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APS News

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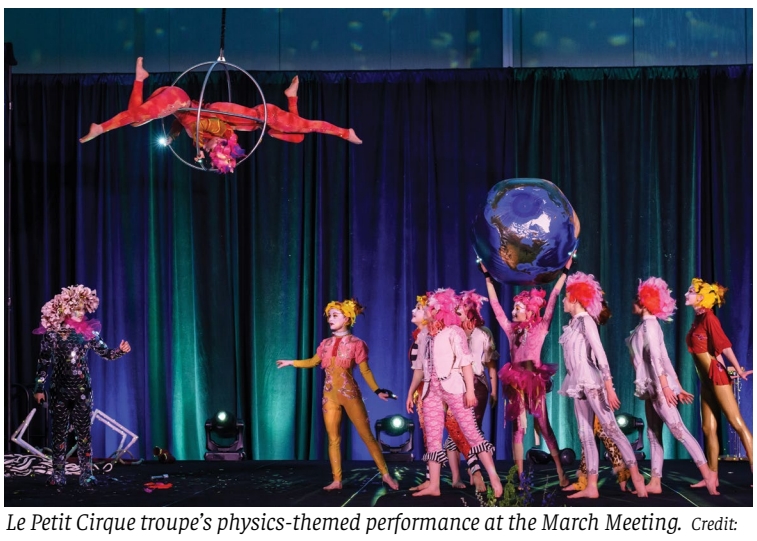
Cosmic Tumbles and Quantum Leaps in Las Vegas

At this years March Meeting, circus performers embodied mind-boggling quantum concepts on the stage.

BY SOPHIA CHEN



Le Petit Cirque troupe's physics-themed performance at the March Meeting. Credit: American Physical Society

The APS March Meeting 2023 took place in star-studded Las Vegas, complete with an Albert Einstein impersonator (an APS hire with a pan-European accent) and 2022 Nobel Laureates John Clauser and Anton Zeilinger (they regaled an audience with quantum mechanics).

But the most eminent celebrity to make an appearance? Schrödinger's cat.

The famous feline made an appearance in an APS-commissioned circus act titled "Cosmic Tumbles and Quantum Leaps" that kicked off the meeting on Sunday, March 5, in Caesar's Forum, the conference venue. In a half-hour program, acrobats and contortionists leapt, spun, and threw each other in the air in choreography inspired by physics concepts. Nathalie Yves Gaulthier, who directed the performance, described the program as "Cirque du Soleil meets Lion King meets quantum physics."

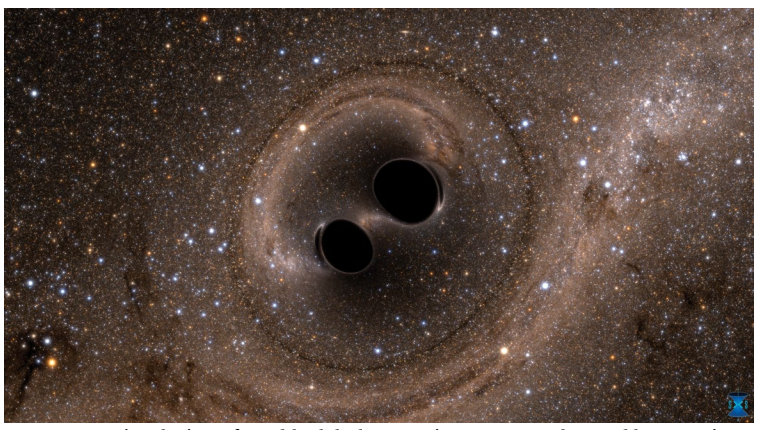
The performers were part of Le Petit Cirque, a Los-Angeles based youth circus troupe whose ages ranged from 9 to 16. They train between 20 and 30 hours a week, said Gaulthier, while also attending school, sometimes through homeschooling when they have to travel. "Even on this trip, they are being monitored by a labor board-certified studio teacher," said Gaulthier.

The group calls themselves a "Youth Humanitarian Circus," as their performances often raise money for important causes, including for people injured in land mines. The group performed at the 2017 Nobel Peace Prize concert in Oslo, Norway, as well as the Dalai La-

Cosmic Tumbles continued on page 4

From Atoms to Black Holes at the March Meeting's Kavli Symposium

BY MEREDITH FORE



A computer simulation of two black holes merging, an event detected by LIGO in 2015. Credit: The SXS Project

The APS March Meeting 2023 kicked off with a bang with the Kavli Symposium, where four speakers from four different fields, at four different scales, shared their work with attendees.

The Kavli Symposium is an annual tradition at the March Meeting, showcasing a variety of speakers and topics that have ranged over the years from cancer-detecting nanotechnology to cosmological observations and beyond. The theme this year, "Frontier Physics from Atomic to Astronomical Scales," highlighted work that focused on the scales of atoms, 2D materials, the Earth, and black holes.

The scale of atoms

Monika Aidelsburger, a professor at the Ludwig Maximilian University of Munich, uses atoms as tools to investigate complex systems,

Kavli continued on page 5

Want to Teach Physics? PhysTEC Teachers of the Year Have Advice.

At the 2023 PhysTEC conference, four physics teachers reflected on the rewards and challenges of teaching.

BY LIZ BOATMAN

Did you know that fewer than half of new physics teachers in high schools hold a degree in physics? This creates a range of challenges in the classroom, and in 2001, the American Physical Society and the American Association of Physics Teachers (AAPT) launched a partnership to tackle them. Known as PhysTEC, short for the Physics Teacher Education Coalition, the partnership today boasts 364 member institutions across the country, which collectively graduate more than half of all new physics teachers.

Every year, each PhysTEC member institution can nominate one of its graduates to be named a Local Teacher of the Year and considered for the National Teacher of the Year title.

Kicking off this year's PhysTEC conference in Las Vegas was a moderated panel at which four 2022 PhysTEC Teachers of the Year shared their perspectives on challenges and opportunities facing the profession today. Here are some of their responses.

1. What aspect of your physics teacher program most helped prepare you for teaching?

"The best experience you're going to get is to be put in front of a class of students," said Patty Mueller of Westbury Public Schools in New York, nominated by Adelphi University. "No matter what they teach you or what they tell you in a [teacher training] class," it's impossible to figure out your own style and methods until you do it yourself, she said. "That's honestly what made me fall in love with teaching."

Samantha Spytek, from Rock Ridge High School in Virginia and

PhysTEC continued on page 3

The Adler Planetarium, an APS Historic Site in Chicago, Offers Visitors a Glimpse Into the History of Astronomy

Beyond its observatory and exhibits, the Adler cares for rare artifacts — some dating back a thousand years.

BY LIZ BOATMAN

This May marks the 93rd anniversary of the Adler Planetarium — the first planetarium built in the Western hemisphere. Located on the windy shores of Lake Michigan in Chicago, the facility was established by Max Adler, who in 1928 gave $500,000 to support its construction — nearly $9 million today.

After retiring from Sears, Roebuck & Co., the company that served as the namesake of Chicago's famous Sears Tower (now Willis Tower), Max Adler wanted to spend his wealth on Chicago's community — and a fateful visit to Germany gave him his big idea. There, in Munich, he saw a new Zeiss projection-based planetarium.

He was determined to bring the landmark technology to the United States. By then, the projection-based planetarium was the hot new thing in Europe, with 15 in Germany alone. Previous planetarium designs had relied on complex mechanical systems, but the projection-based system was more robust and offered the potential for new types of planetarium shows.

Designated as a National Historic Landmark in 1987 and an APS Historic Site in 2019, the Adler today is an astronomical gem. The facility boasts three planetarium domes, a publicly accessible observatory that's popular with researchers, exhibit and educational spaces, and a collection of over 6,000 artifacts, books, and manuscripts related to astronomy and astrophysics, many of which can be viewed online.

The Adler Planetarium in Chicago. Credit: The Adler Planetarium

"I like to say we're small but mighty," says Chris Helms, the Adler's senior collections manager.

The Adler has seen tremendous growth and change over time, including in its collections. When Max Adler first opened the facility on May 12 — his birthday — in 1930, he "envisioned the museum not just as a space that you would come and see cool exhibits and sky shows," says Helms, but as "a place for serious research."

So when Adler learned that art dealer and auctioneer Antonius W. M. Mensing was selling a collection of astronomical instruments and antiques in Amsterdam, he bought the lot.

Nearly a century later, the Adler continues to add items to its collections through formal acquisitions each year. "We're probably top three or four in the world in terms of the importance and the rarity of the objects that we do have," says Helms.

Helms says that the oldest items in the Adler's collection include a Mesopotamian terracotta carving of a lion, long suspected to be a depiction of the constellation Leo the Lion, as well as an astrolabe — an early navigational instrument that ship captains used to determine their latitude based on stars — that dates to the twelfth century.

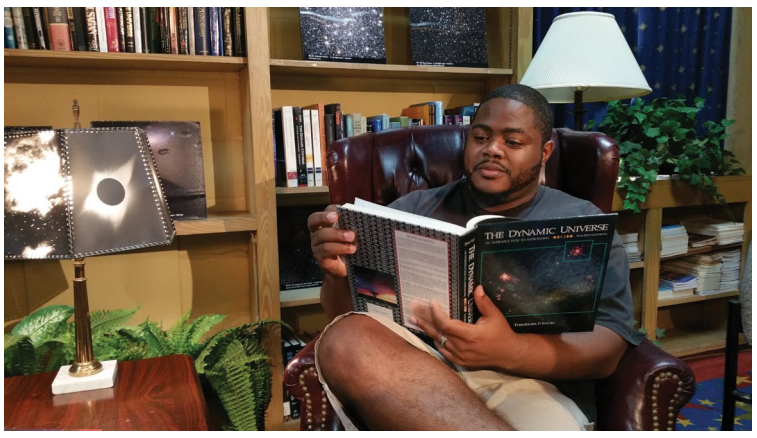
Helms' personal favorite is a filigree celestial sphere, dating to the 1500s, which is on display in the museum. The brass sphere is about 16 inches in diameter and has over 1,000 stars punched into it. "The constellations are your typical Western and Ptolemaic constella-

Adler continued on page 5

A Bridge to Chasing Active Galactic Nuclei

John Hood II, APS Bridge Program graduate, achieved a dream he once thought impossible.

BY RACHEL CROWELL



Astrophysicist John Hood II, who received his doctorate in 2022.

At the centers of most large galaxies, supermassive black holes lurk, pulling in matter and blasting out unusually bright bursts of light.

These luminous areas are called active galactic nuclei (AGN), and astrophysicist John Hood II, a postdoctoral researcher at the University of Chicago and Kavli Institute for Cosmological Physics, and a National Science Foundation Office of Polar Programs Fellow, can't get enough of them.

"I feel like the thing that's most exciting about [AGN] to me ... is there are a lot of questions, but not a lot of solid answers," says Hood, who received support through the APS Bridge Program, which helps underrepresented minority students prepare for graduate school in physics.

As a Boy Scout in Columbus, Georgia, Hood became enthralled with stargazing on troop camping trips. And on trips to visit family in rural Alabama, he would study the "weird-looking clouds" in the night sky — clouds lit, he learned, by stars.

While those experiences kindled his passion for astronomy, some comments dampened it. "As I got older, I fell into the trap of being told, 'Oh, you're not good at math, so there are certain things you can't do,'" Hood says.

When he entered college at Columbus State University in 2009, he majored in aerospace engineering instead. "I was always told I was good with my hands, good with building things and taking things apart, so engineering made sense," he says. But when his girlfriend — now wife — took him to a university-sponsored astronomy event where attendees could use telescopes to view stars, everything changed.

"It was one of the best birthday presents ever," Hood says. Realizing he already met the prerequisite requirements, he dove into "a two-part class of Astronomy I and Astronomy II in the same semester." The professor, Shawn Cruzen, "became very influential in my life and career," he says.

"After the first half of the semester, he pulled me aside one day and was like 'Have you ever considered studying astrophysics? You have a real knack for this," Hood says. He remembers "audibly chuckling."

"I was like, 'Doing astrophysics? There's no possible way!" he says. Cruzen proposed a game plan. "Change your major to astrophysics, take a couple of the classes, see how you like it, and if you don't like it, I'll help you change your major back," Hood remembers him saying. Hood made the shift and never looked back.

But when he applied to graduate school, he received six rejections. "I was in a really deep funk," he says. However, one rejection letter came with a suggestion: Apply to the APS Bridge Program.

Applying was nerve-wracking. "You don't know where you're going to go," he says. "Any of the Bridge programs could pick your application." But he felt he had to take the plunge. "I really want to chase this dream," he recalls thinking.

In 2015, a year after earning his bachelor's degree, he enrolled in the Fisk-Vanderbilt Master's-to-PhD Bridge Program. He says that program had an "almost immeasurable impact." At Columbus State, "my first time meeting a Black scientist was right before I graduated," he says — but at Fisk University, an HBCU, he realized, "I'm not alone out here. There are other people interested in the same thing that look like me." The mentorship he received was invaluable, he adds.

Immediately, Hood was convinced he wanted to study active galactic nuclei. "That was the one thing that I knew," he says. He decided to find "anybody who's studying black holes" and "stick to them like a puppy." One such person was Kelly Holley-Bockelmann, his faculty advisor in the Bridge Program

John Hood II continued on page 4

THIS MONTH IN PHYSICS HISTORY

May 1962: James West and Gerhard Sessler Patent the Electret Microphone

The duo's invention is found in everything today from hearing aids to recording equipment.

BY TESS JOOSSE

It's possible you've never heard of the electret microphone — but if you've talked on a telephone, you've definitely heard *because* of an electret microphone. Over 60 years after it was invented, it's now found in nearly every consumer product that has a microphone, be it a recording device, talking toy, smartphone, or hearing aid.

The electret microphone traces its roots to 1957, when scientist and inventor James "Jim" West completed a summer internship at Bell Labs. Born in Virginia in 1931, his parents raised him to be "either a preacher, teacher, lawyer, or doctor" — not a scientist, West, now 92, recalls. Opportunities for Black scientists were slim, and to drive home the point, West's father introduced him to several Black men who had doctoral degrees in chemistry but who were working at the post office.

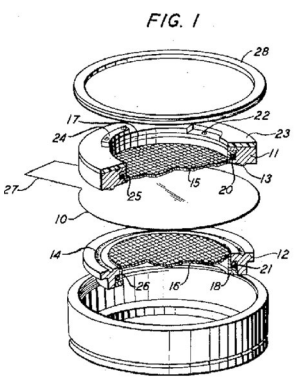
Still, West wanted to know how the world ticked. This curiosity got him into some trouble along the way, like when he took apart his grandfather's pocket watch and couldn't put it back together. But it also led him to the physics department at Philadelphia's Temple University, where on a bulletin board one day he spotted an advertisement for an internship at Bell Labs, widely regarded as a research powerhouse.

He joined a project in the acoustics department, where researchers were trying to determine how long it took the human ear to recognize two sounds. In other words, if you played two "clicks" very close together, "when do you hear the separate clicks?" West explains.

The project needed a new microphone and earphone to transmit these clicks, because the standard condenser microphones of the time did not produce enough sound pressure to generate such precise sounds at a hearable volume. These mics consisted of a capacitor made of a fixed plate and thin membrane diaphragm that vibrated when it encountered sound pressure. The vibrations then changed the connected circuit's capacitance, creating an electrical current that could be amplified and heard. A bulky power source created the circuit's polarizing voltage.

West got to work on a better version. He came across a paper in the journal *Acustica* that detailed how to build microphones and earphones using polystyrene as a dielectric (a material that stores rather than conducts charge), connected to a battery that was also attached to a piece of metal. West used these principles to create an earphone using metal-coated Mylar to which he applied voltage. The design solved for the limitations of the standard earphone — and the earphones worked great. West completed his internship with high marks. "I got a gold star," he laughs.

Gerhard Sessler (left) and James West in their lab holding Teflon foil, with an electret microphone in the foreground, 1976. Credit: Nokia Bell Laboratories



"An exploded perspective view of a condenser earphone" from Sessler and West's patent.
Credit: U.S. Patent Office, Patent 3118022

But just a few months later, he got word that the earphones stopped working — they had only held a charge for about six months. He returned to Bell Labs and paired up with Gerhard Sessler, a German scientist at the company, to revisit the earphone and build a microphone along the same lines. They determined that, to maintain the earphones' charge, they should have reversed the polarity of the battery over time — "our biggest mistake," West says.

One day, the microphone shorted out as West and Sessler tested reversing the battery. Yet the mic somehow still produced sound. The duo had inadvertently turned the dielectric into an electret — a material with a quasi-permanent electric charge.

Though new to West, electrets were not new to science. The term, a portmanteau of "electricity" and "magnet," was coined by Oliver Heaviside in the late 1800s, and Japanese scientist Mototarô Eguchi experimented with waxes and resins as electrets in the 1920s. West and Sessler set about searching for a durable material that could hold a charge for years.

"One of the benefits of Bell Labs was that you couldn't lock your

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Expanding Physics at the March Meeting

BY SOPHIA CHEN

Credit: American Physical Society

The APS March Meeting 2023 was jam-packed with far more than "strictly physics," reflecting the field's evolving boundaries.

The meeting featured topics at the intersection of physics and other fields, like biology, data science, biomedical science, social sciences, and more — but far beyond that, there were sessions on nuclear policy and threat reduction, education, misinformation, art and physics, history and philosophy, and equity and diversity, including an APS session on bias and discrimination.

Biophysics researchers presented studies on a variety of living systems. During a session on animal behavior, scientists reported research on jumping arthropods known as springtails and wiggly nematodes; another researcher analyzed the thermodynamics of a horse's movement. These sessions highlighted collaborations between biologists, who explained and measured animals' behavior, and physicists, who searched for universal laws to describe it.

Robotics researchers also showcased their work, particularly in the field of soft robotics. This emerging technology creates autonomous devices out of elastic materials rather than rigid metals, making them safer to work alongside humans. To design these materials, researchers rely on basic physics research — and borrow concepts from traditional crafts. Leixin Ma of the University of California, Los Angeles presented on using the Japanese art of kirigami, which involves creating 3D structures from 2D materials like paper through folds and cuts. Another robot design came from Wenlong Li of the Agency for Science, Technology and Research in Singapore, whose team connected the lobes of a Venus flytrap to a device that electronically opened and closed them.

Presenters also discussed public communication and outreach. Alice Hanyu Zhang, a graduate student at Cornell University, talked about translating Veritasium, a science YouTube channel with 13.5 million subscribers, to China where the platform was banned. As a high school student who had just moved to the U.S. from China, Zhang was hooked on the channel's viral videos of physics topics, like demos illustrating misconceptions about angular momentum. "When I tried to share these videos with my friends back in China, though, I hit a roadblock — the Chinese firewall," said Zhang during her talk. Zhang worked with the channel's host to migrate the videos onto the Chinese platform Bilibili. Zhang now manages a team to write subtitles for these videos and has gained nearly 300,000 subscribers since her efforts began around 2018.

Jevin West of the University of Washington presented his studies of the process of science itself. He talked about current challenges to scientific credibility, including the reproducibility crisis, in which researchers have been unable to replicate many papers in the biomedical and social sciences; gender inequity; and the tendency of researchers to cite papers even after a journal has retracted them.

Meanwhile, the industry exhibits illustrated the connection of phys-

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PhysTEC continued from page 1

nominated by Virginia Tech, recalled teaching both middle and high school students *and* an undergraduate physics course during her master's program. The experience "gave me the ability to look at what was happening in each level at the same time," she said. By comparing student preparation levels, pedagogies, and challenges across different programs, she developed good teaching practices faster, Spytek said.

Joe Cossette of Minnetonka High School in Minnesota, nominated by the University of Minnesota, made a unique entry into the teaching profession. With several years of experience as an engineer under his belt, he went back to school to complete a one-year accelerated teaching program for individuals who already had a technical bachelor's degree. "That was a powerful experience," he said. Cossette said that his physics teaching coursework was energizing — unlike his classes as a high school student. "It really inspired me to make my classroom look more like that, and less like what I experienced when I was in high school," he said.

2. What challenges do incoming science teachers face that are different from the challenges you encountered when you started?

Jennifer Podel of Northampton High School in Massachusetts, nominated by Smith College, said one of the biggest challenges has been transitioning to standards-based grading, away from the more traditional approach where points are awarded per question or assignment but the concepts being evaluated aren't explicitly tied to overarching course goals. By contrast, in standards-based grading, students are graded based on their mastery of explicit learning standards. The shift is "an interesting challenge" for teachers, she said, because it requires "boxing our curriculum into chunks" that can be mapped to individual learning standards in a way that many new teachers aren't trained to do.

In contrast, Cossette said, "when I started teaching, I entered a team that had been doing pretty similar things for the last 10 years," which meant his team could explore new approaches without feeling overwhelmed. But the COVID-19 pandemic changed that, he said. Each year of teaching during the pandemic varied so greatly that now, when new teachers ask about practices and expectations, the best his team can offer is "a random smorgasbord" of things they've done in recent years. Even though a lot of these practices worked well, he knows that kind of response can be "overwhelming" for new teachers, he said.

Mueller added that she's seen some new teachers struggle to accommodate last-minute changes to their plans, such as a computer system being down. "You've got to teach your lesson, no matter what's thrown your way," she said. She thinks it's important for new teachers to have a simple backup plan, like pivoting to a whiteboard and markers to work a few practice problems. Having a plan also reduces stress, she said.

3. What would you say to a person who is interested, but unsure if they want to become a teacher?

Mueller thinks young folks interested in teaching should ask themselves questions deeper than just "do you enjoy working with others?" or "do you enjoy physics?" Instead, they should think about whether they want to put in the effort and creativity to figure out how to teach well, without knowing ahead of time exactly what type of school they'll work at or students they'll work with. "Every student is not going to learn the same way," she said.

> Podel added that, as a physics teacher, "you have to know your subject, but you don't have to be a genius in it." However, "you do have to know people."

Podel added that, as a physics teacher, "you have to know your subject, but you don't have to be a genius in it." However, "you do have to know people," she said. "It's more important for you to be engaging and inviting ... than it is for you to be a content master."

For those still unsure, Cossette suggested a mental exercise: Imagine what you'd like your life to be like 20 years down the road. When he did that exercise while working as an engineer, he realized he "wanted to have a different sort of interaction and impact" so that he could "work with people and get excited."

In fact, Cossette said, he loves teaching so much that sometimes, he thinks it seems "crazy" that teaching is a job someone can be *paid* to do.

Liz Boatman is a staff writer for APS News.

The Physics Curriculum Needs More Data Science — and One Team is Making it Easier Than Ever to Integrate It

With support from the APS Innovation Fund, the DSECOP team is getting data science into more undergraduate physics classrooms.

BY LIZ BOATMAN

The DSECOP team. *Credit: Anil Colpan Zenginoglu*

Most physics professors today agree that their students should learn coding and computational thinking — but what about more specialized skills, like those in data science?

The movement to incorporate data science into the undergraduate physics curriculum is gaining momentum, bolstered by a 2021 APS Innovation Fund award to a team who met through the APS Topical Group on Data Science (GDS), launched in 2020. The group — Alexis Knaub of the American Association of Physics Teachers, Marilena Longobardi of the University of Basel in Switzerland, William Ratcliff of NIST and the University of Maryland, and Wolfgang Losert of the University of Maryland — saw the Innovation Fund as a chance to respond to a call for help: Physics faculty across the country were asking GDS members to recommend data science textbooks or resources for use in undergraduate classrooms.

"This was something that just needed to be done," says Ratcliff. "If not us, who?"

After receiving a $200,000 Innovation Fund award for the project, which they called the Data Science Education Community of Practice (DSECOP), the team moved quickly. They hired graduate students and postdoctoral researchers as project fellows to develop small data science teaching modules that faculty at any college could easily add to their physics courses. Then, through the GDS, they reached out to colleagues across the country and asked for help piloting the modules with current physics majors.

In addition to the co-PIs, Mohammad Soltanieh-ha of Boston University coordinates the fellows' activities, Jacob Hale of DePauw University reviews the fellows' output, and Anil Zenginoglu of the University of Maryland helps manage the community the project has built.

Last June, the DSECOP team organized a multi-day workshop for about 30 graduate students and faculty on the University of Maryland campus, to tinker with and workshop the new modules. Fellow Julie Butler, a doctoral candidate in physics at Michigan State University, says the workshop was a great opportunity to network with other data science-minded people.

So far, Butler has developed two modules for DSECOP, including one on using neural networks, a type of machine learning algorithm. "I show them how to build a neural network from scratch," she says. The students compare their results with those of a hand calculation and numerical differential equation solver. Beyond just applying a neural network, Butler aims to help students learn how to analyze a problem to determine whether a machine-learning approach would be an appropriate solution, and if so, what type.

In the classroom, "it's been pretty well received," says Butler, who has gotten student feedback to improve the module before it's distributed more widely.

Data science is a comparatively young field, largely enabled by advances in computing power. "I graduated from undergrad in 2006 with a degree in physics, and we weren't taught data science then," says Knaub.

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Cosmic Tumbles continued from page 1

ma's 80th birthday at the University of California, Irvine. "Our next goal is the pope," said Nathalie Yves Gaulthier, the director of the troupe, before the show. The audience chuckled. "Not joking. I'm not kidding," she said.

"People asked me, 'Are you going to encourage our physicists to gamble?'" said Smitha Vishveshwara of the University of Illinois, Urbana-Champaign, who, as program chair of the meeting, helped produce the performance. "No. Las Vegas has an amazing performance scene. 'That's what we're going to tap into,' I said."

Vishveshwara had read in *APS News* about a physicist, Julia Ruth, who had left a graduate school program in geophysics at Scripps Institute of Oceanography to become a full-time circus performer. Last August, Vishveshwara and other meeting organizers emailed Ruth to ask if she could help them produce a circus act for the meeting.

"They sent me a really long email, and I didn't read it right away because it said 'Dear Dr. Ruth,'" said Ruth. "Usually when someone sends that, they think I finished my PhD because of my publications from forever ago, and they want me to subscribe to something."

Fortunately for Vishveshwara, Ruth still read the message. "I was like, 'Yes. This has to happen. I have to be a part of this,'" said Ruth. She connected the APS meeting organizers with Le Petit Cirque, which Ruth used to coach for. Gaulthier, who founded the troupe, jumped at the opportunity. Gaulthier, Ruth, and Vishveshwara met over Zoom several times to plan.

The performance featured numbers such as "Emergence," with acrobats leaping and tumbling in formation with glowing LED lights, and "Entanglement," where an aerialist climbed high into the air on rippling ribbons attached to a trapeze hung from the ceiling. Schrödinger's cat, a contortionist in leopard print, with a tail and ears, started her number trapped in a Plexiglas box with her spine bent in a U shape. She leapt in and out of the box as another performer peered at her through sequined binoculars, the "observer" of the quantum system. The cat toggled between being "awake" and "asleep" in response to the observer, in analogy to Schrödinger's quantum thought experiment. Vishveshwara penned a dramatic voiceover that described the physics behind the performance, which Gaulthier recorded and played for the performance in Las Vegas.

"It's just freeing," Bixby Baker, 13, one of the performers, told *APS News*. "When you're performing, it feels like there's nothing else in the world."

The production required careful planning, as the troupe dangled spinning structures and trapezes from the ceiling that the acrobats performed within. "A lot of times you work with people, and it's like, 'hello? Can we discuss where you're putting those trapezes?' said Gaulthier. "It was really pleasant and refreshing to work with physicists because everyone had a brain. We got to move forward so much more quickly."

Although they were depicting quantum phenomena, the troupe offered a dazzling demonstration of classical physics. As they spun and leaped, each performer had an intuitive mastery of gravity and angular momentum beyond any physics homework problem. "Even though [circus] is a visual representation of physics, I think it also appears to defy physics in some ways, because we're challenging what the human body can do," said Ruth.

A young performer of Le Petit Cirque.
Credit: American Physical Society

"You know when you win something, you get that rush of excitement, and you're like, 'Oh my gosh, I just did that'?" said Lyra Gross, 16, one of the performers. "It's like that, combined with the feeling you get when you help a friend, because you're giving something to the audience."

The circus act was a reminder that physics is everything around us — including our own bodies. It can be easy to lose sight of that during the March Meeting, as physics seems relegated to 12-minute PowerPoint presentations. But meeting participants self-assemble into neat rows; tourists condense into their basest state in front of slot machines in smoke-filled casino lobbies. Physicists are not merely observers of nature, but participants too.

Sophia Chen is a writer based in Columbus, Ohio.

Biden Seeks Broad Increases to Science Budgets for Fiscal Year 2024

BY MITCH AMBROSE

The Biden administration's budget request for fiscal year 2024 includes across-the-board increases for science agencies, with particularly large boosts proposed for programs focused on fusion energy research, emerging technologies, and translating research outcomes into practical applications.

The budget for the Department of Energy Office of Science would increase 9% to $8.8 billion, with its fusion program jumping 32% to just over $1 billion. Much of the new money would support public-private partnerships to develop fusion energy generation technologies, in pursuit of the administration's goal to deploy pilot fusion power plants in the 2030s.

Expanding the National Science Foundation's role in "use-inspired" research and technology development has remained a top priority of the administration. It proposes increasing NSF's budget by about 15% to $11.3 billion, of which $1.2 billion is for the recently created Technology, Innovation, and Partnerships Directorate, a roughly 30% increase. Meanwhile, NSF's Mathematical and Physical Sciences Directorate would see a 9% increase to $1.8 billion, the smallest increase in percentage terms across the agency's main directorates.

The National Institute of Standards and Technology's base budget would surge 32% to $1.6 billion under the budget request. This includes a doubling of NIST's facility maintenance budget to $262 million

credit: JHVEPhoto - stock.adobe.com

to help tackle dire degradation of buildings at the agency's campuses in Maryland and Colorado.

There are exceptions to the administration's budget increases. It also proposes major cuts across the Department of Defense's early-stage R&D portfolio, comprising accounts funding basic research, applied research, and advanced technology development. The administration requests a total of $17.8 billion for these accounts, about 8% more than it sought for last fiscal year but 20% below what Congress ultimately appropriated.

Budget strains are also evident at NASA. While NASA's Science Mission Directorate would increase 6% overall to almost $8.3 billion under the budget request, the Heliophysics Division budget would drop 7% to $751 million. The agency seeks to pause the division's planned Geospace Dynamics Constellation and use the savings to address the growing costs of other missions, such as NASA's effort to return rock samples from Mars to the Earth.

Reactions to the budget request have split along party lines in Congress.

"While the budget request doesn't include everything that we worked hard to authorize in the CHIPS and Science Act, it provides for substantial progress for our federal science efforts," stated House Science Committee Ranking Member Zoe Lofgren (D-CA). "I'm especially encouraged about the strong funding the president has called for to support our fusion energy efforts. We have seen incredible breakthroughs in fusion in the last 18 months — and we cannot afford to lose momentum."

Meanwhile, Committee Chair Frank Lucas (R-OK) argued the budget "shortchanges" basic research while overspending on other areas. "In the past two years, the Biden administration and Democrats in Congress have spent reckless amounts of money, without regard for efficiency, effectiveness, inflation, or our national deficit," he stated. "This budget proposal is, unfortunately, more of the same."

Though Lucas supports the science budget increases recommended in the CHIPS and Science Act, House Republican leaders have pledged to constrain federal spending overall. The House and Senate will advance their own spending proposals this spring, with a standoff over federal limits likely to follow.

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

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But today, physics graduates are taking jobs in industries that are thirsty for opportunities to streamline decision-making processes and innovate quickly. Data science offers a robust way to do this. In industry, "they're using machine learning as one of the tools in their research toolbox to accelerate the pace of their science," says Ratcliff.

Despite the demand for physicists with data science skills, the physics community has not responded quickly, says Ratcliff. "Whenever somebody wants to develop new content [for a course], this takes time," he says.

Knaub adds that "one of the tensions we're facing with any curricular change is, if we add stuff, does that mean we're taking things out?" And adding data science content can be a daunting challenge at smaller schools, says Ratcliff, where a department might want to overhaul its curriculum but lacks a data science expert in its ranks.

The DSECOP team has designed the data science modules to readily fill this gap. Each module that Butler has built, for example, constitutes only three Python notebooks, and each can be completed in just one class period. The whole DSECOP project uses Python, because "it's one of the easier languages to learn." This should reduce the barrier for faculty adopters, she says.

With the project's Innovation Fund support ending later this year, the DSECOP team is planning their next steps. "We need to seek additional funding to start really working on the deployment of this material," says Ratcliff. "It does us no good, even if it's tested material, if it just sits on GitHub." He says that with additional funding, the team will also be able to accept contributions directly from the physics community.

Ratcliff expects that APS and AAPT meetings, as well as future DSECOP workshops, will play a critical role in getting the DSECOP modules into the hands of physics instructors across the country. Connecting with other faculty "at least gives us the chance to influence or to educate those who are going to be most passionate that these resources exist," he says. "And that's often how you start movements."

Liz Boatman is a staff writer for APS News.

John Hood II continued from page 2

who later became one of his doctoral advisors.

Jedidah Isler, then a postdoctoral researcher at Fisk University, became his research advisor for his master's research. "We were doing multi-wavelength observations of AGN from gamma rays to optical and infrared," Hood says. He was transfixed.

After earning his master's degree in 2017, he began his doctoral program at Vanderbilt University — but there was a hurdle. "[Holley-Bockelmann] knew that I was interested in experimental work, and she was like, 'Well, we don't really have anybody here that does that. But we can find somebody who's willing to take a student who has funding,'" he recalls. They eventually landed on Stephan Meyer at the University of Chicago.

There, Hood worked with the South Pole Telescope (SPT) Group, as well as CMB-S4, an international experiment on the cosmic microwave background. "I was doing detector development work with them ... Getting my hands dirty in the lab, learning how to run the cryostats, learning how the detectors work, learning how to manufacture them and make them better than the current ones," he says. "It was just a lot of fun."

When Thomas Crawford, his faculty advisor, mentioned that some researchers wanted to use SPT data to study active galactic nuclei, Hood's experience was a boon. Hood is first author on an AGN-specific analysis paper using SPT data, which was recently accepted to *The Astrophysical Journal*. He received his doctorate in 2022.

In his current position, Hood is continuing that work, and he plans to share the data on a public website. He's also exploring statistical analysis. "We're trying to study the connections between the variability at different wavelengths of AGN," he says. The recent paper represented just one source — or potential AGN — and "we have over 100 sources that we could possibly look at," he notes.

Hood's advice to students in astrophysics and beyond? "Do what you feel you have some sort of passion for, because that makes everything easier." And for anyone considering the APS Bridge Program, his guidance is even simpler: "Do it."

Rachel Crowell is a math and science journalist based in Iowa.

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tions, like Perseus and Hercules," he says, except that "they're made with a Middle Eastern art style. So it's this really awesome mix of Western star charts and Eastern art."

As a collections manager, Helms says that metal objects like the celestial sphere tend to be the easiest to care for. In fact, the Adler possesses several brass and bronze artifacts with preserved fingerprints dating back 400 years or more — possibly the fingerprints of the master craftspeople who made them.

Visitors line up on the Adler Planetarium's opening day in May 1930. Credit: Carl Zeiss Works / The Adler Planetarium

But caring for objects made of wood, bone, ivory, paper, or plastic is more of a challenge, Helms says, especially in a building that wasn't originally designed for climate control. For example, the Adler's collection of hand-painted books requires careful attention. "Those are always a huge challenge, especially when we're building exhibits," he says, because the cases in which the books are housed require finely tuned light, temperature, and humidity levels.

Similarly, one item you'll likely never see in person is a stunning Chinese star map, measuring eight by five feet. The multi-panel map "is dyed almost entirely with blue ink, and our conservationists say we're allowed to show it for 6 weeks every 14 years," says Helms, "because any amount of light would hit the blue pigment and start to fade it pretty much immediately."

The Adler also has an assortment of space-related plastic objects, including about 40 space flight models donated by Robert Gilruth, the former director of NASA's manned space flight program, as well as a space suit helmet and EVA gloves. The helmet and gloves "were designed to work really well in space for a little while — but not to survive for hundreds or thousands of years" in a museum collection, notes Helms.

"The one thing we don't know how to do [in artifact conservation] is prevent plastic from deteriorating," he says. And because plastics outgas as they deteriorate, they can be damaging to other objects in the collection.

Thankfully, the Adler has plans for an upgrade to its HVAC system, in addition to new storage cabinets in its below-ground collections spaces. Even though most of these spaces aren't accessible to the public, it's possible to secure a tour. "We're always working on ways to give people more behind-the-scenes viewing opportunities," says Helms. The Adler's Google Arts & Culture page offers another way to interact with their collections from afar.

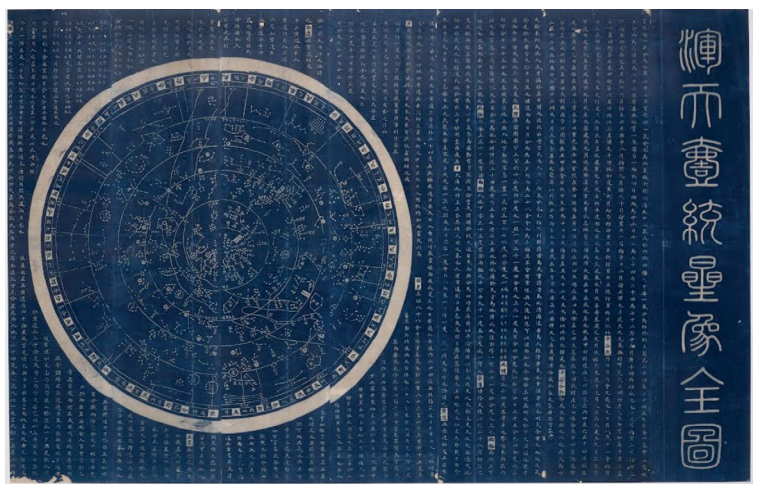
For Helms, creating opportunities for the public to access the Adler's collections and ensuring that historically significant artifacts survive for generations to come is deeply meaningful.

"[The objects] represent individuals, they represent societies, they represent cultures," he says. "They represent stories that are not just fun to tell, but important to tell, and so maintaining them as physical manifestations of those stories is important."

"It's why I do what I do."

If you're attending the 23rd biennial conference of the APS Topical Group on the Compression of Condensed Matter in Chicago this June, make sure the Adler is a stop on your list!

Liz Boatman is a staff writer for APS News.



"Hun T'ien Yi T'ung Hsing Hsiang Ch'uan T'u," a Chinese star map dating back to the 1600s — one of many rare artifacts in the Adler's collections. Credit: The Adler Planetarium

West continued from page 2

Now in his 90s, James West teaches at Johns Hopkins University. "I love working with students and young people," he says. Credit: Will Kirk/Johns Hopkins University

door," West says — the place was intensely collaborative. The duo asked around the other departments, and as it so happened, "the invention of Teflon was only a few years earlier," West says. The polymer seemed to be a good fit, and the two scientists painstakingly worked on setting up the right conditions for the Teflon to retain a charge. "We spent a long time figuring out how to trap these charges," West says. Once they got it to work, they had a microphone that could remain charged likely for hundreds of years, no battery required.

West and Sessler's patent for the microphone was filed on May 22, 1962, and electret microphones began rolling out in telephones and other consumer products later that decade. Today, they are popular for their compact size (smaller than a dime), low cost, and simple construction. The sheer ubiquity of the technology is staggering. As a rough estimate, more than two billion electret mics are made each year, West says. He only earned $1 from the patent and all the others he filed while at Bell Labs combined — researchers at the company didn't profit from inventions they created as employees. But he doesn't have regret. "I can't go back and say, 'Gee whiz,'" West says.

Some of Sessler and West's colleagues at Bell Labs assumed they would quit and start their own company after the invention. But this was never in the cards for West. The research facility was a bona fide playground for scientists and inventors, West says. "Why would we leave?" In the 1970s, Sessler moved back to Germany and became a professor at Darmstadt University of Technology, and in the 1980s pioneered the creation of microphones using silicon micromachining.

West retired from the company in 2001 and became a professor of engineering at Johns Hopkins University. "I love working with students and young people," he says. In addition to being a professor and researcher, West has long been an advocate for diversity in science and academia. Among other honors, he is a recipient of the National Medal of Technology, a member of the National Academy of Engineering, and an inductee in the National Inventors Hall of Fame. His name can be found on over 250 U.S. and international patents, and he's still creating — one recent invention to come out of his research group is a digital stethoscope that can detect and monitor lung diseases like pneumonia.

"I do what I love to do," West told *The Baltimore Sun* in 2018. "Curiosity has always been my motivation."

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

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imitating their physics with a technique called quantum simulation.

Classical simulations of many particles quickly become impractically complex. But understanding the interactions between quantum particles is key for many applications, including quantum computing.

"For these applications, we have to understand how many interacting quantum particles work together and understand their properties. That's the challenge — but also, in some sense, exactly what we want to harness," Aidelsburger said.

To create these simulations, the atoms are captured in a lattice of lasers, creating a "cloud" of atoms at very low temperatures. With experimental adjustment, Aidelsburger showed that this cloud of atoms can demonstrate the quantum Hall effect, which usually occurs in condensed matter rather than a group of individual particles.

This technique, however, can't yet simulate the fields emitted by these systems, such as the electric field from a charged particle.

"What is apparent is that we are only simulating part of the physics," Aidelsburger said. The next step, she said, is to integrate lattice gauge theory, a particular formulation of quantum field theory.

The scale of 2D materials

Pablo Jarillo-Herrero studies strongly correlated quantum materials, where powerful interactions within the system create unique phenomena like high-temperature superconductivity. But the complexity of these interactions makes it difficult to explain the materials' exotic properties.

"The simplest model that we believe captures the essence of this phenomenology only captures the essence — we don't know how to connect it to the phase diagram of the material," Jarillo-Herrero said.

One solution, he says, is exactly what Aidelsburger does: simulating the system using atoms. But he works on a larger scale, using twistronics, two layers of 2D materials in which one is rotated relative to the other. With various angles and materials, the interactions of these systems can model topological, superconductive, magnetic, and strange metal phases of condensed matter. "We can realize all of these phases with just a few ingredients, and that is something that has attracted the attention of a lot of people," Jarillo-Herrero said.

The scale of the Earth

For Brad Marston, professor of physics at Brown University, the two speakers that came before him perfectly set up his talk by talking about topological phases of matter, because "in some sense," he said, "we're living inside a topological insulator."

In 1879, Lord Kelvin published a paper concluding that ocean waves couldn't be modeled like waves in a still tub because the rotation of the Earth shapes the waves and tides. This paper contained an equation for an exponentially trapped boundary mode — the first topological wave in the literature, a century before it was rediscovered in the context of quantum matter.

Now, we have the technology to measure the size of waves at any point on Earth to millimeter resolution. Using this data, Marston shows that the equator acts as a topographic boundary for the ocean water in the northern and southern hemispheres, and that certain large-scale oceanic waves are topologically protected — more difficult for external forces to disrupt.

He ended by advising the audience to join the APS Topical Group on the Physics of Climate.

"We can gain a greater appreciation of our planet's climate by thinking about it from the perspective of physics," Marston concluded. "And this greater appreciation, I hope, will translate into a greater desire to understand it more deeply and perhaps solve some of the many pressing problems that face us."

The scale of black holes

Gabriela Gonzalez, a professor of physics and astronomy at Louisiana State University and a member of LIGO, talked about research at the largest scales — of physics and of scientific collaboration.

"The original 2011 paper [for the first gravitational wave detection] had over a thousand authors," she said. "It crashed the *Physical Review Letters* server because everyone wanted to read it at the same time."

Since that groundbreaking discovery, detected from the merger of two black holes, the gravitational wave observatories have gone through several upgrades to increase sensitivity (LIGO is expected to finish its latest upgrade in May this year). This enabled more detections, including the first instance of multi-messenger astronomy, with the detection of a gamma ray burst from a neutron star merger in 2017.

"That gamma ray burst was actually not that big," Gonzalez said. "Nobody would have paid attention to that gamma ray burst if it hadn't come from the direction we detected the neutron star merger."

She also highlighted the next generation of gravitational wave detectors, which will probe a wider range of gravitational frequencies: LISA, a space-based detector set to be launched in the 2030s, and the Cosmic Explorer, a proposed ground-based detector that would be ten times longer than LIGO.

Gonzalez said she likes thinking of gravitational waves as the music of the universe, since they are more akin to sound waves than light waves. And with these new experiments, she said, "we will have all kinds of different instruments to hear the orchestra of the universe."

Meredith Fore is a science writer for the Chicago Quantum Exchange.

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ics research to emerging technology. Companies selling quantum computing-related products dominated this year's exhibitor hall, from big names like IBM to smaller startups. For example, Colorado-based startup Maybell brought its dilution refrigerator, used to cool quantum computing chips to low temperatures. QBlox, based in the Netherlands, brought their control systems for quantum computers.

The meeting's diverse subjects reflected the changing definition of physics. Beyond the traditional condensed matter topics at March Meeting, the techniques of the field have made their way into other disciplines and far-reaching applications.

Sophia Chen is a writer based in Columbus, Ohio.

THE BACK PAGE

Canary in the Coal Mine: The 1997 Leak at Brookhaven National Laboratory

A harmless leak at a national lab 26 years ago — and the resulting public backlash — holds important lessons for combating misinformation today.

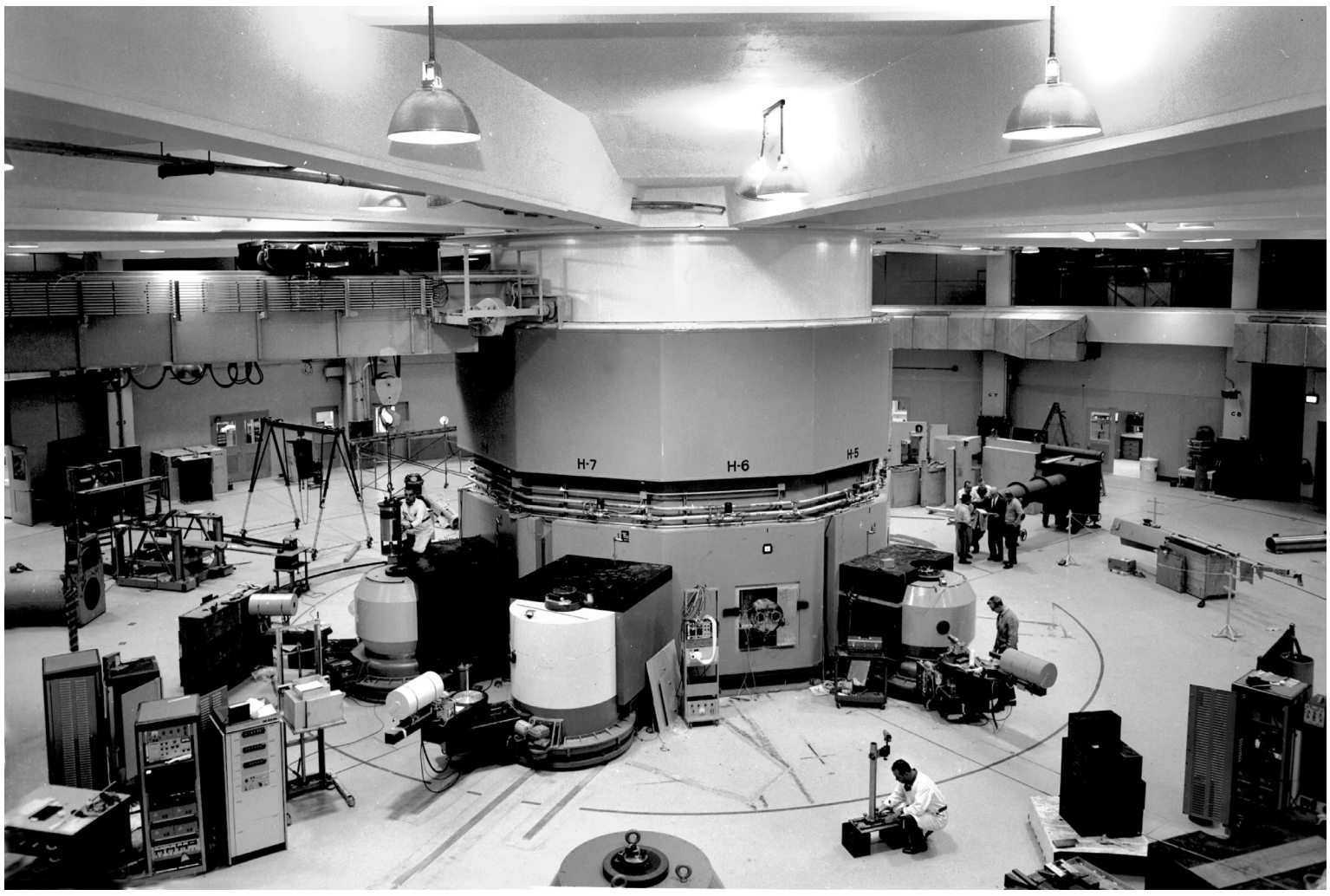
BY ROBERT P. CREASE

Twenty-six years ago, scientists at Brookhaven National Laboratory (BNL) found that the 68,000-gallon spent fuel pool of its High Flux Beam Reactor (HFBR) was leaking. Over a dozen or so years, about eight gallons per day of tritium-containing water had seeped out, leaving about 30 curies of radioactive tritium in the ground, about the amount of tritium in many self-illuminating "EXIT" signs.

The leak was not dangerous. When tritium decays, it emits beta radiation — electrons that are stopped by as little as a sheet of paper — with a half-life of just 12.3 years. The tritium would never make it into the local drinking water because it would dilute and decay to almost background levels in the decades it would take to reach the lab's border. No one on or off site would be exposed to it.

But the announcement of the leak's discovery ignited a firestorm. Its significance was spun out of proportion by activists, politicians, and the media, and fueled anti-nuclear agendas, partisan ambitions, and lurid headlines. The disaster consumed the lab contractor, and the Department of Energy (DOE) terminated the HFBR, one of the world's most important neutron-scattering facilities. The episode also sparked calls to close BNL itself, whose work had earned 4 (now 7) Nobel prizes.

BNL was not innocent. Despite having previously assured regulators and the public that the HFBR was carefully monitored, the lab had failed to detect the leak. Still, the reactions from many outside the organization were disproportionate. Alfonse D'Amato, a conservative New York senator with a poor environmentalist record, seized the opportunity to get credibility as a green by bashing the lab. Actor Alec Baldwin led a group of activists, some of whom called for the HFBR's closure and others for closure of BNL itself. Baldwin insulted and threatened scientists and rejected scientific findings, behaving in real life like the bullying science-denying character he would famously impersonate on Saturday Night Live two decades later, from 2016 to 2020.



Staff at the High Flux Beam Reactor in 1966. *Credit: Courtesy of Brookhaven National Laboratory*

Most memorably, Dan Rattiner, a Long Island newspaper editor, wrote an article alerting readers that dinosaurs would soon be spotted at the lab — although not for long, because they would be eaten by a 40-foot spider and then beamed into the cargo hold of a UFO. Rattiner, naturally, was spoofing the media coverage of BNL, but when he found that not enough readers realized this, he quickly followed with another article, writing that closing the lab would be the "single biggest research disaster" in U.S. history. With that much publicity, novelist Dan Brown even considered the lab as the setting of his novel *Angels and Demons.*

How could something with no environmental or health impact possibly inspire such hysteria, as well as damage to extremely valuable and safely operating scientific institutions?

At the time, I was finishing a book about the early history of BNL. As the firestorm broke, I briefly considered the episode as the topic of my next book. But I rejected the idea. It was idiotic, I felt sure, and would soon fade away without much consequence.

By a quarter-century later, 2022, I changed my mind. In collaboration with BNL's former interim director Peter Bond, we wrote *The Leak: Politics, Activists, and Loss of Trust at Brookhaven National Laboratory* (MIT Press). We did so because we felt that what happened at BNL in 1997 was a canary in the coal mine — an early warning signal — for today's conspiracy stories and fake facts about elections, vaccines, global warming, and other current events.

The High Flux Beam Reactor (HFBR) containment vessel under construction at Brookhaven National Lab in June 1962. The HFBR operated for more than 30 years before being shut down in 1999. *Credit: Courtesy of Brookhaven National Laboratory*

John Marburger, the physicist who ascended to BNL's directorship in 1998 (and then became U.S. Science Advisor to President George W. Bush in 2001), called what happened to the lab a catastrophe in the engineering sense, in which a machine or system grows out of touch with its surroundings, becomes unstable, and all it takes is a simple tweak for the entire system to come crashing down. "The laboratory was operating unwittingly in a region of imbalance with its society," Marburger wrote. "It was only a matter of time before a fluctuation would cause a catastrophic readjustment." At BNL in 1997, the tritium leak was that tweak.

How does one of the Department of Energy laboratories — large and expensive facilities essential to implementing national scientific, technological, medical, and educational ambitions — get that out of touch? The dynamics appear in the BNL story.

One factor is the difference between national and regional media such as *Science*, the *New York Times*, and *Newsday* on the one hand, and the tabloids distributed free at supermarkets and gas stations on the other. Administrators tend to devote attention to the journalists of the former, but the latter can wield greater local influence.

Political relations are another factor. Then-DOE Under Secretary Ernie Moniz told us, "When it comes to being able to start a major facility, and your own Congressman is arguing against it, you haven't done your job." But politicians must also be cultivated differently. Are they local or national? What are their agendas? To whom do they listen?

Local culture and history also have an impact on how the public reacts. Is there a history of toxic spills from industries? What are the perceived health issues? What action groups are influential?

The year after the leak was discovered, DOE officials convened a group of scientists, administrators, and experts from various national laboratories to see if anything could be learned from the episode. No consensus emerged — no easy fixes were in sight. Fermilab's representative began her Powerpoint presentation with the following words: "There but for the grace of God..." What had happened to BNL, she said, could happen to any facility — even to Fermilab, which doesn't have a reactor.

But national laboratories and their instruments shouldn't have to depend on supernatural assistance. Some lessons are obvious: Appeal to tabloids and regional outlets as much as mainstream media. Cultivate relationships with local as well as national politicians. Be transparent about risks and benefits. Expand user bases.

The 2021 rupture of a fuel element at the NIST facility in Gaithersburg, Maryland shows that firestorms do not have to happen. Their reactor mishap resulted in its delayed restart but not its termination, either out of a combination of heeding such lessons, planning, or luck.

In the end, the most important lesson of the BNL tale is the importance of intentional and ongoing engagement with surrounding communities — the absence of which creates potential triggers. Such connections require continually studying and interpreting the complex and evolving character of the mythologies, fears, myths, lore, concerns, and trust in the surrounding communities.

These are not STEM topics. Stable scientific facilities require good science, but robust humanities and social science research as well.

Robert P. Crease is a philosopher and historian of science at Stony Brook University. His most recent book, The Leak, *was published in 2022.*