled" state. They had induced an extended nonflickering state.



From top to bottom, flames exhibiting in-phase flickering, no flickering, and anti-phase flickering. Credit: Xiaoyu Ju et al./APS 2023

Next, the researchers determined the parameters governing this kind of system. Their model, which could guide other researchers, describes "a feasible way to generate nonflickering flames in a moving dual burner system," the authors say.

Understanding flame-flame interactions is important for combustion technology, according to Jacqueline Chen, a senior scientist at Sandia National Laboratories who was not associated with the new research. They can affect burn rate and generate acoustic noise, she says — noise that, in a combustion chamber, "may lead to thermoacoustic instability, which may damage gas turbine combustors." In rocket engines, for example, this instability can cause major problems.

And noise isn't just an issue in combustion. The team's technique might be useful in electrical, optical, and other nonlinear systems, where it's important to suppress flickering noise, Ju says.

Chen also notes that certain fuels increase flame-flame interactions and their complexity. "Solving these challenges would enable broader adoption of hydrogen-rich fuels in gas turbines . . . and in long-haul marine shipping using blends of ammonia and hydrogen," Chen says. "It would also enable better strategies for mitigating greenhouse gas emissions."

Kendra Redmond is a writer based in Minnesota.

Wiki continued from page 1

Wiki Scientist Program participants have created or edited nearly 700 Wikipedia articles, including for (clockwise from top left) scientists Sau Lan Wu, Rediet Abebe, Katia Bertoldi, Peter F. Green, and Ilham Al-Qaradawi. Credit, clockwise from top left: DASwartz, Anoushnajarian, Mattcfernandes, Chairman of the Joint Chiefs of Staff, FeynmanFan4ever.

in editing boot camps to write and edit Wikipedia articles.

One of those trainees is Alexander Moreno, an assistant professor of physics at the Universidad Antonio Nariño in Colombia. Moreno's registration costs for the boot camp he attended were covered by a scholarship from the APS Forum on International Physics. Now, Moreno, a longtime APS member, is helping the Society develop its own project page on Wikipedia's sister site, Wiki Data.

Moreno and APS have many goals for the effort, known as the APS WikiProject, which will launch this spring. For example, the APS website has great data on physics degrees, but few people know where to find it, says Moreno. "The idea is to make that data more visible," he explains, by adding it to the APS WikiProject and thus to Wiki Data.

The project's team is also building a query feature that will allow Wiki Data users to sort through the Society's *Physical Review* journal collection to analyze, for example, how many articles have been authored by women or international contributors. And during future boot camps, participants will be invited to write biographies for individuals from underrepresented groups, such as "Latin American women physicists," Moreno says.

The hope is that the page will become self-sustaining and community-based, with multiple physicists pitching in, just as multiple editors often contribute to one Wikipedia article.

For Moreno, this project began a decade ago, long before the APS Wiki Scientist Program. He was listening to a scientific talk when the presenter did something unusual — he referenced data from a Wiki site. "I was surprised," says Moreno, because citing Wikipedia is usually discouraged within the scientific community.

Moreno's surprise gave way to intrigue. Many scientists value public outreach, he says, but often stick to traditional methods, like giving presentations in schools.

"That's one of our responsibilities — to try to communicate better with everybody, not only with other scientists," says Moreno. He says scientists should be working to engage the public "in all possible ways."

"When you Google something, one of the first returns you get is from Wikipedia," says Moreno. And if members of the public are already using Wikipedia to learn about science, then scientists should help write those articles, he reasoned. In 2021, he got his chance, enrolling in the APS Wiki Scientist Program through the APS website's public engagement page.

In his view, efforts like the APS WikiProject are examples of open science, allowing "the general public to have access to all the things we do as scientists, as physicists."

Moreno's work is just one example of the APS Wiki Scientist Program's impact. According to its public dashboard on Wiki Edu, the program's graduates have contributed to nearly 600 existing Wikipedia articles, mostly related to underrepresented physicists, and added almost 100 new articles. These articles have reached more than 24 million readers in less than four years.

The APS Wiki Scientist Program also runs Wikipedia edit-a-thons. One such event, held at the 2019 APS March Meeting, was attended by British physicist Jess Wade. Wade has contributed more than 1,750 articles to Wikipedia — including a page on APS Fellow and University of Chicago Provost Ka Yee Christina Lee, which has received over 42,000 views.

Moreno says that, often, he feels like efforts toward inclusion in physics lack tangible outcomes. "For instance, in the academic hiring process, we say that inclusion is important," says Moreno, "but in the end, sometimes we just look at whether you have a lot of articles in high-profile journals, and that's it." In contrast, the APS WikiProject could become a quantifiable effort toward measuring real inclusion within the field, he says.

Moreno is hoping that if enough people become involved, the project will achieve critical mass. APS members can help. It's a WikiProject, he adds, so "anyone can contribute."

Liz Boatman is a staff writer for APS News.

CUWiP continued from page 3

to be at a large research university, which can be helpful if you're considering grad school.

How do I decide what kind of internship to pursue?

Ask yourself what your goals are, says Garcia, and frame your goals as concrete skills you want to have by the end of college. "Let your interests lead you," she adds.

If you do a research internship this summer, you could try a private sector internship next summer, suggests Gowen, "so you get a little taste of both cultures." An academic environment can be very different from a company's.

Buettner echoes this. "An internship is a learning experience," she says. "It's like trying on different hats and seeing what fits." You might realize you don't like a certain subject as much as you thought. That's okay. Next summer, you can try a different area of physics to see if it suits you better.

How do I search for internship opportunities?

"Leverage your college or university networks," says Buettner. "Your career services office can help you prepare your résumé and help you with your job search."

"Scour your local resources," says Garcia, by "talking to your major advisor, your professors, and even your friends who might have already done research or had an internship." Asking around can also help you find opportunities on your own campus.

If there's a specific location where you'd like to intern, go directly to that school, company, or institute website and use its search tools, adds Gowen. Many national labs and companies have listservs you can sign up for, delivering opportunities directly to your email inbox.

Most internships branded as REUs (research experiences for undergraduates) are funded by the National Science Foundation (NSF). "The NSF actually has a super convenient web page with a listing of all the host institutions and links to their various programs and coordinators," says Gowen. You can browse thousands of NSF-funded REUs across the country.

What if I'm an international student?

U.S. government-funded internships, like REUs, are typically not available to international students. Instead, search for opportunities in the private sector or direct-paid research internships on college campuses.

Some international students might be interested in opportunities abroad, like in Europe. If so, focus your search on institutions and companies in your countries of interest. In fact, this is a great option for *any* physics student interested in experience abroad during college but lacking the curriculum flexibility to do a full semester or year abroad.

How do I put together a strong application package?

Buettner says to give yourself plenty of time to apply, including time to draft personal statements, get feedback, and revise them. And when you seek feedback, ask both a professor and someone outside the field, she says.

"That way, you have a content expert checking for details that are related to your major … [and] a non-expert who's going to focus on the big picture, like readability," says Buettner. "Remember, sometimes it's an HR professional reviewing applications, not a physicist. They need to be able to understand your application too."

"Always have a really strong letter of recommendation," adds Garcia. In your first few years of college, focus on "developing good rapport with your professors — going to office hours, talking to them about your interests," she says. This will help you feel more confident when you ask one of these professors for a recommendation letter. And be sure to "give your recommenders the minimum of two weeks to complete their letters," reminds Buettner.

Importantly, Garcia says to make sure you "don't underestimate yourself." As you put your application together, focus on "knowing what your strengths and weaknesses are … Being able to articulate what you're willing to learn," she says. Gowen has another interesting piece of advice for your personal statement: "The point isn't to sound smart," she says, but to "show who you are and how you can uniquely contribute to a scientific project."

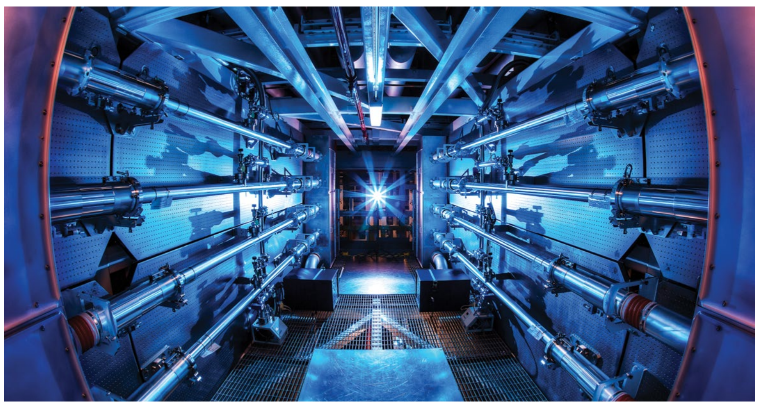
Liz Boatman is a staff writer for APS News.

Five Science Policy Stories to Watch in 2023

BY THE FYI TEAM

In the last two years, lawmakers passed landmark legislation that couples new support for research and development (R&D) with big ambitions for industrial growth, including the CHIPS and Science Act, Infrastructure Investment and Jobs Act, and Inflation Reduction Act. The Biden administration now seeks to swiftly implement the bills, which provide billions in direct funding for new initiatives.

However, most federal science programs still depend on annual appropriations and could face headwinds this year in a divided Congress. But even with partisan gridlock, 2023 is poised to be another busy year for science policy. Here are five stories to watch in the months ahead.



Preamplifiers of the National Ignition Facility at Lawrence Livermore National Lab, which achieved fusion "ignition" in December 2022. Large-scale fusion faces enormous hurdles. Credit: Lawrence Livermore National Laboratory

Test begins for Biden-era industrial policy

The Biden administration will face challenges as it begins implementing the new R&D programs and technology deployment incentives approved by the previous Congress. These include building up capacity within the Departments of Energy (DOE) and Commerce to administer funding and oversee projects. The initiatives will test the possibilities of industrial policy, in which the government actively steers technology development to promote economic transformation. Primed by the promise of federal subsidies, many companies have announced follow-on investments that the Biden administration now hopes to build on by fostering new "ecosystems" that better connect R&D with manufacturing, and that supply companies with financing, tools, materials, and workers. While some of this funding received bipartisan backing, Republicans have said they will closely watch these initiatives for signs of failure.

Divided Congress sets up rough road for science funding

With Republicans holding a narrow House majority, the party's far-right flank is pushing for steep cuts in federal spending, setting up high-stakes standoffs with the Democrat-controlled Senate — including over raising the statutory debt limit by this summer and passing spending bills for fiscal year 2024, which starts Oct. 1. Science agencies would be hit indirectly by the economic fallout of a debt default and directly if Congress does not pass new appropriations bills, adding to current strains from inflation and supply-chain disruptions. Congress likely faces an uphill climb to meet the science budget targets in the CHIPS and Science Act, which largely includes only direct funding for semiconductor initiatives. The Biden administration may also need to rein in its ambitions for the National Science Foundation (NSF) and the Commerce Department, where other CHIPS Act initiatives were planned.

Particle physicists plot new directions for the field

U.S. particle physicists will chart a course for the next decade and beyond in a report, due this fall, from the Particle Physics Project Prioritization Panel (P5). Like the last P5 study, released in 2014, the report will propose a budget-constrained agenda for federal agencies, drawing on input gathered from the research community at last summer's "Snowmass" conference. A recent summary report from the conference affirms the five science priorities identified by the last P5, while recommending a new focus on precision measurements of rare processes. It also proposes the U.S. prepare to "participate in or build" an electron-positron "Higgs factory," a subsequent high-energy muon or hadron collider, and a next-generation gravitational wave observatory.

Fusion faces opportunities and setbacks

Lawrence Livermore National Laboratory's recent achievement of fusion ignition stoked public interest in the potential for fusion power plants, though lab leaders cautioned that the prospect remains distant. Magnetic confinement fusion could offer a shorter path to commercial fusion energy than Livermore's laser-driven method, and private fusion companies have raised billions of dollars in recent years, hoping to bring a magnetic fusion power plant online as early as the 2030s. The Biden administration is betting on it, launching a milestone-based development program to support the industry. However, the world's largest magnetic confinement experiment under construction, ITER, recently discovered major manufacturing flaws that may delay the project by years, on top of a separate three-year delay expected because of the pandemic and supply-chain issues.

Equity push unfolds across science agencies

The Biden administration is also ramping up efforts to promote equity and inclusion in STEM fields. The DOE Office of Science's new RENEW and FAIR programs will support workforce training and build research capability at institutions that have been historically underrepresented in the office's portfolio. Federal agencies are also reworking their grant review processes to better incorporate equity. For example, the DOE Office of Science now requires grant applications to describe how they plan to promote inclusion in their research projects, and the NSF is reviewing the "broader impacts" criterion it has long used when reviewing proposals.

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ered a pendant with the emblem of the Soviet Union to the surface of the mysterious planet," he writes. "We can say this with complete confidence, despite the fact that we lost radio contact with the spacecraft before its approach to the planet."

What's left of Venera 3 still lies somewhere on Venus's hostile surface, a reminder of humanity's first contact with another world.

Both the Soviet Union and the U.S. made further trips to Venus in the following decades (Venera 9 and 10 took the first photos of its surface in 1975), but Earth's sister planet is still shrouded in mystery. Several future missions to Venus are planned, including NASA's DAVINCI, which is scheduled for launch in 2029 and will study whether the planet's atmosphere holds components of water. If all goes to plan, DAVINCI will drop down to Venus's surface and gather data as it descends. It could last up to 18 minutes on the mountainous terrain before succumbing to the hellish pressure and heat — if it survives the landing.

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

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less allowed me to pursue whatever I wanted.

Academia in Jamaica is female-dominated. A lot of the girls in school did much better than the boys, so my vision of a bright student was often a woman. My mother was the embodiment of knowledge to me; when I'd ask her a question, she would always have the answer.

Your dad co-wrote *The Harder They Come*, the internationally acclaimed 1972 film. Were you aware of his fame growing up?

He's extremely famous in Jamaica. I was very proud of him when I was growing up and would often see his plays. One of his books was on the exam syllabus for the Caribbean regional examination, similar to the SATs. I remember one time going through customs at the airport and being asked if we were related.

> "A typical experiment takes a month or more to make a new material and characterize it, so it would take 30,000 months to explore all the variations [on chromium telluride]. ... Enter AI." — Rhone

When did you become interested in physics?

In high school, I had a wonderful physics teacher, Mr. Henry, who made the subject really fun. I pursued it in college because it was such a good experience.

In undergrad, I was also pre-med. My goal was to become a physician. In Jamaica, you have three career options if you're bright — you can become a lawyer, engineer, or physician. When I was a teenager, I didn't want to do law because I thought you had to study history, and I wasn't good at history. Engineering to me meant wearing a hard hat and building bridges, which I didn't think was interesting. Medicine seemed cool until I realized I didn't like having to memorize things. Learning physics was more fun.

You studied 2D materials at graduate school in Columbia University. How did you become interested in this?

When I was looking for research groups at Columbia, I happened across the webpage of Horst Störmer, who won the Nobel Prize in 1998 for discovering the fractional quantum Hall effect. In this effect, particles in a material collectively behave as though they are fractions of charge when you confine them in two dimensions in a high magnetic field. I thought that was so bizarre. I ended up working with Aron Pinczuk, who pioneered the study of these systems using light scattering.

How did you get into AI?

I had the idea in grad school to combine artificial intelligence and materials research back in 2007 or so, to help my adviser on a project to grow graphene samples. I thought that AI could help us select the temperature and other parameters to grow these samples more consistently. The idea was in the back of my head, and in 2015, I wanted to move away from experiments. Data analysis is probably my favorite part of my research, so I started working in artificial intelligence for materials research.

What role does AI play in the materials discovery process?

For example, I was studying a material called chromium germanium telluride. It consists of a plane of chromium atoms in a hexagonal lattice, with a germanium atom and a tellurium atom below and above. If you swap the germanium for silicon, you dramatically change the material's magnetic properties.

I wanted to know, how would the properties change if you replaced germanium with tin, manganese, or some other element? I calculated the possibilities — there are 30,000 variations on chromium telluride. A typical experiment takes a month or more to make a new material and characterize it, so it would take 30,000 months to explore all the variations.

Instead of making these materials, I simulated 200 of them over half a year. Enter AI. I trained the AI to make a mathematical model that related these simulated materials' structures and chemical compositions to their properties. I could then interpolate that model to predict the properties of related materials that haven't been simulated, in seconds. You can use this method on a laptop to quickly screen materials candidates for a particular application rather than making materials somewhat blindly based on chemical intuition.

You volunteer with the National Society for Black Physicists. How did you get involved?

I went to their meeting for the first time as a grad student. At the time, I was the only Black student in the entire department at Columbia. So it felt good at the meeting to be in a space where people looked like me, and I didn't feel judged. I've been going every year since 2008, except the COVID years. In recent years, I've organized the condensed matter physics part of the conference. I've judged the poster competition and encouraged students to continue their education. One gratifying moment was when a student came up to me at the meeting and told me, "Hey, you're the reason I'm still in grad school."

If you could give a piece of advice to your younger self, what would it be?

When I was young, I was focused on finding exciting research to do. Looking back, this approach was naïve. It's important to also research the people you want to work with. If they're toxic people, that can be damaging to your career. During my early years, I had some negative interactions with colleagues, where I felt some people wouldn't even treat me like a human being. When I worked with a more supportive group, I felt I was free to actually do science.

Sophia Chen is a writer based in Columbus, Ohio.

With Sloan Foundation Funding, APS Expands Programs Supporting Ukrainian Scientists

Independence Monument in Kyiv, Ukraine. Credit: Valentin Kundeus

Since Russia's invasion of Ukraine, the American Physical Society has worked to help affected physicists and students. APS offers these physicists free APS membership and meeting registration, and it has matched APS Unit donations to the National Academy of Sciences' Safe Passage Fund, raising nearly $100,000 to support scientific work disrupted by the invasion.

Now, with Sloan Foundation funding, APS is expanding two existing programs to support affected physicists.

APS International Research Travel Award Program (IRTAP)

Since 2004, IRTAP has supported research collaborations between physicists in developed and developing countries. The program provides a pair of collaborators a $2,000 grant, typically funding a physicist's travel from a developing country to a collaborator in a developed country. So far, it has funded 99 teams representing 46 countries.

With the two-year Sloan grant, APS is expanding the program to specifically support physicists affected by the invasion, enabling them to visit collaborators in other countries and receive larger grants for longer visits.

APS Distinguished Student (DS) Program

Since 2015, the DS Program has funded travel and registration for outstanding international graduate students to present their work at APS March and April Meetings. So far, the program has awarded 81 grants.

With Sloan's support, a new branch of the program will focus solely on supporting students affected by Russia's invasion. Ukrainian students can receive expanded awards that support visits to annual APS meetings and any APS Unit meetings. Funds are also available to augment these meetings with additional visits to universities or other institutes.

To learn more about APS initiatives supporting scientists and students, visit aps.org/programs/international.

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en and underrepresented minorities in particle physics.

"She was a true warrior. She fought and fought," Klima says. "There were many people that were not happy with that — very senior people that were offended. She didn't call people names, but she pointed out that we could do a lot better."

After Fermilab, Heintz and Narain both accepted jobs at Boston University, where she began to mentor students. "I always felt protected," says Kevin Black, a particle physicist at the University of Madison, Wisconsin and a former graduate student. "I try to emulate her as an advisor to my students, and postdocs, but I can't do as good a job as she did." Once, Black recalls, Narain flew from Boston to Fermilab to pull an all-nighter with him just so that his analysis worked.

In 2006, Narain joined the Compact Muon Solenoid (CMS) at CERN in Switzerland, where she built off her experience at D-zero to search for physics beyond the Standard Model with top quarks. To do these analyses, Narain also adopted what were, at the time, novel analytical techniques such as boosted decision trees, a form of machine learning.

Narain at her home in Providence, RI, in May 2020. Credit: Ulrich Heintz

As a physicist, Narain was supremely organized. "She had these spreadsheets ... and she could always answer every question: 'This is gonna take that long' and 'you need that many people,'" Heintz says. "She had an organizational talent — it started privately from organizing parties ... she loved to have a big celebration for Diwali, or Holi."

Narain also leveraged these organizational skills to push for changes in CMS. Using her influence as chair of the U.S. CMS Collaboration Board, Narain got the group to change its procedure for filling leadership roles so that diversity — of gender, geography, race, and more — were all considered. "She made a huge difference there because she would really question everything in the process," says Bose. In addition to her advocacy within CMS, Narain helped establish research opportunities for students from HBCUs and organized conferences for women in physics.

In 2020, Narain was diagnosed with cancer as she began working on the Snowmass process to plan the next decades of particle physics. "She dedicated herself to it," Heintz says. "I think it was a way of forgetting the misery of chemotherapy." The Energy Frontier report contains her vision for the next several decades, one in which the Higgs is scrutinized to its fullest extent, and powerful new colliders explore energies above 10 TeV. "This report will be one of her enduring legacies, and a result of her guidance, leadership and vision," its dedication reads. "We will miss her."

"We lost a real giant," Black says. "A person who really just had the energy and the capacity and the strength to keep on pushing for what she thought was right."

Daniel Garisto is a writer based in New York.

THE BACK PAGE

What Can U.S. Scientists Do to Help Their Ukrainian Peers?

Raymond Orbach shares his experience getting funding to physicists in Ukraine.

BY RAYMOND ORBACH

A flag flies above Peremohy Park in Brovary, an eastern suburb of Kyiv, Ukraine, before the war. *Credit: Maksym Diachenko / Wirestock*

On Feb. 24, 2022 — around one year ago — Russia launched a brutal attack on Ukraine, invading cities and towns and destroying lives and livelihoods. The Ukrainian people remain fiercely strong, even as missile attacks still lay waste to homes, shops, and schools.

There is another victim of Russia's atrocity: science. For decades, Ukraine was a bastion of research, which thrived in cities like Kyiv and Kharkiv and attracted international collaboration. In the 1980s, I myself worked with a brilliant Ukrainian physicist, Igor Orestovich Kulik, of the Verkin Institute for Low Temperature Physics and Engineering in Kharkiv (he passed away in 2019).

But from the war's beginning, Russia was undiscerning in its assault, bombing universities and research institutions and killing scientists and other civilians. By mid-April, the war had displaced millions, including one-sixth of Ukraine's scientists — some 15,000, according to Vaughan Turekian, executive director for policy and global affairs at the U.S. National Academies of Sciences.

Remarkably, though, research in Ukraine continues — a testament to the strength of its scientists. Just as military aid from the United States and European Union has helped blunt Russia's assault, so foreign support has helped Ukrainian scientists persist. The American Physical Society, for its part, has programs and funding to assist scientists and students in Ukraine.

We working physicists can add to these efforts, as I learned firsthand last year. On April 4, 2022, the Department of Energy's Office of Science published a 'Dear Colleague' letter that said scientists could request funding "to enhance ongoing research efforts by supporting students and scientists at U.S. institutions or by supporting remote collaborations for students and scientists already located at European institutions."

One supplementary note added, "Supplements may be requested to place personnel in currently funded research groups, or to support sub awards to new institutions, *including European institutions, that complement currently funded research groups*" (italics mine).

In other words, through the DOE, U.S. scientists with existing DOE funding could directly fund their Ukrainian peers. I marvel, even now, at such a timely and effective commitment by a U.S. agency to protect scientists whose lives and work risk being torn apart by this war.

To utilize the program, I first had to find a scientist whose research areas overlapped with mine. Working through multiple contacts, I found a perfect fit: Dr. Maxym Dudka, a physicist at the Institute for Condensed Matter Physics in Lviv, western Ukraine's largest city. Russian attacks have not reached his research institute, though Russian forces have bombed Lviv.

Dr. Dudka studies the critical properties of 3D magnets with random anisotropy, finding critical exponents and universal dimensionless ratios — a perfect complement to my work on spin glasses near their condensation temperature, for which I have DOE funding.

I reached out to him, and over the course of a few weeks in May 2022, we drafted a proposal for a grant that would supplement my existing DOE-funded research. True to the DOE's letter, the proposal was reviewed quickly, and funding arrived at my university, the University of Texas-Austin, in late September 2022.

But funding in Austin would not help Dr. Dudka. The next step was getting the funds to Ukraine.

Generally, grants from the federal government are administered through the institutions that receive them, like universities and laboratories, which must follow the government's grant terms. UT-Austin, then, was responsible for administering the supplement so that funds could flow to Dr. Dudka and his institute.

Normally, this is handled through a subcontract in my own grant. This subcontract would funnel money to the subcontractor — in this case, Dr. Dudka's institution. But what I didn't know then is that, at most universities, these transactions require the receiving institutions to register with SAM.gov, a secure federal platform.

At that time, Dr. Dudka's institute had not registered. We needed to find another route.

Fortunately, we found CRDF Global, a nonprofit authorized by Congress in 1992 that supports international scientific collaboration through grants, training, and technical resources. The organization has offices in Ukraine, which have operated continuously through the war, and SAM.gov credentials. It has become a financial go-between for U.S. universities and Ukrainian institutions — including for precisely the transaction that UT-Austin needed for Dr. Dudka.

With CRDF Global's help, the plan worked. The funds will support Dr. Dukda's and his graduate student's salaries, as well as related equipment, travel, and research, and the Institute's overhead expenses.

Many Ukrainian institutions are now registered with SAM.gov, meaning that direct subcontracts may be a viable path; CRDF Global is, of course, another option.

To utilize these grant proposals via either route, though, you must have a scientific relationship with someone in Ukraine. In other words, you need to identify a Ukrainian scientist or group whose research interests fit into your existing grant objectives.

Luckily, there are resources that can help. The National Research Foundation of Ukraine (NRFU) maintains a public repository of opportunities. A scientist can send NRFU (nrfu@nrfu.org.ua) a one-paragraph statement of their research interests and contact information. NRFU will post the blurb on their website, and Ukrainian scientists with shared research interests can contact the blurb's author. The duo, or their respective teams, can decide whether to pursue a joint supplemental grant.

To my knowledge, aside from the DOE, other federal agencies have not yet written 'Dear Colleagues' letters that invite this kind of joint grant work. That should not deter you from contacting these agencies to find out what might be possible.

As the DOE's 'Dear Colleague' letter notes, these supplements aim to "protect the well-being and livelihood of students and scientists impacted by the war by maintaining strong connections to the worldwide scientific community." Whether through DOE or other agencies, these grants can bolster the professional and scientific lives of our peers in Ukraine. I hope this article inspires others to use these funding opportunities.

In just over a year, Ukraine's scientists and students have shouldered a lifetime's worth of strife and struggle. Displaced, under attack, their rights and lives at risk, they remain fiercely dedicated to the pursuit of science.

In my view, it is our responsibility as research scientists to find ways to help — to assist those deprived of decent working conditions by an unjust and unprovoked war. As governments around the world rally to support Ukraine's war efforts, so we scientists should rally to aid the work of our Ukrainian peers.

Raymond Orbach is a theoretical and experimental physicist, a professor at the University of Texas-Austin in physics and mechanical engineering, and an APS Fellow. He has been involved in science policy for decades, including as the under secretary for science at the Department of Energy from 2006 to 2009.

Rubble of the V. N. Karazin Kharkiv National University after Russian attacks.
Credit: National Research Foundation of Ukraine

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planned for Perello to pursue his doctorate at a Bridge Program site.

In 2017, Perello transitioned to graduate school at Florida State University (FSU). "[It] was challenging on both ends — the academic side and the personal side," says Perello. He moved to FSU early and joined Sergio Almaraz-Calderon's research group. Almaraz-Calderon was a new hire, so his research program was new, too.

For Perello, hands-on, experimental nuclear physics research was a major change from the simulation work he had done at Michigan State. "When you work in the lab, you have to be a jack of all trades," he says. Over the next six years, Perello learned the coding, electronics, and experimental design necessary to run neutron detectors, which he used to study the reactions that form elements in stars and take place in stellar explosions. "[FSU] was a fantastic school," he says. "I had great professors."

Earning his doctoral degree through the Bridge Program gave Perello flexibility with his path: He was allowed to defer his qualifying examination by a year, to get more coursework under his belt. When he failed the exam on his first two attempts, he questioned whether he had what it would take to make it, he says. That's when his mom stepped in. "She was my savior," he says. "She said, 'Listen, you did not go this far just to quit. Either fail or keep going. But don't just quit.'"

Perello doubled down on his studies and took the qualifying exam again. This time, he passed. For the former football player, it felt like a game-winning goal in double overtime, with a stadium full of family, mentors, and friends cheering him on.

In 2021, Perello graduated, got married, and was offered his first job as a nuclear physicist. "It was a great year," he says. He remembers the joy on his mother's face the day he graduated. "My mom couldn't stop crying," he recalls.

Now, as a postdoctoral researcher at Los Alamos National Laboratory in the Intelligence and Space Research Division, Perello works with space-based radiation detector technology that can monitor international compliance with nuclear treaties, including the Limited Test Ban Treaty of 1963. Los Alamos has been involved in developing these detectors for 60 years.

At the APS Division of Nuclear Physics meeting in October 2022, Perello presented his team's recent work with the SENSER CLYC experiment, which launched a satellite payload — complete with neutron and gamma ray detectors — in December 2021. The team received the Secretary of Energy's Achievement Award in 2022 for the work.

He's learning every day, he says — about nuclear fission, near-Earth space radiation, and solar activity.

With about half a year left in his current appointment, Perello is thinking about what comes next. Perhaps his path will take him to a U.S. defense contractor or even NASA, he says. But mostly, he'd like to stay at Los Alamos. "I really enjoy it," he says.

Liz Boatman is a staff writer for APS News.