APS News

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A gallery of fluid motion inspired by Leonardo da Vinci

In a Salt Lake City museum, the Traveling Gallery of Fluid Motion invites visitors to connect art and science, as the famous Italian polymath did.

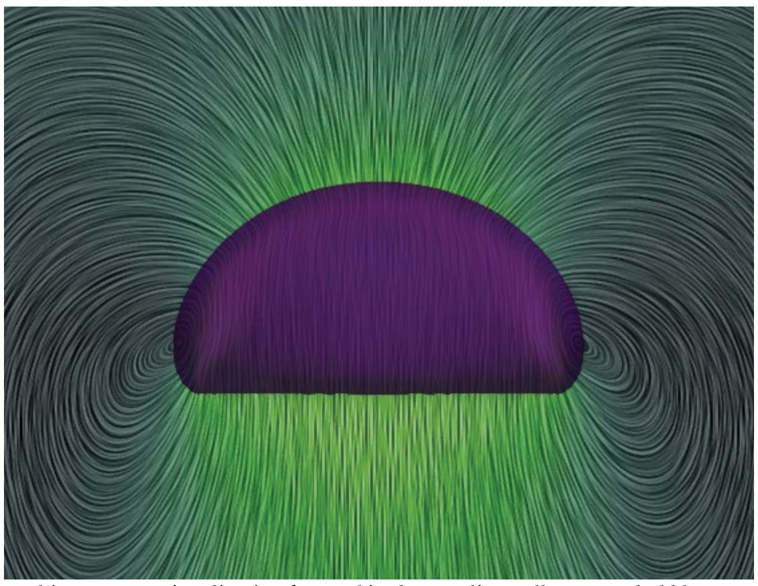
BY ERICA K. BROCKMEIER

Below his 15th-century sketch of the machine now known as the "aerial screw," Leonardo da Vinci mused that "if this screw device is well manufactured... and if the device is quickly rotated, the screw will engage itself in the air and it will rise up on high."

More than 500 years later, the aerial screw and many of da Vinci's other designs continue to inspire research, from real working drones to rigorous simulations.

Now, one such simulation — a swirling column of air currents around an aerial screw — is one of 34 pieces on display at The Leonardo, a science and art museum in Salt Lake City. As the second iteration of the Traveling Gallery of Fluid Motion, an initiative coordinated by the APS Division of Fluid Dynamics, the exhibit, "Spiraling Upwards," explores the intersection of fluid dynamics, flight, and the works of da Vinci.

The Gallery of Fluid Motion began in 1983 to showcase the beauty of fluid mechanics. Scientists would submit videos and posters, and winning entries would be announced at the division's annual meeting. But as the contest ballooned in popularity, its organizers sought new ways to grow. Now, a "traveling" version is exhibited at a museum in the annual meeting's host city.



In this computer visualization featured in the traveling gallery, a gas bubble — deformed into an oblate ellipsoidal cap at low speed — rises in a viscous liquid. Credit: Andre Calado

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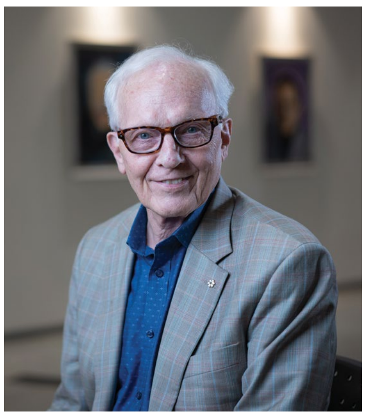
Paul Corkum's journey from experiment to theory and back again

An interview with the 2025 APS Medal winner and attosecond science pioneer.

BY ERICA K. BROCKMEIER

While Paul Corkum considers himself a "natural experimentalist," he admits that others likely think of him as a theorist. It even came up during his interview with the National Research Council of Canada, where he was hoping to land a postdoctoral role in an experimental plasma physics lab after earning a Ph.D. in theoretical physics.

"In graduate school, my wife used to get embarrassed when our old car would spew smoke, [so] I got a book out — like a good theorist — opened it up and started taking the car apart," he recalls. "I replaced the pistons, bearings, and other parts, put it all back together again, and it started right up. So when I was being interviewed for the postdoc position, they asked me, 'What makes you think you can do experiments?' and I told them, 'I can take my car apart, put it back together, and it works,' and they gave me the job."



Paul Corkum Credit: Wolf Foundation

This expertise in both theory and experiment has shaped Corkum's decorated research career. As one of the pioneers of attosecond science, Corkum helped shape our current understanding of how intense light pulses, lasting just one-quintillionth of a second, interact with

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Persistence pays off for APS Bridge Program graduate, now aviation data scientist

In her role identifying aviation safety risks, Daniella Roberts uses the skills she learned as a Ph.D. candidate in physics.

BY KENDRA REDMOND

As a kid, Daniella Roberts learned all she could about the moon, stars, and planets from Microsoft *Encarta*, a now-discontinued digital encyclopedia, and the night sky — although it was tricky to use her telescope from the family's apartment window in Quito, Ecuador.

Now a Ph.D. physicist with expertise in satellite galaxies, Roberts knows how entwined physics and astronomy are. But when she first took physics in tenth grade, she wasn't enamored. She thought the subject was too math-heavy and overly complicated. "I actually hated it," she says.

Her road from loathing physics to her current role — using her physics Ph.D. to identify aviation safety risks for the Federal Aviation Administration — was paved with resolve. Roberts credits the support of her parents, advisors, and the APS Bridge Program, which provides an alternate pathway to graduate school for minority students, for helping her realize her goals.

Daniella Roberts graduated from Ohio State with a Ph.D. in physics. Credit: Abby Reilly

The first inflection point came in Physics II, a required class in Ecuador's high schools. "That teacher made me fall in love with the subject," Roberts says. She loved it so much that, after her family moved to

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Don't lecture — communicate!

Astrophysicist Neil deGrasse Tyson shares thoughts on why and how scientists should communicate with the public.

BY MATTEO RINI

Few physicists are as familiar to the general public as Neil deGrasse Tyson, the astronomer and science communicator who directs the Hayden Planetarium at the American Museum of Natural History in New York City. He has popularized science through books, radio talk shows, documentaries, and many other media appearances. He was featured alongside Superman in a DC Comic and appeared in the TV series *The Big Bang Theory* to defend Pluto's demise as a planet.

Earlier this year, DeGrasse Tyson was honored for his contributions to science at the 25th Stars of Stony Brook Gala, a fundraising event that collected over $2 million for student scholarships at Stony Brook University in New York. Speaking at the ceremony, he stressed the importance of science literacy in today's world, particularly in view of climate change.

"STEM fields are necessary for the survival of our civilization," he said. "You need STEM wisdom so that the future generations will be proud of the decisions we make in this generation."

At the gala, deGrasse Tyson shared with *Physics Magazine* his thoughts on science communication. This interview has been edited for brevity and clarity.

Credit: StarTalk/C. Picadas (foreground); Zhong Jie Chen/stock.adobe.com (background)

Should scientists consider outreach as part of their duties?

Unless you're a researcher in industry, the work you do is funded by taxpayers. So all of us, whose livelihoods depend on the public embracing what we do, have a duty to give something back. Journalists do a great service in building bridges between science and society, but I think the world would be better off if more scientists did that as well.

Yet many scientists feel unprepared to communicate. Why do you think that is?

Unfortunately, the system does not reward reaching out to the public. At best, it's neutral. But in some circles, it's even counted against you. "Why aren't you in the lab?" is one of the reproaches.

Is there anything that universities or academic institutions should do?

Perhaps communication of your field to nonspecialists should become a requirement for all graduate students. One day you might have to talk to a member of Congress. Or you might be at a cocktail party and talk to someone important who has influence over funding or grants. You can't keep promoting a priesthood where only a select group know what's going on and others don't. I am reminded of the cancellation of the superconducting supercollider in 1993. When scientists were defending the project in front of Congress, parts of the testimony I heard lacked the power to reach the audience, to compel them intellectually or emotionally.

Any communication strategies you'd recommend to scientists?

I can't expect every scientist to embrace my approach, but I spend more time than most of my colleagues thinking about what interests the public. That includes exposing myself to a lot of popular culture. So when the Super Bowl comes on, I'm going to watch it, even if I don't care much about football, because the next day everyone is going to be talking about it. And if there's some

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Public opinion divided over role of scientists in policymaking

A recent survey reveals that Democrats and Republicans have starkly different levels of trust in scientists.

BY LINDSAY MCKENZIE

The U.S. public is split over what role, if any, scientists should play in policymaking, the latest Pew Research Center survey examining public trust in scientists reveals.

The survey asked roughly 9,000 U.S. adults how much confidence they have in scientists to act in the public's best interest as well as what role scientists should play in policy decisions. The survey revealed stark differences in how much trust Democrats and Republicans have in scientists.

Just over half of all survey respondents, 51%, said they want scientists to play an active role in policy debates about scientific issues, while 48% said they want scientists to focus on science and stay out of policy debates. The survey found that Democrats are largely in favor of scientists being involved in policy debates, while Republicans are largely against it.

Asked if scientists are better or worse than other people at making policy decisions about scientific issues, 43% of survey respondents said they are usually better, while 46% said they were neither better nor worse, and 10% said they are usually worse. Again, opinions between Republicans and Democrats differed, with 58% of Democrats saying that scientists are better than others at making decisions on scientific policy issues, compared to just 26% of Republicans. These numbers show little change from the results of similar questions asked in previous years.

Public trust in scientists took a hit during the COVID-19 pandemic, falling from 87% in April 2020 to 73% in October 2023. This year's results show a "statistically significant" uptick, said Alec Tyson, associate director of research at Pew Research, during an online event reviewing the survey results, with 76% of the public stating they have either a great deal or fair amount of confidence in scientists to act in the best interests of the public.

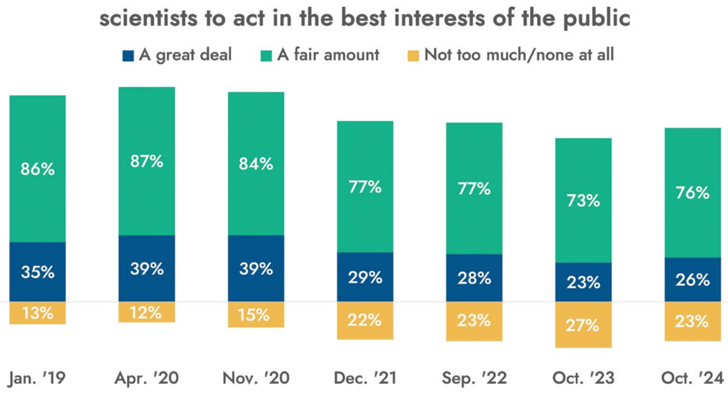
Among Republicans and Democrats, a different trend emerges. Democrats have higher trust in scientists than Republicans, and those high levels of trust have remained relatively stable over the past few years, falling from 91% in April 2020 to 88% in October 2024. Among Republicans, trust in science has fallen more sharply, dropping from 85% in 2020 to 61% in 2023, but rising to 66% this year.

Scientists' public image among U.S. adults is largely positive, with the majority of survey respondents sharing that they believe scientists to be intelligent, focused on solving real-world problems, and honest. But the public takes a dimmer view of scientists' communication skills, with just 45% describing scientists as good communicators, and 47% saying that scientists appear to feel superior to others. That said, Republicans were more likely than Democrats to view scientists' traits negatively, with 61% saying that scientists feel superior to others, compared to 32% of Democrats. Republicans also appear to view scientists' traits more negatively than in the past, with 52% saying that scientists are focused on solving real-world problems compared to 69% in 2019, for example.

While the survey revealed many differences in opinion between Republicans and Democrats, there are also "some really interesting points of bipartisan agreement," Tyson said. One of these is the shared belief that the U.S. ought to be a leader in scientific achievement. "Large shares of Republicans and Democrats believe that," he said, adding that "while the size of the majorities differs somewhat, both Republicans and Democrats think that federal investments in basic academic research [are] worthwhile investments."

Lindsay McKenzie is a science policy reporter at FYI, published by the American Institute of Physics.

Percentage of U.S. adults who have ___ of confidence in scientists to act in the best interests of the public



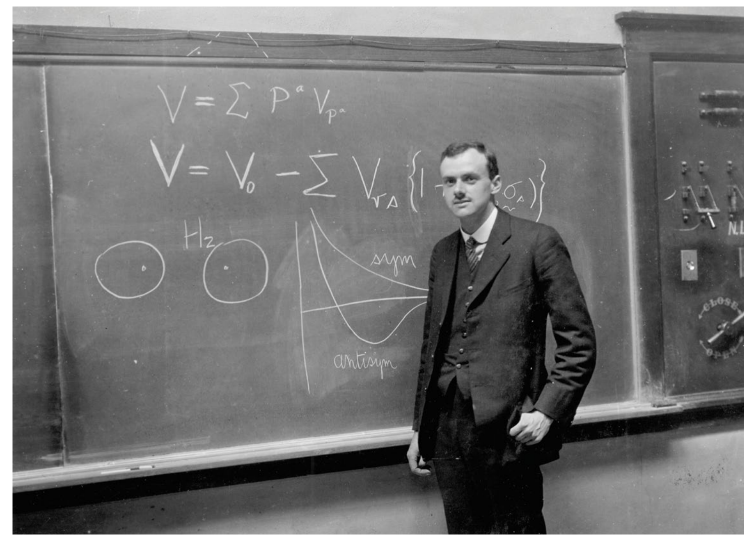
Data from Pew Research Center. Survey of U.S. adults conducted Oct. 21-27, 2024.
Note: Respondents who did not give an answer are not shown.

THIS MONTH IN PHYSICS HISTORY

January 1928: The Dirac equation unifies quantum mechanics and special relativity

A seminal paper by Paul Dirac, who relied on mathematical intuition, laid the foundation for quantum electrodynamics.

BY NYLA HUSAIN



Paul Dirac once noted that his theories are "built up from physical concepts which cannot be explained in words at all." Credit: AIP Emilio Segrè Visual Archives

In the first weeks of 1928, "The Quantum Theory of the Electron," a paper authored by a young British physicist named Paul Dirac, took the theoretical physics community by storm.

The 25-year-old Dirac had worked alone to develop his theory in the last months of 1927. It was the first to fully incorporate the framework for quantum mechanics — formulated over the previous two years by the likes of Werner Heisenberg and Erwin Schrödinger — with Albert Einstein's special relativity. Many of his peers, including Schrödinger, on whose wave equation his results were based, had tried and failed to do the same thing. Dirac's results would soon transform the way theoretical physicists understood how light and matter interact — and, by accident, uncover a completely new class of particles known as antimatter.

When Dirac entered the field of quantum theory, he came with an unorthodox skill set. With bachelor's degrees in electrical engineering and applied mathematics from the University of Bristol, he hadn't obtained a formal physics education.

"It made him a very unusual animal," says Graham Farmelo, biographer, science writer, and author of *The Strangest Man: The Hidden Life of Paul Dirac, Mystic of the Atom.* "Wherever he went, he was an outsider." Being an outsider, it seemed, allowed Dirac to approach the same questions with a different lens than his peers — that of both an engineer trained in practical thinking, and a gifted mathematician who could see equations in terms of pictures and diagrams.

Dirac's trajectory into theoretical physics arguably began with his passion for Albert Einstein's general theory of relativity. After the Eddington solar eclipse experiment confirmed Einstein's theory in 1919, Dirac attended a series of lectures at Bristol given by Charlie Broad, a philosopher of science from Cambridge University. Dirac was no philosopher, but Broad's talks on relativity and scientific thought clarified the theory and inspired him. Farmelo writes in his book that Dirac made a hobby of producing relativistic versions of Newtonian theories "like an engineer upgrading tried-and-tested designs to ones that perform to a higher specification."

In 1923, when Dirac became a doctoral student at St. John's College in Cambridge, he hoped to study relativity. Instead, he was assigned to Ralph Fowler, one of few researchers in Britain involved in the burgeoning field of quantum theory.

Two years into Dirac's studies, German physicists Werner Heisenberg, Max Born, and Pascual Jordan revolutionized the old quantum theory by introducing a new approach to describe particle behavior in atomic systems. Their matrix mechanics was the first mathematical formulation to describe, with arrays of discrete numbers, only *observable* quantities of a particle's behavior — ones that could be measured experimentally — like its position or momentum. Months later, Schrödinger — inspired by Louis de Broglie's idea that matter behaves like a wave — proposed an entirely different, but mathematically equivalent, formulation of particle behavior based on the better-known mathematics of waves.

> Dirac's formulation ... could solve, in sharp detail, the spectral character of emission or absorption of radiation by an atom, which Schrödinger's equation had failed to do.

This reinterpretation overcame critical limitations of the old quantum theory. Yet, by late 1927, the theory was far from complete. Among its most glaring deficiencies was the fact that, despite multiple efforts, no equation adequately accounted for relativistic effects — changes in particles' behavior when moving at incredibly high speeds. Dissatisfied with previous attempts, Dirac set out to solve the mathematical puzzle himself.

Dirac made a habit of working independently and preferred to spend most of his time alone. Described by colleagues as reticent and unemotional, he developed a reputation for monosyllabic responses — "yes," "no," or "I don't know." His writing was equally precise and condensed, saying only what needed to be said to convey his ideas.

"Dirac would give a seminar and when asked a question, he would just repeat verbatim what he said the first time," says David Kaiser, physicist and historian at the Massachusetts Institute of Technology. "Not to be rude, I don't think, but because he thought that was the most economical expression."

By Jan. 2, 1928, Dirac had written up his results and submitted them to the *Proceedings of the Royal Society A*. His formulation — a fully relativistic version of Schrödinger's wave equation for the electron — could solve, in sharp detail, the spectral character of emission or absorption of radiation by an atom, which Schrödinger's equation had failed to do.

More surprising results unfurled when Dirac extended his equation to describe an electron interacting with an electromagnetic field. Experimentalists had confirmed that the electron's intrinsic angular momentum, or spin, was equal to 1/2, but theoreticians couldn't figure out how to properly incorporate it into their theories. With his new equa-

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After wildfires threatened her hometown, APS Congressional Science Fellow pivoted to climate policy

Sophia Chan spent a year on Capitol Hill, working on federal policy to mitigate climate change.

BY TAWANDA W. JOHNSON

In the summer of 2020, Sophia Chan was in Manhattan, working toward her doctorate in chemical engineering at Columbia University — but her attention was on her California hometown. Record-breaking wildfires were sweeping the state, and her family was facing the threat of evacuation.

Chan did what she could from 2,500 miles away, sharing emergency checklists and urging them to wear N95 masks to prevent smoke inhalation, but she felt helpless.

Ultimately, Chan's family did not have to evacuate, but the situation served as a clarion call. "It really woke me up to the reality that climate change is happening right now," recalls Chan.

She decided to shift her focus from energy research to policy. "There are so many scientists working on research and not enough on the policy side," she says.

Fast forward to 2023, when Chan was named the APS Congressional Science Fellow and headed to Washington, D.C. APS sponsors the fellowship under the umbrella of the American Association for the Advancement of Science's Science and Technology fellowships. The fellowship makes individuals with scientific knowledge and skills available to members of Congress, few of whom have technical backgrounds. In turn, the program enables scientists to broaden their experience through direct involvement with the policymaking process.

Sophia Chan, the 2023-24 APS Congressional Science Fellow. Credit: Sophia Chan

For a year, Chan worked on Capitol Hill in the office of Sen. Sheldon Whitehouse (D-RI), where she contributed to materials for Senate hearings and helped develop legislative proposals, among other responsibilities. Her work on a bipartisan Budget Committee hearing on electric vehicles was among her top accomplishments during the fellowship, says Ed Higgins, a legislative assistant in Whitehouse's office who mentored Chan.

"The hearing was a success, thanks in no small part to Sophia's writing, research, and preparation," he says. "Sophia is smart and extremely passionate, particularly about transportation policy. Her work was always thoroughly researched and thoughtful, and it showed."

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Miami, Roberts took physics again her senior year, just for fun. This time, her teacher was a woman. "I thought that was so cool," Roberts says. She wanted to be a veterinarian but, for the first time, could picture herself as a physicist.

A poster adorning her physics classroom highlighted the many professions open to people who study the subject. Intrigued, she entered Florida International University as a physics major preparing for vet school — which meant taking *lots* of chemistry alongside physics. After a while, facing the reality of just how much chemistry she would need for vet school, Roberts decided to instead see where physics took her.

At FIU, she immersed herself in classes and in astronomy research with Professor James Webb. She got involved with the Stocker AstroScience Observatory being built on campus, learning to use the 24-inch telescope, teaching groups of students to observe, and hosting "star parties" with the astronomy club. As she neared graduation, Roberts realized she wasn't ready to drop her focus on learning. Graduate school it was.

Roberts applied to several graduate programs and was devastated when she wasn't accepted. "That was seriously heartbreaking for me," she says. Studying for and taking the GRE had been difficult, and it hit hard that after so much effort, she hadn't made the cut. But Roberts didn't give up.

At the urging of one of her professors, she applied to the APS Bridge Program and was offered a one-year trial in the Ohio State University's program. If she did well, OSU would consider admitting her to their bridge program the following year. Roberts went all in and spent the year as an unofficial member of OSU's Bridge Program cohort. The next year, she received offers from two bridge programs, including OSU. "I was very, very happy," she says. She decided to stay where she was.

"For me, the shift between undergraduate and graduate school was really big," she says. "I'm glad I had that extra year." Being part of the Bridge Program came with several benefits, including having a supportive, collaborative cohort; being paired with her research advisor, Annika Peter, right from the start; and not needing to be a teaching assistant the first few years, Roberts says.

In 2022, Roberts graduated from OSU with a Ph.D. in physics. She is now a data scientist at the nonprofit corporation MITRE, which operates research and development centers on behalf of government agencies. She works with huge datasets from airports and flight tracking programs to identify and address safety concerns in the National Airspace System. That often involves cleaning up datasets, which can be like putting puzzle pieces together, Roberts says. Only when datasets are reliable, formatted correctly, and properly interfacing with one another can she begin the analysis.

Aviation safety might seem far removed from the subject of her thesis — identifying satellite galaxies, smaller galaxies that orbit around more massive galaxies and can reveal information about the evolution of the universe — but there are many parallels. Both rely heavily on data analysis, coding, developing evidence-based findings, and effectively communicating with others.

The first inflection point came in Physics II, a required class in Ecuador's high schools. "That teacher made me fall in love with the subject," Roberts says.

In research, Roberts says, you can't just put up a plot and say, "Here's my answer." You have to explain why you made that plot and why it's important. Although she works with different data sets now, the process is similar. "I get data and I present it to my group and say, 'Hey, this is what I think it's saying. This is why I think it's saying this.'"

During graduate school, Roberts came to appreciate the collaborative process so much that she sought positions that relied on it. MITRE is a great fit, she says. In her current role, she works with other data scientists, software engineers, statisticians, and additional technical experts.

To students considering graduate school, Roberts says to surround yourself with people you trust and who support your persistence. "If you really do want to go to grad school, don't give up," she says. "If this is a dream of yours, you can do this."

Kendra Redmond is a writer based in Minnesota.

APS announces recipients of the 2024 Innovation Fund

Since 2019, the APS Innovation Fund has provided grants to collaborative projects that advance physics education, community, and beyond.

In celebration of the 2025 International Year of Quantum Science and Technology, the 2024 APS Innovation Fund has awarded six recipients whose projects aim to bolster public engagement and education in quantum science.

APS congratulates this year's recipients and their teams:

Magnetic levitation suit and sleigh — A pioneering maglev suit and sleigh for hands-on K-12 quantum science outreach (PI: Michael P. Short, Massachusetts Institute of Technology).

Quantum explorations: A global toolkit — A toolkit to overcome global barriers to quantum education for K-12 students (PI: John Donohue, University of Waterloo).

Quantum explorations: A global toolkit (WS² edition) — Empowering women in physics through accessible, low-cost quantum learning activities (PI: Jill Wenderott, Drexel University)

Imagining the future: An encounter with quantum technologies — An interactive airport exhibit to demystify quantum science for the public (PI: Nancy Kawalek, University of Chicago).

The Schrödinger sessions: quantum information meets science communication — Training content creators to spread accurate, engaging quantum information (PI: Christopher Cesare, University of Maryland).

Quantum pathways: Bridging traditions and innovation in quantum learning — A summer program merging quantum science and Indigenous culture for middle and high school students (PI: Mario Borunda, Oklahoma State University).

Dirac equation continued from page 2

From left to right, Paul Dirac, Werner Heisenberg, and Erwin Schrodinger at a Stockholm train station in 1933. Credit: Max Planck Institute, courtesy AIP Emilio Segrè Visual Archives

tion, Dirac had found, almost as an afterthought, that the spin emerged naturally. His colleagues were shocked and energized by these results. "It was a happy surprise to see that spin was already kind of built into his equation," says Kaiser.

The Dirac equation was simple and elegant, yet dense with implications. Perhaps its most profound feature was that, instead of producing two components for negative and positive spin states, it produced four: a negative and positive spin state for each of two particles with positive and negative energy states. It was absurd to think that an electron could possess energy of less than zero, but the alternative was even stranger: that there existed an entirely new, unobserved particle. "Dirac eventually came to convince himself that these would correspond to objects with the opposite electric charge," Kaiser says.

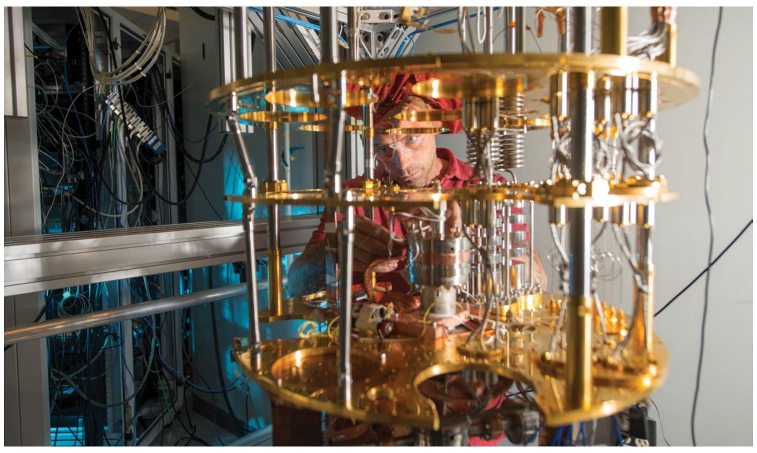
It wasn't until 1932 that American physicist Carl Anderson confirmed the existence of the antielectron, or positron as he called it, with cosmic ray experiments. Dirac would earn the 1933 Nobel Prize in Physics for his discovery, which he shared with Schrödinger.

The Dirac equation laid the foundation for quantum electrodynamics, a quantum field theory that has enabled technologies like lasers and semiconductors. Yet the technique employed to make the theory useful — renormalization — repulsed Dirac because he found it mathematically ugly. Positron emission tomography (PET) scanning, first developed in the 1960s, also wouldn't have been possible without his discovery, but it's unclear whether he knew about the medical imaging technique or would have cared. Dirac generally followed his intuition — and his intuition spoke only in equations.

Nyla Husain is the science communications manager at APS.

Letter to the editor: Science requires openness

A reader responds to recent federal proposals on research security.



Quantum equipment at Fermilab, a U.S. national lab outside Chicago. Recent legislation has proposed barring some foreign nationals from accessing national labs. Credit: Reidar Hahn/Fermilab

Responding to "US lawmakers propose barring Chinese and Russian citizens from DOE labs" (Mitch Ambrose, July 2024) and "White House issues new security rules for federally funded research" (Lindsay McKenzie, August 2024).

In the face of restrictions being called upon by Congress and the White House, scientists and organizations such as APS should push back and stand firm on our core fundamental values, including that science is universal, public knowledge, not restricted by racial, gender, ethnic, national, or other divisions. When proposed legislation focuses on the U.S. maintaining its leading technological edge vs. "adversarial nations," what is good for science itself is forgotten. Science thrives and advances on open exchange and discussion. Classified research in a government laboratory may require safeguards and restrictions, but fundamental, unclassified work in our universities and elsewhere, even if funded by government agencies, should not become targets of unjustified restrictions.

Even at the height of the Cold War, U.S. and Soviet scientists traveled to each other's countries and visited, discussed, and collaborated in universities and other open institutions. Therefore, when the current director of the White House Office of Science and Technology talks of "navigating a world characterized by fierce military and economic competition" and an "altered global landscape," it smacks more of a current hysteria than any real objective change. This OSTP response seems to be to a presidential memorandum at the end of the Trump administration.

Because of many global political developments, these targets of Russia, China, and Iran (and always the perennial thorn of Cuba for some in the U.S.), are more a reflection of disagreements at the national level. If China is now a strong competitor in economic and technological terms, posing a challenge to unilateral U.S. dominance, then let us compete with a sense of our own self-confidence and can-do spirit. Through agencies like the FBI, those that manage immigration and border control, and others, nations control who is admitted to a country. If there is serious concern about spying, again, it is for national security agencies to counter.

National laboratories can and do police classified or defense work within fenced boundaries. But universities and places of unclassified scientific research should not become surrogates to enforce the outsourced restrictions being proposed. Whether by mail, electronic communication, or visits in person, we should be free to discuss and interact just as we do in our everyday activities of submitting work for publication, refereeing research, and having research refereed. Our other identities of race, gender, and ethnic and national origin should have no place.

— A. R. P. Rau (Baton Rouge, LA)

Letters to the editor: Careers beyond academia

Readers respond to Cara Giovanetti's op-ed on faculty's tendency to overemphasize academic jobs.

Responding to "Why do so many physics students want to work in academia?" (Cara Giovanetti, September 2024).

Letter: Helping students succeed beyond academia

I greatly appreciated Cara Giovanetti's Back Page article in the October issue of *APS News*. Although it addresses the problem as a current-day issue, it closely reflects my grad school experience from 60 years ago. I can attest that the solutions Cara plans to try in her teaching career are good ones.

I had a wonderful undergraduate physics experience at a (then) small state college. It even helped me on my chosen career path in federal government physics by placing me in summer intern positions with Army and NASA missile programs. However, all I knew then about graduate school was that I needed to go there to learn enough physics to actually have a career. When my undergrad advisor told me to go to Clemson University (and the Clemson physics department offered me an assistantship), I went.

As it turned out, Clemson and I were not a good fit, as I discovered in

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matter. Corkum and his fellow attosecond pioneers Anne L'Huillier and Ferenc Krausz were recognized for their contributions with the 2022 Wolf Prize in Physics. L'Huillier and Krausz also received the 2023 Nobel Prize in Physics for their experimental contributions.

Now, Corkum — who splits his time between the University of Ottawa and the National Research Council of Canada — is the recipient of the 2025 APS Medal for Exceptional Achievement in Research, the largest prize awarded by APS. He is recognized "for the synthesis of plasma physics, strong-field spectroscopy, and electron scattering concepts to form a new science of strong-field physics ranging from atomic to solid state physics, as well as for pioneering of attosecond science."

Corkum spoke with *APS News* about his career path, how attosecond science has evolved since his seminal papers, and his advice for early-career researchers.

This interview has been edited for length and clarity.

Tell us about your academic journey.

I had a superb physics teacher in high school who really ignited an interest in physics. He began his lectures by talking about equations and how, if they were to be real, they had to balance. A bit like apples to apples, except in physics it's mass to mass, length to length, and time to time. I liked that idea.

I went to Acadia University, which was close to where I grew up. I signed up for engineering under the influence of my mother, who thought I should be an engineer. In high school, I had the chance to take a first-year college physics course, so I came straight into the second-year course.

All of a sudden, I was doing physics at what seemed like a rapid rate and doing engineering at what seemed like a glacial rate, so I changed my major and said I was going to be a physicist from now on. A professor hired me during my first summer, so I got involved in research — mainly fluid dynamics, looking at wakes behind bubbles and things like that. My first paper was in *Nature*.

I went to Lehigh University in Pennsylvania for graduate school. I was initially intimidated, coming from the peripheral part of Canada out to the East Coast. I thought all the students would know way more than I knew, but they didn't. Lehigh was a good place for me, and they taught physics well.

I thought I would do fluids research, and I even did a Master's project with a professor who was quite famous in fluid experiments. However, I was keen on doing theory and wanted to do something more esoteric, so I did my Ph.D. in statistical mechanics.

What were the origins of your work on attosecond laser pulses?

Before I joined the NRC, I had been thinking about how you transport materials in plasma and how this was related to the scattering of light from a plasma. In the 1960s, a Russian physicist named Leonid Keldysh was thinking about laser electric fields and how the electron would get out of an atom's field. The plasma physicists accepted his ideas, but the atomic physicists less so. He went on to talk about what the electrons would look like, but nobody knew it because it was couched so deep in theory that you couldn't really see it.

I was influenced by Keldysh, and I began to look at this as a plasma problem. I rediscovered his idea but in a way that was very simple. I did that in 1989 with the first part of my most famous work, and in 1993, the second part, where I put it all together. Both papers described the atomic physics problem like a plasma physics problem.

> "I'm not sure yet, but I think producing high harmonics and attosecond pulses is a universal response of all matter. In our day, we don't often get a chance to discover a universal response." — Corkum

Then it hit me on the head. I had a way of making attosecond pulses. We started doing experiments on what is now called polarization gating very quickly and the theory of how to measure.

What are some of the most significant findings from this field so far?

Maybe the most interesting experimental finding is that when an atom ionizes, the electron interferes with its former self, because quantum mechanics allows any quantum particle to be in many places at once. That interference allows you to do tomography. Like medical tomography, you can determine what an object looks like.

There is a second, related point that's important. I'm not sure yet, but I think producing high harmonics and attosecond pulses is a universal response of all matter. In our day, we don't often get a chance to discover a universal response.

That ability to create an interferometer from a material's own electrons with light is amazing. One might argue that an interferometer is the most important tool in physics, and attosecond science has found a way to put an electron interferometer inside any material and to control the interferometer.

That's important. We might exhaust what can be measured with attosecond pulses, but we will never get tired of putting interferometers inside materials.

What do you see as the potential of attosecond science moving forward?

I think going small will be important. Each cell in your body is subdivided into organelles on the nanometers scale. These organelles do all kinds of important things, and now we have a laser- based tool to see and manipulate those organelles.

Also, because you've got x-rays, you can excite electrons from core states. In a molecule, the core state is fixed to an atom. So now you have a position inside materials, or molecules, from which to probe the material. We know almost nothing about these core electrons, except they move really fast, so attosecond techniques are required if we are to exploit the non-valence electrons for material science or chemistry.

Given your academic background in theory and your experience working as an experimentalist, how do you think about these two approaches in physics?

I don't see theory and experiment as two different things. Experimentalists and theorists use the tools available to them, and they are not necessarily the same tools — just two alternate ways of looking at the same thing.

I consider myself an experimentalist — I don't look at an equation and see the beauty and simplicity of it, but I more see how I go about doing it. However, I think my study of theory for my Ph.D. encouraged me to look at the concept behind any theory or experiment. At the concept level, experiment and theory merge.

What is your advice for students and early-career physicists?

Do something creative, something new, and trust your instincts. Don't try to follow what somebody else has done. You spend your whole education learning about what everybody else has done, and now the test is to do it yourself. That's tough, and many people struggle with it, so I think you just have to have faith in yourself and give it a try.

How do you feel about receiving the APS Medal?

The APS Medal means my colleagues, the people who really know, think I've made a major contribution. It's humbling, and I can't think of a more meaningful award that I can get in my whole career.

Erica K. Brockmeier is the science writer at APS.

AMERICAN PHYSICAL SOCIETY

2024-25 PRIZES AND AWARDS

APS congratulates all prize and award recipients. Recipients will be honored at APS meetings throughout the year, and each will be invited to give a talk at the meeting where they receive their prize or award. For the full schedule of APS meetings, visit aps.org/meetings.

APS Medal

Paul Corkum
National Research Council Canada; University of Ottawa

For the synthesis of plasma physics, strong-field spectroscopy, and electron scattering concepts to form a new science of strong-field physics ranging from atomic to solid state physics, as well as for pioneering of attosecond science.

Adler Lectureship Award in the Field of Materials Physics

Sergei V. Kalinin
University of Tennessee, Knoxville; Pacific Northwest National Laboratory

For sustained leadership and vision in integrating machine learning methods with physical sciences, particularly in the development of autonomous electron and scanning probe microscopies and applications to nanoscale electromechanics of ferroelectric and energy materials.

Allis Prize for the Study of Ionized Gases

Jonathan Tennyson
University College London

For development and application of theoretical methods for electron impact processes with molecules in low temperature plasmas, and empowering the modeling of complex plasma chemistry.

Apker Award

Jin Ming Koh
California Institute of Technology

For the first experimental realization of a measurement-induced entanglement phase transition on a superconducting quantum processor.

Apker Award

Eritas Yang
Harvey Mudd College

For developing a perturbative model for the long-term secular dynamics of coplanar three-planet systems, elucidating the physics of such systems.

Ashcroft Early Career Award for Studies of Matter at Extreme High Pressure Conditions

Rebecca K. Lindsey
University of Michigan, Ann Arbor

For outstanding achievements in the creation of machine learning models of reactive materials, including energetic materials under detonation conditions, nano-carbon synthesis, and cluster condensation in molecular liquids under extreme conditions.

Bethe Prize

A. Baha Balantekin
University of Wisconsin-Madison

For seminal contributions to neutrino physics and astrophysics — especially the neutrino flavor transformation problem — both for solar neutrinos and the nonlinear supernova environment.

Bonner Prize in Nuclear Physics

Volker D. Burkert
Thomas Jefferson National Accelerator Facility

For exemplary leadership in the development of high-performance instrumentation for large acceptance spectrometers that have enabled breakthroughs in fundamental nuclear physics through electroproduction measurements of exclusive processes.

Bouchet Award

Geraldine L. Cochran
The Ohio State University

For contributions to physics education research, including intersectional and equity-oriented scholastic approaches, resource papers that remove systemic obstacles for interested scholars, and efforts to improve the experience of marginalized people in physics.

Broida Award

Lucio Frydman
Weizmann Institute of Sciences

For outstanding achievements in nuclear magnetic resonance (NMR) spectroscopy and imaging, particularly advances in extending single-shot multidimensional techniques from solid and solution state NMR into magnetic resonance imaging in vivo.

Buckley Condensed Matter Physics Prize

Steven A. Kivelson
Stanford University

For broad and insightful theoretical contributions that have significantly advanced the understanding of correlated quantum systems.

Burton Forum Award

Sébastien Philippe
Princeton University

For accurately estimating radiation doses from French and U.S. nuclear tests and effectively communicating these findings to the public, as well as assessing potential radiation from nuclear attacks on U.S. ICBM silos, demonstrating the importance of addressing scientific findings and consulting affected individuals.

Corrsin Award

Bérengère Dubrulle
National Centre for Scientific Research

For seminal contributions to the theory of fully-developed turbulence and astro- and geophysical fluid dynamics, including illuminating intermittency and the role of multiple states in turbulent flows.

Davisson-Germer Prize in Atomic or Surface Physics

Gwo-Ching Wang
Rensselaer Polytechnic Institute

For pioneering contributions to the development and use of electron diffraction techniques to study surfaces, growth-front ordering, and two dimensional materials.

TEAM AWARD

Dawson Award for Excellence in Plasma Physics Research

For pioneering the development of statistical modeling to predict, design, and analyze implosion experiments on the 30kJ OMEGA laser, achieving hot spot energy gains above unity and record Lawson triple products for direct-drive laser fusion.

Riccardo Betti
University of Rochester

E. Michael Campbell
University of California, San Diego

Duc M. Cao
University of Rochester

Chad J. Forrest
University of Rochester

Varchas Gopalaswamy
University of Rochester

James P. Knauer
University of Rochester

Aarne Lees
University of Rochester

Sean P. Regan
University of Rochester

Rahul C. Shah
University of Rochester

Cliff A. Thomas
University of Rochester

Connor Alexander Williams
Sandia National Laboratories

Delbrück Prize in Biological Physics

Devarajan Thirumalai
The University of Texas at Austin

For pioneering theoretical models that guided experimentalists and explained experimental results for protein and RNA folding, chromosome dynamics, molecular motors, and collective cell dynamics, and for changing our understanding of how molecular chaperones facilitate folding.

Dillon Medal

Robert J. Hickey
Pennsylvania State University

For pioneering work in creating nonequilibrium structured soft materials.

TEAM PRIZE

Dresselhaus Prize in Nanoscience and Nanomaterials

For developing theoretical and calculational methods able to predict and explain electronic, optical, magnetic, and topological properties of nanomaterials.

Marvin L. Cohen
University of California, Berkeley

Steven Gwon Sheng Louie
University of California, Berkeley

Duvall Shock Compression Science Award

Justin S. Wark
University of Oxford

For the initial instigation and subsequent development of time-resolved X-ray diffraction from laser-shocked materials, leading to major advances in our understanding of shock-induced plasticity and phase transformations at the lattice level.

Early Career Award for Soft Matter Research

Lilian Hsiao
North Carolina State University

For using in-situ confocal rheometry to identify microscale structure-property physics of anisotropic colloids during shear flow, and for applying self-assembly principles and scaling relations to address knowledge gaps in the friction of soft materials.

Education Award

Stephen Padalino
State University of New York, Geneseo

For creating an inclusive undergraduate physics education program in the classroom and laboratory settings that captures the imaginations of undergraduate students to perform fundamental research in preparation for a life of research.

Einstein Prize

Eric G. Adelberger
University of Washington, Seattle

For outstanding contributions to experimental gravity using precision torsion-balance measurements, which have profound implications for fundamental physics.

Faculty Research Prize

Will Raven
Smith College

For high precision laser spectroscopy of complex atoms and the percent level verification of quantum electrodynamics in Beryllium-9, and for innovative and extensive involvement of undergraduate students at Smith College in this research.

Feshbach Prize in Theoretical Nuclear Physics

Richard Furnstahl
The Ohio State University

For foundational contributions to calculations of nuclei, including applying the Similarity Renormalization Group to the nuclear force, grounding nuclear density functional theory in those forces, and using Bayesian methods to quantify the uncertainties in effective field theory predictions of nuclear observables.

FIAP Career Lectureship Award

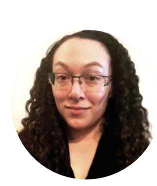
Judith Olson
Infleqtion

For contributions to breakthrough quantum technologies for precision timing and navigation.

Fluid Dynamics Prize

Javier Jiménez
Universidad Politécnica Madrid

For groundbreaking advancements in unraveling turbulence through direct numerical simulation, conceptual experiments, and theoretical analysis.



Freedman Award in Experimental Nuclear Physics

Caryn A. Palatchi
Indiana University

For contributions to the measurement of the weak nuclear form factors, including the development of improved systems for controlling polarized electron beams.

Heineman Prize for Mathematical Physics

Samson L. Shatashvili
Trinity College Dublin

For clever use of various techniques in studying symmetry in quantum field theory, in particular, for work with L. Faddeev on anomalies, with C. Vafa on exceptional holonomy compactifications of superstrings, and for the co-discovery of Bethe/gauge correspondence between supersymmetric vacua and quantum integrability.

Isaacson Award in Gravitational-Wave Science

Frederick J. Raab
California Institute of Technology

For many seminal contributions to gravitational-wave science, including co-leading the LIGO construction proposal, achieving unprecedented strain sensitivities on the 40m prototype interferometer, skillful leading of the LIGO Hanford Observatory from its genesis through the era of the first detections, and passionate outreach to the scientific community and the public.

Kadanoff Prize

Andrea J. Liu
University of Pennsylvania

For broad contributions to the statistical mechanics of disordered systems and biological matter, including the theory of jamming.

Keithley Award for Advances in Measurement Science

Frances M. Ross
Massachusetts Institute of Technology

For groundbreaking advances in in situ electron microscopy in vacuum and liquid environments.

TEAM AWARD

Landau-Spitzer Award for Outstanding Contributions to Plasma Physics

For the critical advancement in the understanding of the particle acceleration physics in astrophysically-relevant shocks through theoretical analysis and experiments at the National Ignition Facility.

Frederico Fiuza
Instituto Superior Técnico

Anna Grassi
Sorbonne University

Hye-Sook Park
Lawrence Livermore National Laboratory

George F. Swadling
Lawrence Livermore National Laboratory

Landauer-Bennett Award in Quantum Computing

Jeongwan Haah
Stanford University

For outstanding contributions to the theory of quantum error correction, quantum phases of matter, and quantum dynamics.

Langmuir Award in Chemical Physics

Sharon Glotzer
University of Michigan, Ann Arbor

For demonstrating the critical role of shape entropy in colloidal assembly, developing methods to predict, measure, and engineer entropic bonding in colloidal shapes, and providing essential insights for predicting and understanding colloidal self-assembly experiments.

Lilienfeld Prize

Bharat Ratra
Kansas State University

For pioneering research in cosmology and particle astrophysics, including on the quantum mechanics of inflation and dark energy dynamics, and for contributions to science education and popularization at all levels.

TEAM PRIZE

Maxwell Prize for Plasma Physics

For pioneering work in kinetic plasma turbulence that revolutionizes turbulent transport calculations for magnetic confinement devices and inspires research in astrophysical plasma turbulence.

William Dorland
University of Maryland

Gregory W. Hammett
Princeton Plasma Physics Laboratory

Mayer Award

Wennie Wang
The University of Texas at Austin

For outstanding contributions to the field of materials science, including pioneering research on defective transition metal oxides for energy sustainability, a commitment to broadening participation of underrepresented groups in computational materials science, and leadership and advocacy in the scientific community.

TEAM PRIZE

McGroddy Prize for New Materials

For seminal theoretical and experimental research, materials design and discoveries that pioneered the exploration of novel forms of topological quantum matter in spin-orbit assisted Mott insulators realized in transition metal oxides.

George Jackeli
Max Planck Institute for Solid State Research

Giniyat Khaliullin
Max Planck Institute for Solid State Research

Hidenori Takagi
Max Planck Institute for Solid State Research

Nicholson Medal

Don Lincoln
Fermi National Accelerator Laboratory

For worldwide presentations and publications that educate students and general audiences on the meaning of fundamental scientific research.

Narain Mentoring Award

Tao Han
University of Pittsburgh

For outstanding mentoring, sustained and caring early-career advising, and a quarter century cultivating the welcoming and supportive Phenomenology symposium.

TEAM PRIZE

Onsager Prize

For fundamental advances describing out-of-equilibrium disordered systems, especially complex aging.

Jean-Phillippe Bouchaud
Capital Fund Management; Académie des Sciences

Leticia Fernanda Cugliandolo
Sorbonne Université

Jorge Kurchan
Ècole Normale Supèrieure de Paris

TEAM AWARD

Oppenheim Award

For the formulation of a geometric theory of mechanical screening in two dimensional solids, which is applicable to a range of systems including granular matter, cellular tissue, and mechanical metamaterials.

Noémie S. Livné
The Hebrew University of Jerusalem

Michael Moshe
The Hebrew University of Jerusalem

Pais Prize for History of Physics

Michael Riordan
University of California, Santa Cruz

For important contributions to the history of post-World War II physics, including the discovery of quarks, the invention and development of the transistor, and the search for the Higgs boson — and for making these stories interesting and accessible to both non-academic and academic readers.

TEAM PRIZE

Panofsky Prize in Experimental Particle Physics

For pioneering work in establishing the HERA physics program and detectors, leadership in HERA physics exploitation resulting in the measurement of the proton's structure in new kinematic regions of vital importance in confronting new aspects of quantum chromodynamics, and enabling discoveries at the Large Hadron Collider.

Eckhard E. Elsen
Deutsches Elektronen-Synchrotron

Robert Klanner
University of Hamburg

Pipkin Award

Kyle Leach
Colorado School of Mines

For initiating and establishing new measurement techniques using rare-isotope-doped superconducting sensors as sensitive probes of fundamental physics in the electroweak sector.

Plyler Prize for Molecular Spectroscopy and Dynamics

R. J. Dwayne Miller
University of Toronto

For contributions to multidimensional spectroscopies and femtosecond electron diffraction that give an atomic perspective of molecular reaction dynamics — the physics by which innumerable possibilities distill to a few key modes directing chemistry.

Polymer Physics Prize

Scott Milner
Pennsylvania State University

For insightful contributions to the theory of polymer brushes, copolymers, molecular entanglement rheology, interaction parameter estimation, and polymer crystallization.

Primakoff Award for Early-Career Particle Physics

Kevin J. Kelly
Texas A&M University

For significant contributions to our understanding of the neutrino sector and proposing novel directions and search strategies, bolstering the physics output of current and future neutrino experiments.

Rabi Prize in Atomic, Molecular, and Optical Physics

Norman Ying Yao
Harvard University

For pioneering contributions to broad areas of atomic, molecular, and optical physics, including quantum information, metrology, and many-body physics.

Rahman Prize for Computational Physics

Chris G. Van de Walle
University of California, Santa Barbara

For the development and application of first-principles methods for computing the structural, electronic, and optoelectronic properties of point defects and interfaces.

Ramsey Prize in Atomic, Molecular and Optical Physics, and in Precision Tests of Fundamental Laws and Symmetries

Alan Kostelecky
Indiana University

For the development of the Standard Model Extension and for its application to, and inspiration for, a broad set of precision measurement tests across various physical systems, some of which have reached Planck-scale sensitivity.

TEAM AWARD

Reichert and Wolff-Reichert Award for Excellence in Advanced Laboratory Instruction

For continuous physical measurement laboratory improvements, leveraging industrial and academic partnerships that enable innovative and diversified independent student projects, and giving rise to practical skillsets yielding outstanding student outcomes.

Jason D. Slinker
The University of Texas at Dallas

David W. Taylor
The University of Texas at Dallas

TEAM PRIZE

Sakurai Prize for Theoretical Particle Physics

For outstanding contributions to the physics of baryons, including deriving many physical properties of nucleons and hyperons in the large number of colors limit of quantum chromodynamics and deriving the renormalization group evolution of the standard model effective field theory at one loop.

Elizabeth E. Jenkins
University of California, San Diego

Aneesh V. Manohar
University of California, San Diego

Schawlow Prize in Laser Science

Vladan Vuletic
Massachusetts Institute of Technology

For pioneering work on spin squeezing for optical atomic clocks, quantum nonlinear optics, and laser cooling to quantum degeneracy.

Stix Award for Outstanding Early Career Contributions to Plasma Physics Research

Alexander Philippov
University of Maryland

For seminal contributions to the theory and simulation of collisionless astrophysical plasmas, especially compact objects.

Szilard Lectureship Award

Alexander Glaser
Princeton University

For seminal scientific contributions and innovations to advance nuclear arms control, nonproliferation, and disarmament verification, and for leading the Princeton Program on Science and Global Security and mentoring many students and young researchers over the years.

Valley Prize

Ruben Verresen
University of Chicago

For pioneering contributions to the quantum dynamics and topology of strongly coupled systems, enabling the creation of highly entangled states, including the first non-Abelian phase in quantum platforms.

TEAM AWARD

Wheatley Award

For exceptional contributions to capacity building in Africa, the Middle East, and other developing regions, including leadership in training researchers in beamline techniques at synchrotron light sources and establishing the groundwork for future facilities in the Global South.

Simon H. Connell
University of Johannesburg

Gihan Kamel
Synchrotron-Light for Experimental Science and Applications in the Middle East

Sekazi Kauze Mtingwa
TriSEED Consultants, LLC

Wilson Prize for Achievement in the Physics of Particle Accelerators

Alexander Zholents
Argonne National Laboratory

For many important contributions to particle accelerators and light sources, including ultra-fast X-ray techniques for electron beams and beam cooling methods.

Dissertation Awards

Dissertation Award in Nuclear Physics

Garrett King
Washington University in St. Louis

For significant implementation and extensive application of Quantum Monte Carlo many-body methods to the study of electroweak structure and reactions in light nuclei across a wide range of experimentally relevant kinematics.

Metropolis Award for Outstanding Doctoral Thesis Work in Computational Physics

Seán R. Kavanagh
Harvard University

For developing computational techniques and open-source toolkits for the study of defects in solids, and their application to electron-hole recombination processes in semiconducting materials.

Dissertation Award in Statistical and Nonlinear Physics

Jacob Andreas Zavatone-Veth
Harvard University

For an exceptional doctoral thesis that applies statistical mechanics to deepen our understanding of Bayesian inference and learning in neural networks, offering significant theoretical insights into the functioning of both artificial and biological neural systems.

Rosenbluth Doctoral Thesis Award

Eduardo Rodriguez Urretavizcaya
Max Planck Institute

For fundamental and path-breaking discoveries in the theory of quasisymmetric magnetic fields, and their applications to stellarators.

Acrivos Dissertation Award in Fluid Dynamics

Anuj Kumar
University of California, Santa Cruz

For deep insight into the Navier-Stokes equations using novel analytical methods, establishing rigorous bounds for optimal turbulent transport, and bridging applied mathematics with fluid flow physics.

Outstanding Doctoral Thesis Research in Biological Physics

Jiliang Hu
Massachusetts Institute of Technology

For groundbreaking biophysical contributions to microbial ecology that bridge experiment and theory, showing how only a few coarse-grained features of ecological networks can predict emergent phases of diversity, dynamics, and invasibility in microbial communities.

Anderson Division of Laser Science Dissertation Award

Jeremy J. Axelrod
University of California, Berkeley

For the development of laser-based phase contrast in cryogenic electron microscopy.

Fellowships

Division of Atomic, Molecular, and Optical Physics

Xiwen Guan
Chinese Academy of Sciences

Kurt Jacobs
Army Research Laboratory

Vladimir S. Malinovsky
Army Research Laboratory

Anatoli Polkovnikov
Boston University

Daniel Rolles
Kansas State University

James P. Shaffer
Quantum Valley Ideas Laboratories

Dajun Wang
The Chinese University of Hong Kong

Yanhong Xiao
Shanxi University

Division of Astrophysics

Matthew Geoffrey Baring
Rice University

Alex Drlica-Wagner
Fermi National Accelerator Laboratory

Philip Fajardo Hopkins
California Institute of Technology

Rachel Mandelbaum
Carnegie Mellon University

Naoko Kurahashi Neilson
Drexel University

Joseph E. Pesce
National Science Foundation

Division of Biological Physics

Nancy R. Forde
Simon Fraser University

Kinneret Keren
Technion - Israel Institute of Technology

Rohit V. Pappu
Washington University in St. Louis

Michael G. Poirier
The Ohio State University

Benjamin Schuler
University of Zurich

Pascal Silberzan
Institut Curie

Division of Condensed Matter Physics

Cui-Zu Chang
Pennsylvania State University

Joseph George Checkelsky
Massachusetts Institute of Technology

Gabor Csathy
Purdue University

Dmitri E. Feldman
Brown University

Rudolf Hackl
Technical University of Munich

Jennifer Hoffman
Harvard University

Taylor L. Hughes
University of Illinois, Urbana-Champaign

Kam Tuen Law
The Hong Kong University of Science and Technology

Philip J. W. Moll
Max Planck Institute for the Structure and Dynamics of Matter

Olexei Motrunich
California Institute of Technology

Prineha Narang
University of California, Los Angeles

Wei Pan
Sandia National Laboratories

Nicolas Regnault
Laboratoire de Physique de l'Ecole Normale Supérieure Paris

Division of Computational Physics

Tanmoy Bhattacharya
Los Alamos National Laboratory

Valentino R. Cooper
Oak Ridge National Laboratory

Zhi-Feng Huang
Wayne State University

Yosuke Kanai
University of North Carolina at Chapel Hill

Sheng Meng
Chinese Academy of Sciences

Xiangang Wan
Nanjing University

Division of Chemical Physics

Kelly J. Gaffney
SLAC National Accelerator Laboratory

Neepa T. Maitra
Rutgers University, Newark

Francesco Paesani
University of California, San Diego

Division of Fluid Dynamics

Steven L. Brunton
University of Washington

Takuji Ishikawa
Tohoku University

Ruben Juanes
Massachusetts Institute of Technology

Christian J. Kaehler
University of the Bundeswehr Munich

William D. Ristenpart
University of California, Davis

Ying Sun
University of Cincinnati

Kunihiko Taira
University of California, Los Angeles

Pavlos P. Vlachos
Purdue University

Division of Gravitational Physics

Emil Mottola
University of New Mexico

Mark A. Scheel
California Institute of Technology

Xavier Siemens
Oregon State University

Division of Laser Science

Mercedeh Khajavikhan
University of Southern California

Boon S. Ooi
King Abdullah University of Science and Technology

Division of Materials Physics

Judy Jeeyong Cha
Cornell University

Jiaqing He
Southern University of Science and Technology

Oana D. Jurchescu
Wake Forest University

Seth Ariel Tongay
Arizona State University

Stephen D. Wilson
University of California, Santa Barbara

Haidong Zhou
University of Tennessee

Division of Nuclear Physics

Constantia Alexandrou
University of Cyprus

Gail Dodge
Old Dominion University

Jozef J. Dudek
The College of William and Mary

Stefano Gandolfi
Los Alamos National Laboratory

Calvin W. Johnson
San Diego State University

David Kawall
University of Massachusetts Amherst

Andrea Pocar
University of Massachusetts Amherst

Patrizia Rossi
Thomas Jefferson National Accelerator Facility

Division of Physics of Beams

Giorgio Ambrosio
Fermi National Accelerator Laboratory

S. Alex Bogacz
Thomas Jefferson National Accelerator Facility

Sam Posen
Fermi National Accelerator Laboratory

Division of Particles and Fields

Brendan Casey
Fermi National Accelerator Laboratory

Zackaria Chacko
University of Maryland, College Park

Douglas Cowen
Pennsylvania State University

Yuval Grossman
Cornell University

Patrick Meade
Stony Brook University

Vaia Papadimitriou
Fermi National Accelerator Laboratory

Martin Schmaltz
Boston University

Eric Torrence
University of Oregon

Jaroslav Trnka
University of California, Davis

Division of Polymer Physics

Zahra Fakhraai
University of Pennsylvania

Du Yeol Ryu
Yonsei University

Rafael Verduzco
Rice University

Division of Plasma Physics

Emily A. Belli
General Atomics

Stepan Bulanov
Lawrence Berkeley National Laboratory

Daniel Casey
Lawrence Livermore National Laboratory

Daniel Clark
Lawrence Livermore National Laboratory

Simon Hooker
University of Oxford

David Humphreys
General Atomics

Carlos Paz-Soldan
Columbia University

Howard Wilson
Oak Ridge National Laboratory

Division of Quantum Information

Guido Burkard
University of Konstanz

John Chiaverini
MIT Lincoln Laboratory

Kai-Mei Fu
University of Washington

Adrian Kent
University of Cambridge

Chao-Yang Lu
University of Science and Technology of China

Britton Plourde
University of Wisconsin-Madison

Division of Soft Matter

Aparna Baskaran
Brandeis University

Anthony Dinsmore
University of Massachusetts Amherst

Gijsje Koenderink
Delft University of Technology

Robert L. Leheny
Johns Hopkins University

Forum on Diversity and Inclusion

Edmundo J. Garcia-Solis
Chicago State University

Tino Nyawelo
University of Utah

Patricia Rankin
Arizona State University

Willie S. Rockward
Morgan State University

Forum on Education

Enrique Jose Galvez
Colgate University

Katemari Rosa
Federal University de Bahia

Forum on the History and Philosophy of Physics

Danian Hu
Southern University of Science and Technology

Forum on Industrial and Applied Physics

David Hsingkuo Chow
HRL Laboratories, LLC

Tahir Ghani
Intel Corporation

Dafine Ravelosona
French National Centre for Scientific Research

Alla Reznik
Lakehead University

Curt A. Richter
National Institute of Standards and Technology

Lei Zhou
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Forum on International Physics

Patrizia Azzi
INFN Sezione di Padova

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Neeti Parashar
Purdue University Northwest

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SLAC National Accelerator Laboratory

Forum on Outreach and Engaging the Public

Shane Bergin
University College Dublin

Tim Murphy
National High Magnetic Field Laboratory

Forum on Physics and Society

Areg Danagoulian
Massachusetts Institute of Technology

Kazi Rajibul Islam
University of Waterloo

Robert Tchitnga
Droste-Hülshoff Gymnasium Freiburg

Topical Group on Compression of Condensed Matter

Raymond F. Smith
Lawrence Livermore National Laboratory

Choong-Shik Yoo
Washington State University

Topical Group on Data Science

Sergei Gleyzer
University of Alabama

Frank Noe
Microsoft Corporation

Topical Group on Energy Research and Applications

Maria K. Chan
Argonne National Laboratory

Topical Group on Few-Body Systems and Multiparticle Dynamics

Pierre Capel
Johannes Gutenberg Universität Mainz

Topical Group on Hadronic Physics

Mark Kevin Jones
Thomas Jefferson National Accelerator Facility

Simonetta Liuti
University of Virginia

Topical Group on Instrument and Measurement Science

B. C. Regan
University of California, Los Angeles

David Alexander Shapiro
Lawrence Berkeley National Laboratory

Topical Group on Magnetism and Its Applications

Tiffany S. Santos
Sandisk Technologies, Inc.

Nian Xiang Sun
Northeastern University

Hao Zeng
State University of New York, Buffalo

Topical Group on Medical Physics

Thomas Bortfeld
Massachusetts General Hospital

Topical Group in Plasma Astrophysics

Yi-Min Huang
University of Maryland, College Park

Topical Group on the Physics of Climate

Justin Burton
Emory University

Tiffany Shaw
University of Chicago

Topical Group on Physics Education Research

Stephanie Viola Chasteen
Chasteen Educational Consulting

Vashti Sawtelle
Michigan State University

Topical Group on Precision Measurement and Fundamental Constants

Dylan Curtis Yost
Colorado State University

Topical Group on Quantum Materials Synthesis

Jiaqiang Yan
Oak Ridge National Laboratory

Topical Group on Statistical and Nonlinear Physics

Stefano Boccaletti
Consiglio Nazionale delle Ricerche

Erwin Frey
Ludwig Maximilians Universität

M. Ángeles Serrano
Universitat de Barcelona

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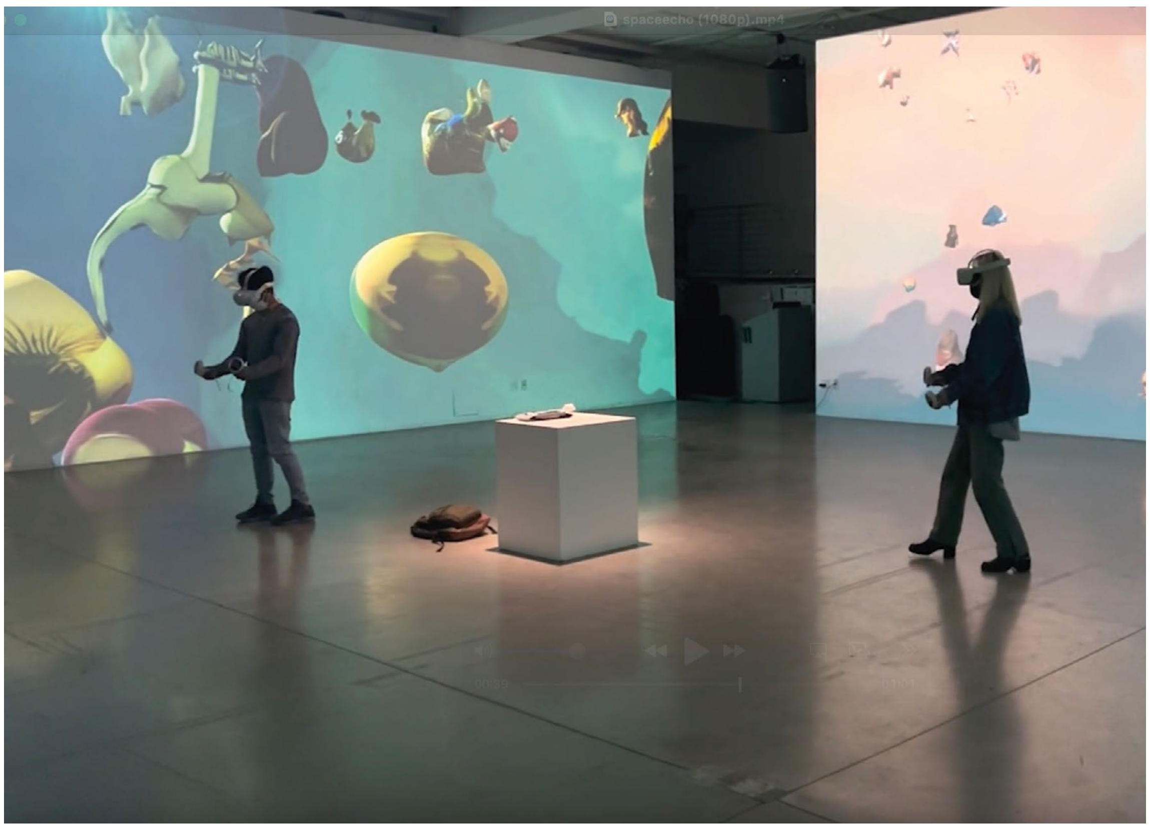

Exhibit visitors try out "Space Echo," a multiplayer virtual reality installation that explores human-AI interactions. Credit: Hyun Cho

"Art and science merge into each other very organically" in fluid dynamics, says Azar Panah, a professor at George Washington University and the coordinator of the Gallery of Fluid Motion. "You can create artwork with fluids, but at the same time, when we are capturing art, we also learn about the science behind it." As a result, the gallery isn't only a way to reach scientists. "We can also teach the general public about science through art," she says.

Building on the success of last year's inaugural traveling gallery at the National Academy of Sciences in Washington, D.C., Panah worked again with curators and artists Natalia Almonte and Nicole Economides to coordinate this year's exhibit. Along with selecting pieces from the archives of the Gallery of Fluid Motion, "Spiraling Upwards" includes the works of artists selected through an open call.

"We wanted to expand [the exhibit] to artists that are working with the language of fluid dynamics, even if their work is not necessarily science," says Almonte.

The curators avoided distinguishing scientists' work from artists' work, since both showcase "how science is beautiful, and how it can be seen in the context of art," says Economides. "It was important for us to bring art pieces into the same space, to have the viewers see that they're not so different after all."

Da Vinci helped inspire this approach. "Leonardo [was] an artist who did science experiments," says Almonte. "Even though Leonardo was an innovator, he always presented himself as an artist first, and I think it was interesting for us to work with him in the back of our minds, with the spirit of science present but then it's presented as artwork."

After workshopping ideas for the theme, the team landed on "Spiraling Upwards" to invoke natural processes and flows — like Earth's water cycle — and a sense of curiosity, creativity, and optimism. "We thought of it also as going up against gravity — lifting your hope, your emotions, and everything else as you pursue your dreams," says Panah.

As part of a previous year's submission to the Gallery of Fluid Motion, researchers traced the vortex wake that forms behind synthetic seal whiskers in a water tunnel. Credit: Vrishank Raghav

The main exhibition room, "The Snake Eating Its Tail," is themed around the ancient symbol ouroboros and contains pieces that are designed to inspire viewers to see the world like da Vinci, who noticed that even repetitive cycles in the physical world vary each time. "Waste and Wonder" is a darker room filled with bright images and videos, designed to emulate both the emptiness and energy of outer space, while "The Waiting Room" is a transient, in-between area for reflection.

"This exhibit is an opportunity for someone to really sit and pause, to observe and make connections that aren't obvious," says Economides. "It's designed to teach us to be more like scientists and artists — to stop and just exist for a moment so we can observe, think, and feel."

True to the theme of "Spiraling Upwards," plans for future galleries are also on an upward trajectory. Panah says work is underway to curate pieces for two spaces during next year's meeting in Houston — one in an art gallery and one in a science museum, enabling the Traveling Gallery to reach different types of audiences.

"Leonardo [was] an artist who did science experiments," says Almonte.

Panah says she hopes the Gallery of Fluid Motion and its traveling counterpart also help fluid dynamics scientists see the impact and beauty of their work. "If people from different backgrounds understand what you are doing, you can inspire others [and] generate new ideas and perspectives," she says. "They can teach you about the future of your own work."

Visit "Spiraling Upwards: The Traveling Gallery of Fluid Motion" from Nov. 1, 2024, to Jan. 31, 2025, at The Leonardo in Salt Lake City. View winning entries from past gallery contests at gfm.aps.org/, or explore more resources related to the traveling gallery at The Leonardo at go.aps.org/LeoGallery, including interviews with the artists and scientists, DIY activities, and articles on Da Vinci.

Erica K. Brockmeier is the science writer at APS.

Exhibit visitors can watch portions of "Does it Work on Mars?," a short film about experiments conducted at the Mars Desert Research Station on how Earth objects would perform under Martian gravity. Credit: Juan José Cielo (documentary); photo courtesy of the curators

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my first year. As Cara described, the physics faculty was very focused on graduating future university professors (at that time, I should point out; things may have changed by now). My plans did not fit that model. Why not transfer to another grad school, you ask? It was the middle of the Vietnam War. If you left the school where you were registered, you were sent immediately to basic training, and Vietnam eight weeks later. So I stuck it out, eventually leaving with a master's degree and a lot of Ph.D.-level courses under my belt.

Thanks to my summer intern jobs, I was able to have two careers: one with Boeing doing space research for NASA, and one in the Scientific and Technical Intelligence (S&TI) community of the Department of Defense. And in the S&TI position, I was able to complete a Doctor of Science degree in the field of non-linear laser beam propagation. In that position I was able to do what Cara plans to do, but in reverse. I stayed in touch with many of my Clemson classmates who became college professors, and recruited students they recommended when my group needed to fill positions for directed energy weapons analysts. Thus, I applaud Cara's thinking ahead to how to help students prepare for jobs outside of academia.

— By Ronald I. Miller (Huntsville, AL)

Letter: Resources for non-academic pathways

The October Back Page essay does indeed describe a major issue in physics: the incessant push for full-time academic careers (which will be achieved, ultimately, by only 5% of physics students).

I am proud to have been part of the J-TUPP (Joint Task Force on Undergraduate Physics Programs) team, which published the PHYS21 report, as well as the PIPELINE (Promoting Physics Innovation and Entrepreneurship Education) program, which published the EPIC report, both of which address the issues the essay highlighted. The EP3 Guide is yet another project to address career development for physics students. The APS Careers office, headed by Crystal Bailey, does an amazing job promoting non-academic careers and the education preparation for them.

I urge APS members to engage with these documents and programs, as the future of the discipline is critically dependent on preparing students for the careers they will most likely pursue — in many fields, disciplines, and applications.

— Douglas N. Arion (Bethlehem, NH)

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Chan attributes her success, in part, to her ability "to talk across the aisle and embrace bipartisanship," and she considers herself an advocate for diversity, equity, and inclusion. She also brought to the fellowship years of experience researching batteries and carbon capture, both in academia and industry.

For Chan, the fellowship helped catapult a long-time interest in climate policy. After the 2020 wildfires, Chan began advocating for climate change legislation and taking environmental policy and law classes. She also attended a symposium sponsored by the American Meteorological Society on climate change policy that hosted lawmakers and their staff.

The policy classes and colloquium inspired her to apply for science policy fellowships across the country. As a result, Chan served as a California Council of Science and Technology policy fellow with the California Environmental Protection Agency. There, she wrote bill analyses for the governor's office, organized meetings for community leaders, and heard diverse perspectives from constituents.

Chan says her APS Congressional Science Fellowship was a life-changing experience, where she had the chance to explore her many ideas for transportation policy. "Developing the right transportation policies, like investments in large-scale infrastructure, will be key to combating climate change," she says. "With this fellowship jumpstarting my career in transportation policy, I want to be a leading transportation and infrastructure policy adviser."

Tawanda W. Johnson is the senior public relations manager at APS.

THE BACK PAGE

To boost mentorship, boost the incentives

Great research in physics is measured, rewarded, and shared. Why isn't mentorship?

BY NIA BURRELL

In physics academia, certain faculty priorities are rewarded over others. Research? Great. Grant funding? Excellent. Mentorship? That's nice, I suppose. Mentorship is frequently an afterthought, relegated to minor lines on performance rubrics, despite its crucial role in supporting young physicists like me.

I am the first person in my family to earn a bachelor's degree in physics, and the first to pursue a doctorate in the field. I'm proud of both, but I accomplished neither alone: Excellent mentors guided me through the trials and triumphs of my education.

Some of my early mentors were my undergraduate physics professors, who gave me the confidence to pursue a Ph.D. My professors connected me to research opportunities, wrote strong recommendation letters even though I struggled on the physics GRE, and supported my breaks from research when I needed them. When I doubted myself, my professors saw my potential and believed I could be successful.

Mentorship helps students of all backgrounds. But for students from groups underrepresented in physics, like women and Black, Indigenous, and Hispanic students, mentorship is especially crucial. According to research from the American Institute of Physics, women and underrepresented students who left the physics major tended to have fewer encouraging interactions with professors, and they interacted less with professors outside of class. A study from George Mason University on women's sense of belonging in physics found that faculty mentorship helps students feel more confident and positive about their physics experience.

> If mentorship does not earn faculty the rewards that research does, even well-intentioned professors — already struggling in cutthroat academia — tend to deprioritize mentorship.

Why is mentorship missing in many departments? Lack of training is a factor. Faculty may be experts in quantum mechanics or cosmology, but far fewer are formally taught mentorship.

But basic incentives are at play, too. Physics professors have many responsibilities, including grant writing, conducting and publishing research, and teaching courses — duties that tend to be heavily weighted in the normal processes of academic promotion. By contrast, while many tenure review guidelines mention mentorship, these mentions tend to be vague. The implication is that mentorship is not a "serious" part of a professor's responsibilities.

If mentorship does not earn faculty the rewards that research does, even well-intentioned professors — already struggling in cutthroat academia — tend to deprioritize mentorship.

This stacks the deck against students, but it's no picnic for certain faculty either. As some professors drop mentorship for more professionally fruitful duties, a small number pick up the slack — and this work tends to fall on the shoulders of faculty from underrepresented groups. I saw this firsthand in my own department, when just two faculty members — both women — worked for years to establish a mentoring group.

If departments are serious about their wish to educate and retain more students, especially women and students of color, they must get serious about mentorship. Plenty of tips and tricks exist for *individual* mentors — encourage a growth mindset, show genuine concern, and keep your mentees plugged into larger communities. But individual efforts must be accompanied by bigger department shifts. Here are three of them.

Measuring mentorship

Physicists are trained to measure things. Why not measure mentorship? It's needed: At many universities, performance review processes ask faculty to list the number of students they supervise — a metric that says little about mentorship quality and impact.

Better metrics exist, including, per a 2019 National Academies report, evaluations of mentorship quality by both mentee and mentor, mentees' placement into jobs, and "whether the mentored scientists are coauthors on manuscripts and grants."

In the same way that data and methodology is discussed openly in physics labs, so too should mentorship approaches — challenges, successes, and ideas for improvement. By bringing these conversations out of the shadows, strategies for effective mentorship can become a normal part of day-to-day conversations in physics departments.

Rewarding mentorship

For many mentors, supporting young scientists is satisfying work — but to improve mentorship department-wide, stronger external incentives must exist.

Many schools recognize mentors with specific awards, like Virginia Tech or the University of Georgia. APS recognizes excellent mentorship in physics with prizes like the Narain Mentoring Award. These awards are a positive step, but mentoring must also be a larger part of performance, promotion, and tenure reviews. A tenure packet might include, among other things, a mentor's learning resources or completed workshops, evidence of mentees' placement into roles or jobs they want, and mentoring evaluation metrics measured over time.

Even funding agencies are elevating the value of mentorship. For example, the National Science Foundation recently updated its research grant applications, requiring principal investigators to outline how they plan to provide mentorship for postdocs and graduate students. If other funding agencies start requiring similar guidelines for grant applications, professors can incorporate mentoring more easily into their responsibilities.

Sharing mentorship

The work of mentorship is often distributed unevenly among physics faculty, but there are thoughtful approaches to even out these responsibilities. The mentoring program at George Mason University, called Spectrum, models one such approach. Founded by students in the physics and astronomy department, the program uses a mentoring structure it calls a "constellation," a mentor group consisting of one or two faculty members and a group of students at different career stages.

A network like this more evenly distributes the responsibility of mentorship, preventing any one person from doing the heavy lifting — and for many students, it's a more effective and enduring form of network. The program also emphasizes principles of access, justice, equity, diversity, and inclusion in its teaching, aiming to reduce imposter syndrome and build a greater sense of belonging.

Departments can also help students look beyond their institutions for help when it's needed. For example, the APS National Mentoring Community connects Black, Latino, and Indigenous students with physicists at any career level and in any field. Mentors and mentees have access to workshops, resources, and strategies to get the most from the community.

Moving the needle

When I reflect on my career in physics, I feel lucky that my mentors were there to help me succeed. As I have heard from other young physicists — and as research shows — not all students have the same good fortune.

While mentorship is rarer in physics than it should be, physics departments can apply research-backed strategies to give mentorship the boost it needs. But the status quo is easy, and culture change is hard. Department leaders must also have the will to make these shifts. If they do, they can become champions of strong mentorship — and reap the benefits it will have on the next generation of physicists and the field we all love.

Nia Burrell is a sixth-year graduate student in physics at Northwestern University.

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bit of physics I can infuse into that conversation, I'll do it.

Can you give an example?

There was a football game a few years ago that went to a sudden-death overtime: Whoever scores next, wins the game. One of the teams, the Cincinnati Bengals, had the ball at the 45-yard line and attempted a field goal. The kick goes up, and no one breathes while the ball tumbles through the air, hits the left upright, and careens in for the win. I said, wait a minute, could the Coriolis force have played a role? I checked the orientation of the stadium and did a fast back-of-the-envelope calculation. I then posted on social media that the sudden-death victory by the Cincinnati Bengals was aided by a third-of-an-inch deflection to the right caused by the rotation of Earth. People lost their minds.

My point here is that everyone already knows football, so I don't have to explain what a field goal is or what the upright is. So that's a scaffold to which I can then affix science. I posted that tweet to get people's attention, and then I went on to describe the effects of the Coriolis force. Football is the excuse, and people stay for the science. There is a lot of value in knowing pop culture as an educator, as it allows you to communicate rather than lecture. When you are a lecturer, you require that people come 90% of the way to you. As a communicator, you go 90% of the way to your audience.

How do you see the landscape of communication evolving, with overconsumption of social media and decreasing attention spans?

If that's what we have to deal with, then I'll navigate that. I cannot change the attention span of people who live on TikTok. But I can post TikTok content that's competitive with other content and reaches 5.8 million followers. Disclosure: People a third my age are telling me what's trending and what I should pay attention to!

And there are some positive developments in terms of gender balance and diversity: At least half of online science communicators are now women, like Science Girl and Physics Girl. I have this fantasy where enough other people get onto the media landscape that I can just back up slowly and exit without anyone noticing.

What research directions are you paying attention to these days?

I'd like to know if there's life under the frozen surface of Europa — there are some missions headed there in the coming years. I'd also like to dig under the surface of Mars to look for water. It'd be fun to pitch a tent at the South Pole of the Moon, where we think water may be trapped in craters. I'd like to see more international cooperation in space. The Artemis Accords, which has been signed by multiple countries, is a forward-thinking recipe for conduct in space. If we have the chance to be friends in space, maybe we can bring some of that back on Earth.

Matteo Rini is the Editor of APS' Physics Magazine.

Opinion articles on the Back Page are member commentary; their views are not necessarily those of APS. To respond to an opinion piece or pitch your own (we welcome both), email letters@aps.org.