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COVID

Physicists Rise to the Challenge

BY SOPHIA CHEN

On the evening of March 10, at the University of Illinois, Urbana-Champaign (UIUC) campus, two physicists stayed late to chat about the upcoming spring break.

The conversation, however, did not center on sunny beaches or forest hikes. Nigel Goldenfeld and Sergei Maslov were worried. In four days, a significant fraction of the school's 48,000 students and 13,000 faculty and staff would be trudging through crowded airports, sharing hugs and kisses with loved ones, celebrating in restaurants and bars—and then, after eight days, returning to campus.

At the time, the impact of COVID-19 had not fully descended on Illinois, with only 19 confirmed cases. But Goldenfeld and Maslov had followed the news in China and in Italy. "We were both very alarmed by how quickly the virus replicates and spreads through the population," says Maslov. That evening, they built a simple mathematical model of their hometown, the twin cities of Urbana and Champaign, Illinois, to forecast the impact of spring break.


Nigel Goldenfeld


Sergei Maslov

Little did they know that just eleven days later, the governor of Illinois would issue a statewide stay-at-home order citing their work as part of the reasoning.

Neither Goldenfeld nor Maslov had advised policymakers before. A 63-year-old bespectacled theorist originally from the UK, Goldenfeld began his research career studying superconductors and polymers. Over more than three decades at UIUC, he had branched into computational biology to study flocking and evolutionary patterns in various ecosystems, among other research interests.

Maslov, a 51-year-old Russian-American who kept his hair long even prior to the pandemic, followed a similarly interdisciplinary academic career. Skipping around from magnetic materials

CHALLENGE CONTINUED ON PAGE 5

MEETINGS

The April Meeting Must Go On..line

BY LEAH POFFENBERGER

Had 2020 been like any normal year, APS would have hosted a March Meeting in Denver, CO, and an April Meeting in Washington, DC. Everything was set for these meetings, until the COVID-19 pandemic hit the United States, causing the March event to be cancelled and April to initially be in limbo.

But thanks to tireless work from several APS departments, decisive leadership from the meeting's program committee, and support from the physics community, the April Meeting wasn't cancelled—it just went virtual. The meeting took place on April 18 to 21 as scheduled and drew in over 7,000 participants, almost five times the expected number for a typical, in-person April Meeting.

"I think it was purely amazing: that we did the meeting as a whole, the number of people [who attended] and the number of sessions that went on—and they went off mainly without a hitch, aside from a little glitch here or there," says Hunter Clemens, Director of Meetings at APS. "What I loved was seeing comments like 'I've always wanted to go to this meeting and I haven't been able to attend. It was great to be able to participate.'"

Meeting Virtually

For anyone who has attended an April Meeting, this year's line-up was familiar, despite the venue changing from hotel meeting rooms to home offices, kitchen tables, and living rooms. As usual,

MEETING CONTINUED ON PAGE 5

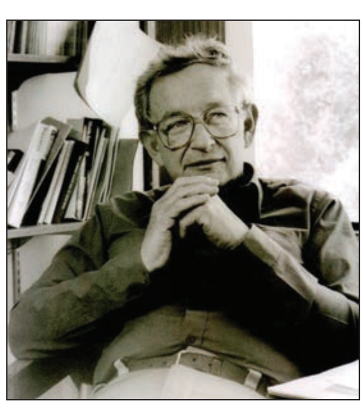
OBITUARY

Philip Anderson 1923–2020

BY ALAINA G. LEVINE

Philip Warren Anderson, condensed matter physicist, Nobel Laureate, and demystifier of diverse fields of scholarship, died on March 29 at the age of 96. "He is easily the leading figure in condensed matter physics in the second half of the 20th century," says Daniel L. Stein, Professor of Physics and Mathematics at New York University. "He was the guiding light."

But Anderson was known for much more than condensed matter physics. He was a visionary in showing how fields as diverse as economics and physics, or sociology and computer science, could intertwine. His paper "More is Different" in *Science* Magazine in 1979, which served as a rallying cry for interdisciplinary investigations, set the stage for much of his later research into the interconnectivity of subjects. The article "could be thought of as a Magna Carta for modern complexity research institutions," says Stein. And indeed, in 1984, Anderson co-founded the Santa Fe Institute, the first research institute dedicated to the study of complex adaptive systems. "He was very prescient," notes Stein, who served as Anderson's protégé while pursuing his doctorate. "He saw and thought about things before others came along to understand them. He was a natural at this. That was typical of Phil."


Philip Anderson

Early on, Anderson had been contemplating order and hierarchy in nature and how complexity can serve as a lens through which we can investigate many other fields. "Back then physicists tended to think hierarchically: that there is a hierarchy of fundamental science with particle physics at the fun-

ANDERSON CONTINUED ON PAGE 7

LETTERS

Physicists and COVID

The response to the COVID-19 pandemic has meant radical changes for scientists as they adjust to laboratory shutdowns, online teaching, and travel restrictions. APS News *and* Physics *want to hear about your experiences at letters@aps.org. More letters are available at the* Physics *website (physics.aps.org).*

Keeping Research Going, and Contributing in Other Ways

Fortunately, my research is theoretical and computational, so it has not been difficult for my group to continue working and to stay in touch as we all hunker down at home. But graduate students in campus housing have been particularly affected. Many of them have had to vacate their housing and find new lodging on extremely short notice. [My group] also volunteered for the Rapid Assistance in Modelling the Pandemic (RAMP) initiative in the UK, which brings together researchers with many kinds of computational skills. We hope that our expertise will be valuable there. *– Andrea Liu is a physicist at the University of Pennsylvania and Speaker of the Council of the American Physical Society.*

I guess my story is pretty standard: healthy so far, quarantined for two and a half weeks, bathtub office. I help my students on Slack and Skype frequently and attend seminars and meetings on Zoom, which turns out to work really well. Running calculations is not a problem for now. But running things from home with my 4-year-old son is challenging. *– Juan Carrasquilla is a physicist at the Vector Institute for Artificial Intelligence in Canada.*

I've been asked to participate in a group of epidemiologists, virologists, and modelers who are trying to estimate, in different scenarios, how this pandemic will strike Buenos Aires and its surroundings. I closed the lab, maintaining minimal guards for the animals, and I do simulations at home. *– Gabriel Midlin is a physicist at the University of Buenos Aires.*

A Silver Lining

I enjoyed writing short stories in my high school and college years. But after getting my doctorate in physics and then teaching large undergraduate classes, I had no time to indulge in this pastime. The coronavirus outbreak forced me to join the ranks of college faculty around the world who communicate with their students online. How could I continue to make physics exciting to my students when I could no longer interact with them personally? Then the inspiration came to me: I would write short stories centered round the topic to be covered in class. One of them is a detective story about the charging and discharging of capacitors. *– Basil S. Davis is a physicist at Xavier University of Louisiana in New Orleans.*

Completing a Thesis

Following the government's call for social distancing, I have not left my apartment in over a week. As a PhD student in my final year, I am very busy. I split my time between writing my thesis and working on three research projects with my collaborators. Being a theorist, all I really need is my laptop, pen, and paper, so my work has not really been affected that much. I continue to talk to my advisor regularly, and I have Skype meetings with my collaborators almost every day. Unfortunately, two conferences I was planning on attending have been canceled. A few more scheduled for June and July are currently in limbo. Apart from that, I am grateful to be one of the lucky few whose life has not been completely scrambled. *– Alexander Yosifov is a PhD student at the Space Research and Technology Institute, Bulgarian Academy of Sciences.*

Donating Supplies

On the morning of March 20th, we were closing our labs at the School of Physics and Astronomy when a call came, asking whether we had personal protection equipment (PPE) that could be donated to the UK's National Health Service (NHS). We have a lot of this equipment because we are active in biophysics, nanotechnology, and device fabrication. Within an hour, three colleagues and I had packed up all of the PPE we could find, and it was on a truck to the NHS, along with supplies from the Electrical Engineering Department's clean room. I heard later that some institutions across the world were hitting administrative barriers when trying to do the same thing. But our dean was very happy to hear what we'd done.

LETTERS CONTINUED ON PAGE 6

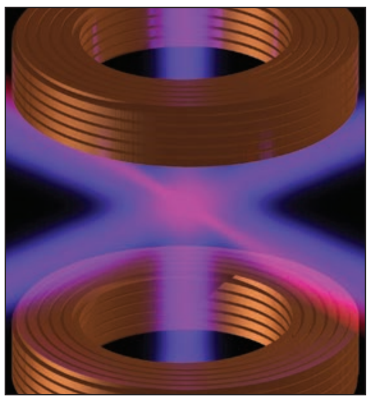
Revised 05/11/2020

MEMBERSHIP UNITS

The Topical Group on Precision Measurements and Fundamental Constants

BY ABIGAIL DOVE

The Topical Group on Precision Measurement and Fundamental Constants (GPMFC) is a home for physicists interested in investigating the fundamental laws of physics, determining fundamental constants, and developing and improving basic measurement standards with high precision experiments. As GPMFC chair-elect Derek Kimball (California State University, East Bay) put it, "We use all possible tools at the disposal of the experimental physicist—and all calculations at the disposal of the theoretical physicist—to do precise measurements and calculations of various quantities in physics."



Atomic clocks are among the tools used for precision measurement. One such clock at NIST uses two magnetic coils (red rings) and an optical lattice (red laser beam), as well as intersecting violet lasers to cool ytterbium atoms, slowing their motion. IMAGE: NIST

Much of this work focuses on what Kimball calls "the precision frontier"—that is, the ability of increasingly precise measurements to reveal gaps in our current models of physics. "Experimental results may agree with predicted calculations when measured out to the 12th decimal place for example, but at the 13th or 14th decimal place maybe you find disagreement," he explained. "That opens the window into something that we don't yet understand and could represent the discovery of new physics."

As GPMFC chair Susan Gardner (University of Kentucky) put it, "there are a number of reasons why experimental results may not agree with Standard Model predictions—not the least of which is that there is a deficiency in the Standard Model." As became clear at the turn of the century with the development of quantum mechanics and relativity, physics models that work on one scale may break down at another. Precision measurement is an important tool for detecting such anomalies.

Since its founding in 1987, GPMFC has attracted a highly interdisciplinary membership base of approximately 500. The largest proportion of GPMFC members hail from the Division of Atomic, Molecular, and Optical Physics (DAMOP; see *APS News* April 2020), with a substantial number from the Divisions of Nuclear Physics (DNP) and Particles and Fields (DPF) as well.

"There is a natural interconnectedness between disciplines that appears when measuring particular quantities very precisely," noted Gardner. Indeed, beyond including scientists from different branches of physics, GPMFC welcomes a unique mix of theorists and experimentalists owing to the necessary back-and-forth between practitioners of precision measurement experiments and theoreticians involved in the interpretation.

Vice Chair David Hanneke (Amherst College) pointed out that the diversity within GPMFC also extends to the scale of analysis, with group members pursuing precision measurement of everything from the fine structure constant (to describe the strength of electromagnetic interactions between elementary particles) to the Hubble constant (to describe the speed of the expansion of the universe).

Current topics of particular excitement within the purview of GPMFC include searches for dark matter and dark energy, improving the determination of lepton magnetic moments (a new muon g-2 measurement is expected this spring), the "proton radius puzzle" (a hotly debated question related to the charge radius of the proton), and, perhaps most notably, the search for permanent electric dipole moments of the electron, neutron, and proton. The Standard Model of particle physics predicts that these should have extremely small values, but theoretical extensions of the Standard Model invoking super-

GPMFC CONTINUED ON PAGE 6

THIS MONTH IN

Physics History

May 1664: Hooke vs. Cassini: Who Discovered Jupiter's Red Spot?

One of the most easily identifiable features of the planet Jupiter is its famous Great Red Spot, a gigantic storm in the planetary atmosphere, about 22 degrees south of the equator, that rotates counter-clockwise, akin to an anti-cyclone. Astronomers think the current red spot may have been present for at least several hundred years. The 17th century polymath and *Micrographia* author, Robert Hooke, is often credited with making the first recorded observation in May 1664. But many argue that it was his Italian counterpart, Giovanni Cassini, who should get due credit for his observations the following year.

Although he relied on London instrument maker Christopher Cock to build his microscopes, Hooke enjoyed a reputation as one of London's finest makers of precision scientific instruments. He had a long-standing passion for astronomical instruments, like the telescope, and for clocks. In fact, as a child he once examined the various parts of a brass clock, and used what he learned to build his own working model out of wood. His microscopic observations formed the basis for his magnum opus, the *Micrographia*, which first appeared in bookshops in January 1665.

Astronomy was another of Hooke's many interests. The *Micrographia* includes his illustrations of the Pleiades star cluster and lunar craters. He observed the rings of Saturn early on, and once attempted to measure the distance to the star Gamma Draconis, although his instruments weren't quite up to the task. Around 9 pm on May 9, 1664, Hooke observed a small spot "in the biggest of the three obscurer belts of Jupiter, and that, observing it from time to time, within two hours after, the said spot had moved from East to West, about half the length of the diameter of Jupiter."

But the spot Hooke observed might not have been what we now call the Great Red Spot. In a 1987 paper for the *Journal of the British Astronomical Association*, Marco Forlani suggested—based on Hooke's original announcement and a 1666 recorded observation—that the observed "small spot" was embedded in what is now known as the North Equatorial Belt (or "great black belt"), while the Great Red Spot is currently found in the South Equatorial Belt. Rather, Forlani argued that what Hooke observed was more consistent with a transit satellite shadow—the moon Callisto was noticeably transiting at the time.

The Royal Society backed Hooke's claim at the time. Forlani attributed their support in part to a kind of "scientific nationalism," given Hooke's

Detailed image of Jupiter's Great Red Spot, taken by the Juno spacecraft flyover (PERIJOVE 7) on July 11, 2017 IMAGE: NASA

prominent standing with the Society, bolstered further by his quarrelsome tendencies.

Cassini—who went on to become director of the Paris Observatory, changing his name to Jean-Dominique when he settled in France permanently—likely first observed the red spot between the summer and fall of 1665; he described his observations at length in letters to the Abbot Ottavio Falconieri. Cassini was able to weed out spots likely to be caused by a satellite transit shadow, and showed that the remaining observations of a spot in his data were indeed located on Jupiter's surface. One in particular stood out: "a permanent one which was often seen to return in the same place with the same size and shape," Cassini wrote.

He observed this spot 13 times between August 19 and October 30, eventually compiling a table of its transits that enabled him to calculate its rotation period: 9 hours and 56 minutes. The only attribute Cassini did not describe was the spot's trademark red color, however, likely due to instrumentation limitations. According to Forlani,

RED SPOT CONTINUED ON PAGE 3

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RED SPOT CONTINUED FROM PAGE 2

"It is out of the question that he would have been able to distinguish it because of the low light-grasp of telescopes of that time."

There is little doubt among science historians that Cassini witnessed, repeatedly, a spot on Jupiter that bears a remarkable similarity to the Great Red Spot we know and love today. There is still some uncertainty as to whether it is exactly the same spot, centuries later, because of imperfect historical records. There were no reported observations of the red spot after 1713 for more than a century, until it was spotted again in 1831 in a drawing of Jupiter by Samuel Schwabe. American astronomer C. W. Pritchett "rediscovered" the Great Red Spot in 1878, and astronomers have been monitoring it closely ever since.

That said, "Even if the identity of the old Permanent Spot with the modern Red Spot is still in doubt," Forlani concluded, "there can be no dispute over the identical nature of the phenomenon, and the discovery must be attributed to Cassini."

Since 2004, astronomers have worried that the red spot might be shrinking, and that the process was occurring more rapidly since 2012. In 2019, several amateur astronomers reported a strange flaking off of bits of the red spot, fueling fears that Jupiter's most famous feature might be disappearing at long last.

University of California, Berkeley, physicist Philip Marcus, however, has found no reason for alarm. At the 2019 APS Division of Fluid Dynamics meeting, he offered an intriguing counter-explanation for the flaking, based on his own computer models (see *APS News*, January 2020). He concluded that the flaking is a perfectly natural weather phenomenon on Jupiter, the result of the complicated fluid dynamics of the planet's atmosphere. If Marcus is correct, the Great Red Spot should endure for several more centuries, barring some cataclysmic event.

Further Reading:

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Connor, Elizabeth. (1947) "The Cassini Family and the Paris Observatory," *Astronomical Society of the Pacific Leaflets* 5(218): 164-153.

Falorni, Marco. (1987) "The discovery of the Great Red Spot of Jupiter," *Journal of the British Astronomical Association* 97(4): 215-219.

Marcus, Philip. "Contrary to recent reports, Jupiter's Great Red Spot is not in danger of disappearing," *The Conversation*, November 25, 2019.

OUTREACH

PhysicsQuest Expands Online with Help from the Eucalyptus Foundation

BY LEAH POFFENBERGER

Since 2005, the APS PhysicsQuest program has been delivering physics experiments to middle school classrooms all across the country. These hands-on experiment kits, designed to help get kids interested in science, have been a hit with teachers and students alike. PhysicsQuest kits have traditionally consisted of teacher and student guides and all the materials to conduct four experiments, but thanks to a new grant and input from teachers, PhysicsQuest is hoping to offer even more with new online resources.

The Eucalyptus Foundation, a non-profit organization that supports science education efforts, has awarded PhysicsQuest a $400,000 grant to help expand and improve the program, specifically its online component. Starting in 2020, the grant will help bring PhysicsQuest alive with new video content from working scientists to educate and inspire students.

"We have been taking a lot of input from teachers, the [APS] Committee on Informing the Public, and others to find out what online resources they use and what gaps there are in the PhysicsQuest program," says APS Public Engagement Manager James Roche. "We want to use online resources to bolster—not replace—the other parts of PhysicsQuest."

A new online suite for PhysicsQuest will be designed to complement the teacher and student guides that classrooms already receive, with resources for teachers and students. Eventually, according to Roche, the online component of PhysicsQuest will include content such as lesson plans, experiment videos, and other educational tools.

"We're early in the process of coming up with the best ways to provide resources, but we will start releasing content online with the 2020 kit," says Roche. "It might not be the full suite of resources we're working on, but it's an exciting first step."

The 2020 PhysicsQuest will feature NASA scientist Katherine Johnson in the activity guide, giving students an opportunity to learn more about her life while conducting experiments on force and motion. The online component will feature videos of other scientists who are currently doing related research who can share their personal stories to inspire the next generation.

"Thanks to the Eucalyptus Foundation grant, we are able to continue offering the PhysicsQuest program while making it even more accessible to a broader audience," says Roche.

Signups to receive a 2020 PhysicsQuest kit will open online this summer. In the meantime, all past activity guides—including PhysicsQuest 2019 featuring "First Lady of Physics" Chien-Shiung Wu—are available online and include experiments that can be done with household items. .

For more about the PhysicsQuest program visit physicscentral.com/experiment/physicsquest/

MEETINGS

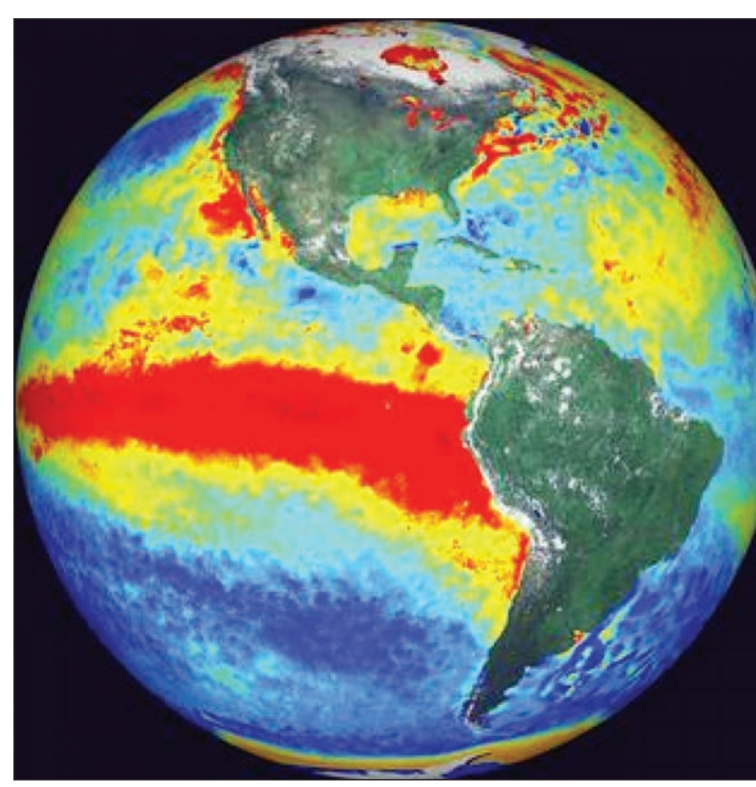
Understanding the Dynamic Climate System

BY ABIGAIL EISENSTADT

The climate system is dynamic, and its behavior is irregular, making it hard to anticipate the full severity of anthropogenic effects on climate. Creating climate models that accurately predict these changes demands a comprehensive understanding of the physical, biological, and chemical processes on Earth.

However, collecting information about these processes can be difficult: Some phenomena, like turbulence inside clouds, are impossible to observe with existing technologies. Other information, like the rate at which plants take up carbon dioxide and emit water vapor, are difficult to constrain with model equations. High-resolution models that can test each possible parameter and simulate these processes are too computationally expensive to run on a global scale.

Overcoming the challenges of modeling climate has been an ongoing subject of rigorous discussion among physicists and the topic was scheduled to have a dedicated session sponsored by the Topical Group on Physics of Climate during the canceled 2020 APS March Meeting. Michael Ghil, Tapio Schneider, and Katherine Dagon, who would have all been part of this session, are tackling different aspects of climate modeling through their research.



One of the challenges in understanding climate is combining long-term behavior with sudden changes like ENSO (the El Niño Southern Oscillation), shown here (red indicates higher sea level and thus higher temperature). IMAGE: NASA

"A big concern that the climate community has become aware of is that, aside from the relatively smooth change of mean temperatures, there may also be other sudden [climatological] changes," said Ghil, a physicist and professor at the University of California, Los Angeles. He has developed a new framework for climate modeling, synthesizing long-term climate trends with abrupt weather patterns, like the El-Niño Southern Oscillation.

Natural weather patterns respond in surprising ways to manmade climate change. Current climate models try to account for these surprises by estimating the overall impact of factors like climate forcing. Positive climate forcing refers to the surplus of sunlight, or heat, that remains on Earth once Earth radiates its own heat into space. Positive anthropogenic climate forcing occurs when manmade atmospheric pollution increases the amount of solar energy trapped on Earth, causing a gradual increase in global warming and changes in the climate's natural variability.

Ghil's modeling framework combines intrinsic climate oscillations like the El Niño–Southern Oscillation with long-term anthropogenic warming trends. Major weather and climate patterns are either nearly periodic (like day and night) or irregular. Periodic climate patterns repeat in exact, equal intervals, while irregular patterns can be either deterministically aperiodic—for example, non-random with irregular intervals—or random. Anthropogenic

CLIMATE CONTINUED ON PAGE 6

OUTREACH

Wikipedia Editing Course Gives a Voice to Women and Minorities in Physics

BY LEAH POFFENBERGER

Despite millions of pageviews and millions of articles, Wikipedia, the world's largest encyclopedia, has a problem: women and underrepresented minorities are often missing from its pages. When she became the third woman to ever win the Nobel Prize in Physics, Donna Strickland didn't have a Wikipedia page, and many other deserving women don't either, with only 18 percent of biographies on Wikipedia belonging to women (see "Fixing Wikipedia's Diversity Problem," *APS News*, April 2019).

To help bridge this gap and recognize women and minorities in physics for their achievements, APS partnered with Wiki Education to train APS members on how to contribute articles and edits to Wikipedia. Over a 12-week course that started on February 10, a group of 14 APS members edited 43 pages, adding 127 references to articles that wracked-up 148,000 pageviews.

"The Wiki Education course taught the ins and outs of being wiki-editors, and how to create and maintain biographies that satisfy Wikipedia's notability requirements," says James Roche, Public Engagement Programs Manager. "Wikipedia has come a long way and instituted a lot of policies to discourage poor editing practices—there's a lot that goes into these articles."

Wiki Education, a non-profit spun off from the Wikipedia Foundation that runs Wikipedia, was created in 2013 with the vision of creating "a broader and more diverse Wikipedia that welcomes public and academic participation, in which students, scholars, and institutions of higher learning are actively engaged in investigating and representing knowledge." To meet the goal of a more diverse Wikipedia, Wiki Education has been partnering with institutions to involve students, academics, and scholars in the process of contributing to and improving Wikipedia's catalogue of articles.

Through the APS and Wiki Education Wiki Scientist course, APS members were given an opportunity to receive training from Wikipedia experts through weekly hour-long Zoom sessions. Participants also spent two hours a week outside of class sessions applying their new-found Wikipedia skills to improving entries about women and minority physicists.

"The course specifically focused on adding more biographies on women and minorities in physics because, for a variety of reasons, Wikipedia has some catching up to do in these areas," says Roche. "This course was a pilot program, but we're hoping to do more in the future with Wiki Education to get more APS members involved."

For more information about Wiki Education visit wikiedu.org.

GOVERNMENT AFFAIRS

New Physicists' Coalition to Advocate for Nuclear Threat Reduction

BY TAWANDA W. JOHNSON

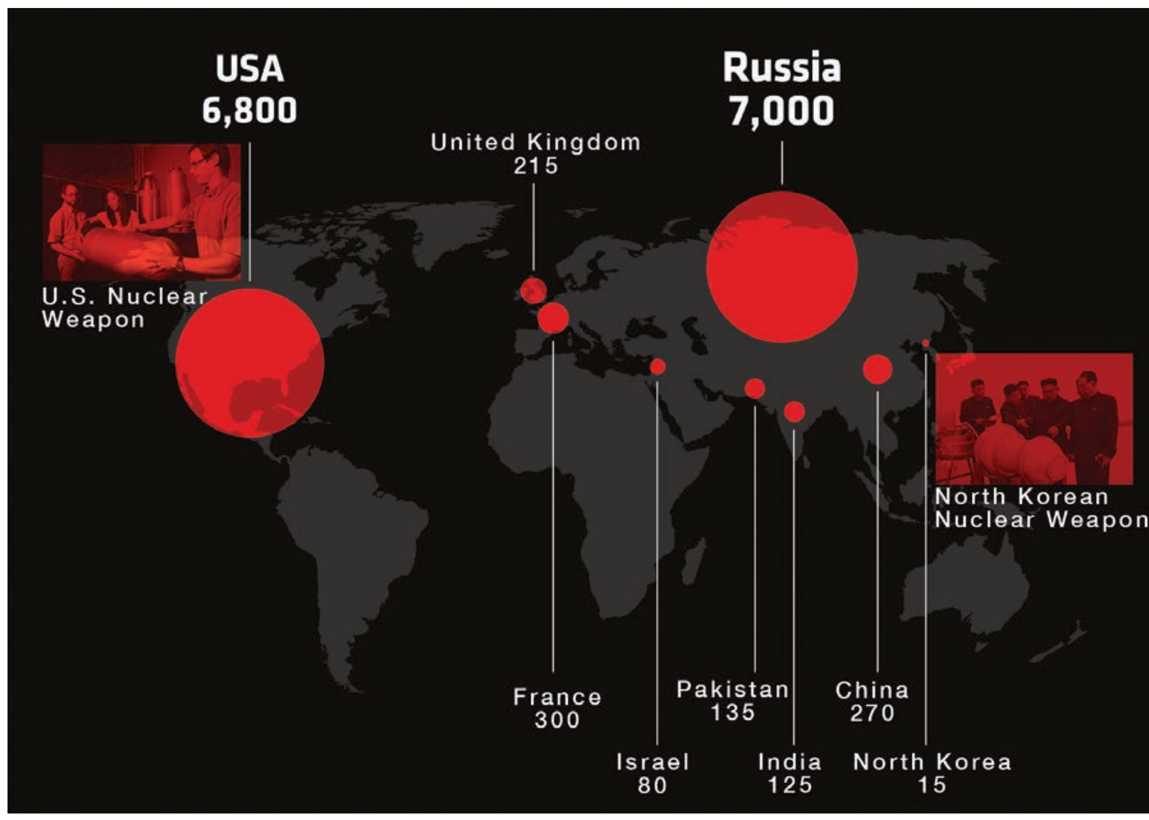
The Physicists Coalition for Nuclear Threat Reduction—a new project supported by the APS Innovation Fund—has been launched to inform, engage, and mobilize the US physics community around the danger posed by the world's nuclear weapons.

"The goal is to establish a coalition of informed physicists to advocate for steps to reduce the nuclear threat," said Stewart Prager, professor of astrophysical sciences at Princeton University, who is leading the coalition. Princeton's Program on Science and Global Security is coordinating the coalition.

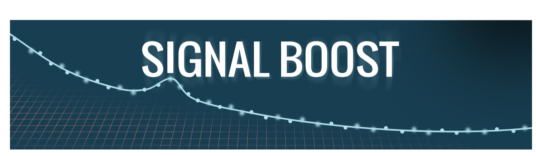
The first step is to hold colloquia at universities, labs, industry, and conferences that will provide an overview of the technological and policy landscape of the nuclear arms issue. Topics to be covered include a review of the current world arsenal, recent developments in new offensive and defensive capabilities, new technologies that alter nuclear strategic stability, and the potential physical effects of the weapons in the arsenal if used.

The policy portion will cover the substantial history of successful key treaties and agreements that have provided some degree of safety for the world, recent troubling changes in the framework of arms control agreements, the emerging new nuclear arms race, and policy

ADVOCATE CONTINUED ON PAGE 7



Over 14,000 nuclear weapons in the world today are distributed over nine nations. IMAGE: ALEX GLASER/PRINCETON UNIVERSITY



Signal Boost is a monthly email video newsletter alerting APS members to policy issues and identifying opportunities to get involved. Past issues are available at go.aps.org/2nr298D. **Join Our Mailing List: visit the sign-up page at go.aps.org/2nqGtJP.**

OUTREACH

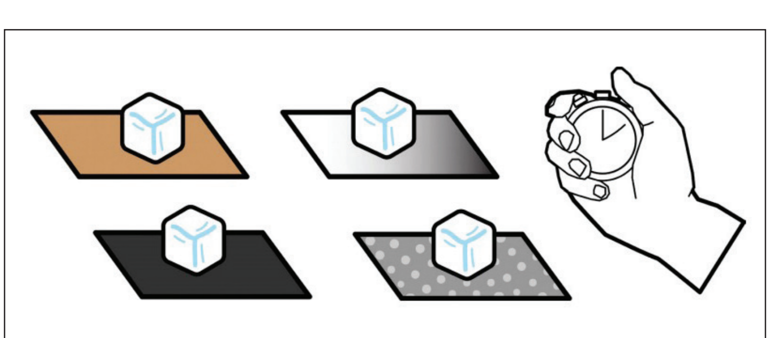
Sparking the Joy of Physics at Home

BY LEAH POFFENBERGER

As millions of people are being asked to stay at home to stop the spread of COVID-19, parents are faced with the task of keeping energy-filled kids occupied while stuck in the house. Fortunately, using household items or an internet connection, it's possible to turn the house into a DIY-lab and spark excitement about physics.

For more than a decade, APS's PhysicsCentral has been on a mission to communicate the importance and excitement of physics with a variety of educational resources, from blog posts tackling physics news to classroom experiment kits. Each year, the PhysicsQuest program sends boxes of materials and experiment guides to middle-school classrooms all over the country, but at-home scientists can easily jump in to experimenting, too: all PhysicsQuest guides are available online, and most of the experiments are designed to use normal household items. PhysicsQuest 2019

JOY OF PHYSICS CONTINUED ON PAGE 6



One easy at-home experiment involves putting ice cubes on different materials (wood, plastic, metal, etc) and measuring how long the ice takes to melt. The APS PhysicsQuest guide has more. IMAGE: APS PHYSICSQUEST

FYI: SCIENCE POLICY NEWS FROM AIP

National Labs Pivot to Pandemic Research

BY MITCH AMBROSE

At the outset of April, all but two of the 17 Department of Energy (DOE) national laboratories were in states whose governors had issued stay-at-home orders to blunt the spread of the coronavirus pandemic. Though most lab employees are now teleworking en masse, some on-site work that has been deemed essential continues, particularly research related to the pandemic.

DOE has mobilized its suite of user facilities and other infrastructure to complement research efforts underway at public health agencies, casting a wide net for ideas on how to support the national response.

"Not every lab has the capability, but they are all participating together in a working group that we've put together to ask questions, 'Hey, have you thought of this? Did you try that?'" remarked DOE Office of Science Director Chis Fall in a March interview.

As one major thrust of its effort, DOE has enlisted light and neutron sources across the lab complex to study the structure of SARS-CoV-2, the virus that causes the respiratory disease COVID-19.

For instance, the National Synchrotron Light Source II at Brookhaven National Lab in New York has run experiments with protein crystallography beamlines to characterize viral components that could be targeted by drugs. The Advanced Light Source at Lawrence Berkley National Lab in California has likewise made its beams available for structural biology studies, as have light sources at other DOE labs.

The Advanced Light Source was initially put on "warm standby" after several counties in the San Francisco Bay Area issued stay-at-home orders in mid-March, the first such directives in the country, but the facility resumed limited operations in April to support coronavirus research. Berkeley Lab's Joint Genome Institute has also offered expertise in high-throughput automation to aid a robotic coronavirus testing initiative at the University of California, Berkeley, and staff from its Molecular Foundry Facility are working with Stanford University to synthesize peptoids that could be used to develop antiviral agents.

DOE's two neutron sources at Oak Ridge National Lab in Tennessee were on scheduled shutdowns when the pandemic first escalated in the US, but they began accepting rapid access proposals for coronavirus research in April. Meanwhile, the pandemic has shuttered the country's one other major neutron source user facility. The National Institute of Standards and Technology (NIST) Center for Neutron Research was shut down in mid-March due to a potential case of COVID-19 among its staff,

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CHALLENGE CONTINUED FROM PAGE 1

to financial statistics to microbial ecology, the theorist arrived at UIUC in 2015 after nearly two decades at Brookhaven National Laboratory. As members of the same research team, they frequently chatted. "Our offices are right next to each other," says Maslov. Goldenfeld is the winner of this year's APS Leo Kadanoff Prize.

For them, transitioning to epidemiology was easy. "The equations that describe epidemics are simplified versions of ones that describe ecology," says Goldenfeld. For the COVID-19 model, they chose equations that echoed models of predator and prey.

Working in Goldenfeld's office on March 10, the two collaborated on a simple model that took a few hours to run. In the model, they divided the population into four categories: those who were susceptible to COVID-19, exposed, infected, and recovered, the commonly used SEIR model. Its results delivered a stark message. According to the model, if students were allowed to return to campus, "there would be a huge wave of epidemics," says Maslov.

That night, they immediately contacted their university provost, whom they knew personally. Upon receiving their message, school administrators moved swiftly. On March 11, they alerted students that courses would be moved online after spring break, and by March 16, they asked students to move home. Those administrators also relayed Goldenfeld and Maslov's work to the Illinois governor's office, which then invited them to meet with a group of officials, hospital administrators, and other scientists on March 13.

Meanwhile, Goldenfeld and Maslov began modeling the effects of a lockdown on the entire state of Illinois. With little time to perfect their models, and flawed data available to them, they decided against modeling specific lockdown strategies, such as shutting down schools. Instead, they left the strategy vague—whatever it was, the model assumed it would reduce transmission of the virus by some factor. Assuming that the state would implement the strategy, they then asked, what would be the consequences of delaying implementation?

This simple framing allowed them to largely avoid using the bad public data. "We were comparing apples to apples, however imperfectly calculated," says Goldenfeld. "The only thing we were changing was the date the mitigation strategy was put in place." They found that, to avoid a scenario like Italy's, the state would need to implement some sort of lockdown soon. Any delays would drastically increase hospital occupancy and the number of deaths.

The two presented some of these results via videoconference in their scheduled meeting with the governor. But their message was nearly lost. At the time, policymakers were more focused on the availability of COVID-19 testing, rather than a lockdown.

"You have to imagine a room, and the governor walks in, and Nigel's on a TV behind him," says David Ansell, a doctor and former chief medical officer at Chicago's Rush University Medical Center. Ansell attended the meeting in person. "There are a lot of people on Zoom calls, and we're all trying to wrap the governor's head around the scale of the emergency....So Nigel's idea, I think, got lost in that moment. But I knew there was something there, so I looked him up and e-mailed him [a few days later] to ask him to talk."

Ansell was exactly the collaborator that Goldenfeld and Maslov needed. With Ansell's professional connections, they were able to roughly tally the number of patients in Chicago ICUs. Using that data, they then estimated how a mitigation strategy would change ICU occupancy depending on the day the lockdown began. They found that without mitigation, Chicago's ICU capacity would be exceeded, "probably by a factor of ten," they wrote in a document uploaded to arXiv.org. In addition, the lockdown would need to occur by April 1 in order to "avert a worst-case scenario."

On March 18, they sent the results to the governor's office, along with a "strongly worded" memo that Ansell authored. "We both agreed the most important measure was for the governor to order the shelter-in-place," says Ansell.

The state had already begun to act. On March 16, Governor J. B. Pritzker ordered all schools, bars, and restaurants to close. On March 21, Pritzker issued a statewide stay-at-home order. In a press conference, the governor acknowledged the "mathematicians and modelers" whose advice led to his decision.

Since then, Illinois has largely avoided the crisis that hit New York, which implemented its stay-at-home order the day after, when it already had ten times as many confirmed cases as Illinois.

"We closed down at a time when you might say, 'What's the big fuss about?'" says Goldenfeld. While it's impossible to know exactly how many lives the pre-emptive lockdown saved, Rush University Medical Center is "cool as a cucumber," Ansell told APS News on April 15. According to Ansell, Chicago hospitals aren't overwhelmed, and doctors are taking care of COVID-19 patients as they come.

"I get the feeling that all of Chicago is managing pretty well," says Ansell.

Goldenfeld and Maslov credit science-trusting policymakers for the state's relative success. "We're very lucky that we're in a state where leadership not only listens to scientists, but actively seeks our input, unlike the situation in the federal government," says Goldenfeld.

The two continue to work with the state government on more epidemiological models. Without their usual safeguards such as peer review, they check their calculations against the results of two other modeling teams. "We're doing quick and dirty engineering-type calculations on models that have lots of limitations and deficiencies," says Goldenfeld.

Their contribution to the state reads like a success story, of physicists demonstrating the real-world applicability of their skills. But the two of them see it as a failure of government. "I wish that the country was better prepared, and that it wasn't up to a ragtag group of physicists who decided they needed to do something," says Goldenfeld.

Maslov and Goldenfeld have set aside their own research for the foreseeable future, to continue helping the state government. This work "is much more important," says Maslov.

But their pivot does come with a nostalgia for their former lives, just months ago. "We learned to like [epidemiology], but I cannot imagine spending another five years doing it," says Maslov. For him and Goldenfeld, epidemiological modeling just doesn't provide the same intellectual thrill that the statistically complex ecological models do. It's a small loss compared to lives and livelihoods—but intellectual curiosity, too, has been a sacrifice of this pandemic.

The author is a freelance writer based in Tucson, Arizona.

MEETING CONTINUED FROM PAGE 1

the meeting kicked off Saturday morning with the Kavli Foundation Keynote Plenary—this year featuring three Nobel Laureates: James Peebles, Michel Mayor, and Eric Cornell—and continued through Tuesday with exciting live talks, poster sessions, and networking opportunities.

A brand-new virtual meeting platform, hosted by the Freeman company, the long-time audio-visual support provider for APS meetings, allowed speakers the option of presenting a live talk or uploading their presentations into an "on demand" session. In live sessions, attendees could use a chat window to have discussions, ask questions, and shower speakers with (emoji) applause.

"The [meeting] platform wasn't in its final form, but I think the overall experience for the attendees was a very positive one in terms of delivering the scientific content, considering that all of the speakers, all of the staff, all of the session chairs were working from home," says Mark Doyle, Chief Information Officer at APS. "Nobody was really in their place of work, and the content was able to be delivered. It was all recorded and it's available online for a long time to come."

More than 700 speakers who had committed to the original April Meeting were still able to give live talks during the 4-day conference, while others uploaded theirs for later viewing. Typically, decisions about speakers and the scientific program are made far in advance—but to completely change the format of the meeting required some last-minute coordination.

"The hardest part, I think, was getting all of the program coordinated. But in this case, we had to go back to speakers and reconfirm: do they still want to give [a talk?] Do they want to do 'on demand'? Do they want to 'live-stream'?" says Clemens. "I think that was the biggest challenge."

One Month Notice

APS leadership formally cancelled the in-person event on March 12 and continued to meet to set a structure for a virtual meeting. On March 18, program chair Tao Han proposed that the meeting take place on its original dates in order to keep on board invited speakers who had already committed to a certain timeslot.

"I made it clear: I would be the last one to accept this cancellation. I would be hugely disappointed...I was obviously emotional," says Han. "We worked so hard for a great program and physics does not stop. Science does not stop. We had to move on in some way."

Fortunately, Doyle and Clemens had already identified Freeman's meeting platform as a potential place to hold a virtual meeting. On April 3, exactly two weeks out from the meeting, Freeman officially started working on the April Meeting and the APS IT, Meetings, and Communications departments undertook a herculean effort to bring the meeting to fruition.

"At first, I said why don't we only do the plenary sessions and the public lecture—those are high profile talks—and leave the rest to our divisions," says Han. "[Doyle] said, 'Okay, let's see how far we can go'...It's just amazing for them to have put everything online and I'm really extremely grateful."

Learning—and Looking Ahead

Launching an all-virtual meeting was a monumental task, but the developed tools and lessons learned can likely be used for future meetings, especially in a post-COVID-19 world.

"I think there's going to be a new normal next year. I don't know what it is yet in terms of live meetings. I'm hoping it doesn't affect them too much, but I have a feeling it will," says Clemens. "I do think we should, going forward, have much more of a hybrid meeting. And when I say hybrid, I mean a virtual component of the live meeting so that we can reach that audience that doesn't go [to meetings] and hopefully grow the audience."

While other societies are launching online meetings, the APS April Meeting currently stands as one of the largest ever online meetings, thanks to support from the physics community.

"I want to show appreciation for the support all over the physics world. Our APS leadership, our program committee, and our APS staff members, they're the real heroes," says Han. "I also want to thank our community: our Society. For 7,000 people to sign up at such a short notice—That's strong support."

GPMFC CONTINUED FROM PAGE 2

symmetry, for instance, predict much larger ones. With increasingly precise measurement tools, it may be possible to measure a nonzero result, finally bringing positive experimental evidence to bear on the question of supersymmetry.

Another major emphasis at GPMFC is the development of increasingly accurate sensors of various properties. This technological development spans atomic clocks to measure time and frequency to an ever-greater accuracy, magnetometers to measure magnetic fields to ever-greater sensitivity, and atom interferometers to measure the energies and forces between atoms.

Perhaps the most high-profile event in the world of precision measurement occurred last year, with the redefinition of four of the seven SI base units—the ampere, kelvin, mole, and most famously, the kilogram—in terms of fundamental constants (see *APS News* May 2019). Importantly, this marked the transformation of the SI system from being partially artifact-based (that is, defining units in terms of physical objects like standard weights) to being based entirely on experimentally realizable and interlinked fundamental constants. According to Hanneke, several GPMFC members were on the international committee that voted on this reshaping of the SI system, and many more directly worked on measurements that led to the updated definitions of various SI units.

Historically GPMFC has had a strong presence at both the APS April Meeting and the annual DAMOP Meeting in May/June, hosting invited talks, a poster competition, and, most notably, a popular one-day workshop on precision measurement topics (alternating between the April Meeting and DAMOP). This year's workshop will be held at DAMOP, possibly in a virtual format, and will highlight "precision measurement searches for new physics."

Looking forward, the GPMFC executive committee hopes for continued membership growth, particularly outside of its traditional AMO physics base. "We are a blended group of theorists and experimentalists, and my hope is that showcasing this will help people in different subfields appreciate each other more," noted Gardner.

Increasing the diversity of GPMFC's membership (currently more than 80 percent male) is another key priority. "There is so much amazing intellectual talent out there in the world, and any barriers we have to creating a broader community is hurting us because we're losing those ideas and perspectives," explained Kimball. On a hopeful note, Hanneke pointed out that most of GPMFC's recent growth has come from a new and more diverse generation of students and post-docs.

Overall, GPMFC stands out as an innovative and collaborative community of scientists, promoting research and exchange of ideas at the frontier of fundamental physics.

"It's a great time to be in precision measurement," Kimball emphasized. "No matter what field you're in—solid state physics, particle physics, astrophysics—there are all sorts of new tools for new measurements, and many diverse theories about physics beyond the Standard Model. It's an enormous opportunity for new discoveries and new ideas."

More information on this unit can be found at aps.org/units/gpmfc

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LETTERS CONTINUED FROM PAGE 1

We've since been able to offer other equipment from our biophysics lab, and colleagues are contributing by modeling and developing sensitive and specific sensors for diagnostics and screening. This of course goes alongside the huge effort of working with our students remotely and shifting to online teaching. It's a terribly difficult time for everyone. But I'm proud to be part of the team at Leeds. – *Helen Gleeson heads the School of Physics and Astronomy at the University of Leeds, UK.*

An Unexpected Collaboration

I am a second-year graduate student, mainly working on computational and theoretical aspects of complex nonlinear and quantum dynamics. My university closed and the state where I live, Maryland, is in lockdown. However, I am exceptionally lucky to have colleagues and an alumnus from my department as my housemates, and I thought it would be a good idea to start some collaborations with them. As of now, apart from continuing my previous work, I have started two new projects with my housemates. These projects are now running at full speed, and we have been able to uncover connections between concepts in vastly different areas of physics. When we are not busy collaborating, we share in the housekeeping and eat free-delivery or buy-one-get-one-free pizzas. It also helps to have a Netflix subscription, a good stock of red wine, and someone who can bake cheesecakes. – *Amitava Banerjee is a graduate student in the Department of Physics and the Institute for Research in Electronics & Applied Physics at the University of Maryland, College Park.*

Rethinking the Markers of Progress

I'm an experimental physicist close to the end of a research project and about to make my first few independent steps on an upcoming fellowship. When it's due to start in a few months, I hope this crisis will have passed or moved into a much more manageable phase for everyone.

The leader of our group of around 12 physicists has been proactive, moving our meetings online and ensuring that all members can contribute. Each of us received help to switch our thinking to planning, analysis, and writing. Personally, with only a few months left before a very productive lab project comes to a close, the temporary inability to collect data is not a major concern. However, I am among the exceptions. For those undertaking PhDs or newer projects, where the requirement for new experimental data is often a prerequisite for progress, the pressure is greater. I do my bit to reassure them that "normal" markers of progress can't possibly apply at the moment. I expect a silver lining though. In our last meeting, several people showed that with extra time, they had improved their analysis of a problem. Realizing the value of "time to think" is something we can hopefully retain when we are back to normal. – *Mike Weir is a researcher in the Department of Physics and Astronomy at Sheffield University, UK.*

Earthquake Follows Pandemic

The coronavirus epidemic is still under good control in Croatia, but our quarantine continues. Unfortunately, on March 22nd, we had an additional disaster: a strong earthquake in Zagreb, where I live. About 26,000 buildings in the city were damaged, some 2000 beyond repair. The good thing is that, because the pandemic had forced most people to be at home, there were almost no casualties, which for a city of close to one million inhabitants is close to a miracle. The experience was very frightening and stressful to all of us, and while the rebuilding has already started, a complete recovery will take several years. – *Maja Planinić is a professor in the Department of Physics at the University of Zagreb and an editorial board member for the journal* Physical Review Physics Education Research.

New Tools for Teaching

The COVID-19 pandemic has been slowing my productivity as a professor, as I shift from partial lectures and lab interactions with students to totally online teaching and evaluation. Fortunately, I had already experimented with online artificial intelligence tools for providing one-on-one interactions, assignments, teaching, and testing of my students in general chemistry. (I use the ALEKS system from McGraw Hill.) During this time, I am also using my chemistry knowledge to theorize methods of treating COVID-19. – *Reginald B. Little is an Associate Professor of Chemistry at Stillman College in Alabama.*

Readers are encouraged to submit brief letters to letters@aps.org. Letters are edited for length and clarity. The views expressed are solely those of the authors.

CLIMATE CONTINUED FROM PAGE 3

forcing is aperiodic and deterministic: it does not exhibit exact repetitions but it is not random either. Ghil's framework defines the climate system's behavior as including both deterministically chaotic processes and random ones.

Predicting climate volatility also requires observational data, but information about small-scale processes that impact global climate, like turbulent motion inside clouds, can be virtually impossible to obtain.

"If we want to predict how climate will change, first we must predict how the physical system will change. The equations governing all of that are essentially equations of classical physics," said Schneider, climate scientist and professor of environmental science and engineering at the California Institute of Technology. "The challenge is that we have to solve [these equations] for the entire planet, and we have to solve them for scales of motion that range from millimeters to the planetary scale."

He and his colleagues study how global cloud behavior will evolve as climate change progresses. Understanding global cloud dynamics requires information about small details in the turbulence of clouds and the micro-scale physics of droplet and ice crystal formation. Schneider's team has developed coarse-grained models—which build a picture of overall cloud behavior by starting from molecule interactions—to represent these processes.

But calibrating these models of cloud dynamics and quantifying their uncertainties involves running simulations hundreds of thousands of times. Calibration ensures the model fits the data in the best way possible. Quantifying uncertainty helps scientists predict potential climate risks. However, the calibration and quantification process requires some of the world's largest supercomputers, rendering it computationally expensive.

To overcome this obstacle, Schneider and his team developed an algorithm, combining ideas from data assimilation and machine learning, that accelerates the model calibration time to around 1000 runs—roughly 1000 times faster than existing modeling methods. The formula lessens how much computation is needed, or reduces climate models' cost.

Using neural networks to derive data for climatological processes that are difficult to observe—like the rates of carbon dioxide and water vapor exchange through leaves' pores, called stomatal conductance—could also boost models' computational efficiency and reduce uncertainty.

"We're using machine learning to build a simpler model, essentially to replicate the behavior of the complex climate model," said Dagon, a climate physicist at the National Center for Atmospheric Research.

She and her colleagues employed machine learning to quantify uncertainty and to streamline the modeling process. They used artificial neural networks, or emulators, to train a simple model to provide estimates for certain climate variables, like global photosynthesis or CO_2 uptake by plants. They then assessed the simpler model's accuracy by comparing its results to a more complex model's predictions. The simple model mirrored the complex model's predictions without as much data because it was able to generate its own simulated data. It also took less time to run, making it more computationally efficient.

"Once we have an emulator, we can optimize parameter values, like factors in the equation to calculate photosynthesis, that are a very large source of uncertainty in climate predictions," said Dagon. "We can use these machine learning tools to see how much uncertainty is coming from those parameters."

Although climate is irregular, models are costly, and observational small-scale data is limited, physicists throughout the world are working together to improve existing climate models.

"This is rapidly evolving and intensely energetic work… I think we all feel a great sense of urgency because climate is changing very rapidly, and we'd like to provide a prediction of how that change will happen before it does," said Schneider.

The author is the Science Communications Intern at APS.

JOY OF PHYSICS CONTINUED FROM PAGE 4

features Chien-Shiung Wu, the "First Lady of Physics." For comic book lovers, or anyone looking for their next read, a brand-new special issue of Spectra: The Laser Superhero, featuring LIGO, is also available.

Funsize Physics also offers at-home physics activities that allow scientists of all ages to explore condensed matter physics. Physicists from across the country contribute short articles, featuring stunning visuals and easy to follow explanations of cutting edge research, as well as "funsize activities" to explore physics concepts. However, Funsize Physics comes with a warning: "Funsize Physics is not responsible for any minds that are blown."

Popular science magazine *Scientific American* and STEM education non-profit Science Buddies have teamed up to help parents Bring Science Home. With more than 400 science activities using household items for kids 6 to 12, *Scientific American* and Science Buddies offer hours of science fun without leaving the house. Try some "balloon magic" to explore Bernoulli's principle, learn about conservation of energy with a make-your own cotton ball launcher, and more!

Speaking of science fun, students can explore physics concepts like circuits and waves through games: The Universe and More, created by 2019 PhysTEC Teacher of the Year Matthew Blackburn, offers five different educational online games. Another online resource, Girls Who Code, has made their Girls Who Code At Home Activities free to download. Popular YouTube channels like MinutePhysics, PBS Digital Studios' Physics Girl, and SciShow's Physics playlist can also help physics-interested kids dive into simple explanations of a variety of physics topics.

APS PhysicsCentral:
physicscentral.com
Funsize Physics:
funsizephysics.com
Bring Science Home:
scientificamerican.com/education/bring-science-home/
The Universe and More:
universeandmore.com

Did we miss your favorite at-home physics resource? Let us know at lettes@aps.org.

ANDERSON CONTINUED FROM PAGE 1

damental level, and then nuclear, atomic, and so on, and beyond is biology and psychology, and so forth," says Stein. "Phil's argument was that each new level could not be understood or predicted solely using concepts borrowed from the previous level. It was an antireductionist argument. Conceptually, each level is just as fundamental." Although other scholars were addressing this idea, "Phil was the first one to put this all together and to represent it in a forceful and coherent manner," he adds.

As a condensed matter physicist, Anderson became fascinated by spin glasses—disordered networks of magnetic moments—viewing them as a bridge to other arenas, including economics, biology, and computer science. His appreciation for spin glasses demonstrated his ability to "extract the quintessence of experiment," says Premala Chandra, Professor of Physics at Rutgers University. "He could look at the result of a measurement, sense what was important, and then ask intuitive questions that would launch a number of sub-fields." With spin glasses, he developed a whole new set of methods to approach these problems, which are presently applied in combinatorial optimization, neural networks, and machine learning.

Anderson's 1977 Nobel Prize in Physics was for his collaborative work on fundamental theoretical investigations of the electronic structure of magnetic and disordered systems.

As Anderson's interests grew, he became increasingly vocal about issues of public concern, especially those touching the scientific community. He was vocal in his disapproval of the Superconducting Super Collider (SSC), skeptical of the supposed boost it would provide to science in the US and the claim that the spin-offs would provide great return on investment. Regarding spin-offs, he felt that "those arguments were overblown and largely inaccurate," says Stein. "He argued that the evidence that the SSC would have a strong payoff in terms of technology spin-offs was weak and didn't hold up under closer scrutiny. The bang for the buck would not be what was what people were claiming." And the investment in the most fundamental of STEM? Anderson wanted to spread what limited financial resources the US had to other areas of science which he felt were just as important, adds Stein.

Legacy as a "wonderful human being"

Those who had the opportunity to be around Anderson describe him as someone who was innately curious and desired to share that enthusiasm with others, especially those early in their careers. "I think Phil was extremely thoughtful about young people in physics," says David Krakauer, President and William H. Miller Professor of Complex Systems at the Santa Fe Institute. Chandra notes a story about how Anderson was one of the only senior faculty at Princeton who would eagerly climb up the stairs to the students' offices to share his latest ideas. "They were literally just flowing out of him," she says. He had friendships and mentorships well beyond his students graduating. For example, Anderson threw Stein's engagement party in Anderson's own home.

But "Phil was quite measured," adds Krakauer. "He didn't speak when he didn't have to." And yet over and over he is described as very generous with his ideas, says Chandra. When Chandra approached him to be a co-author on a paper, he insisted an acknowledgement was sufficient.

Anderson had other talents as well. One night at a small gathering at the Coyote Cafe in Santa Fe, Brian Arthur, an economist at Stanford and at the Santa Fe Institute says that Anderson was asked if he played chess or checkers. "He shook his head and I asked him if he played any games. He said 'no, not really.' But it didn't ring true to me, and I pushed him a bit. He said 'I play a bit of Go,' and to me that sounded like more than just a bit of Go—I had gotten to know Phil and suspected there was more there. I asked if he was any good, and he said 'yeah.' It was like peeling layers. I said 'how good?' and he said 'Oh there are four people in Japan who can beat me,' and then there's dead silence and all the mouths were open and we're staring at Phil and then he says 'but they meditate.'"

As late as this winter, Anderson was still engaged with friends. Chandra and her husband, Rutgers physics professor Piers Coleman, met Anderson for dinner. "He was in good spirits," says Chandra. "He brought along the obligatory bottle of red wine, hidden in his walker compartment. Once he sat down, he asked Piers to uncork it and then insisted on serving us all. We had to drink more than we intended just to make sure he did not consume too much Phil was full of gusto and the conversation topics were wide-ranging. I am grateful for these poignant recent images of him, spirited and animated as ever."

Adds Chandra: "Phil is a hero to so many of us for his intellectual breadth and depth, his wonderful curiosity, his magical intuition and his active support of young researchers. He will be sorely missed but never forgotten."

ADVOCATE CONTINUED FROM PAGE 4

steps that can substantially reduce the nuclear threat.

A second aspect of the project involves building a coalition for advocacy and education.

"Before we can use the coalition for advocacy and education, we first need to build the coalition. [The colloquia will] lay the foundation for why the coalition is needed. We'll then have a follow-on meeting at each visit, with a smaller group," Prager explained.

He continued, "The purpose of the smaller meeting is two-fold: (1) to discuss the coalition, its goals, and activities, and to sign up those interested in joining the coalition; (2) to present an opportunity for further discussion about nuclear weapons and arms control. So, we hope to conclude each visit with some new members. Joining the coalition will provide the opportunity for someone to contribute to advocacy."

Prager is working with five other physicists to launch the project: Steve Fetter, professor in the School of Public Policy at the University of Maryland, College Park; and Frank von Hippel, Zia Mian, Alex Glaser, and Sébastien Philippe, all from Princeton's Program on Science and Global Security. More than a dozen team members from a collection of universities across the US stand ready to present colloquia. Colloquia can be arranged by contacting Prager or team members directly, by visiting the website physicistscoalition.org.

Fetter said he hopes the project will inspire physicists to become more involved in addressing nuclear threats, just as they did when he was in college.

"When I was an undergraduate student in physics in the late 1970s, students were aware of the risks posed by nuclear weapons and the nuclear arms race, and faculty were personally involved in efforts to reduce those risks, perhaps because of the central role physicists played in developing nuclear weapons," recalled Fetter.

He added, "The risks haven't gone away—indeed, in some respects they have increased as nuclear weapons spread to more countries and concerns about nuclear terrorism have grown. But physicists are less concerned and involved. I hope our project will raise awareness among both faculty and students, and that the physics community will once again become a leading voice in calling attention to the risks posed by nuclear weapons and in supporting measures to reduce those risks."

While coalition leadership will identify opportunities for advocacy, the APS Office of Government Affairs (APS OGA) will serve in an advisory capacity for the project, providing input to coalition leaders on advocacy topics, including developing target lists of states and congressional districts, as well as messaging materials. A dedicated staffer will support the coalition's day-to-day activities. APS OGA will also facilitate meetings and provide updates by coalition leaders to appropriate APS committees, and the APS Board and Council.

"This project is dealing with an important area of advocacy that physicists have a notable history of engaging on. Seeing a dedicated team of experts from the community working to rally a new generation to action is inspiring," said Callie Pruett, APS Senior Strategist for Grassroots Advocacy. "Our office is excited to support this bold initiative and to help build a strong coalition of advocates."

Pruett noted that APS OGA has had tremendous success working on advocacy campaigns with graduate students, and she believes the nuclear threat reduction project will inspire them to engage on another important issue.

The idea to develop the nuclear threat reduction coalition grew out of concern regarding the enormous arsenal of weapons among nine nations: United States, Russia, China, United Kingdom, France, India, Pakistan, Israel and North Korea.

"The more than 9,000 nuclear warheads in the active international nuclear stockpile can destroy civilization many times over," warned Prager. "The massive nuclear weapon system modernization being undertaken by the United States and Russia and, to a lesser extent by China, France, and the United Kingdom, constitutes a renewed century-scale commitment to nuclear weapons."

Prager said physicists are in a special position to make a difference in the reduction of nuclear weapons, given their historic role in nuclear arms control.

"Physicists, acting as informed citizens, can be a powerful voice to educate and to promote steps to reduce the nuclear threat. Their voice was exercised during the 1940s when physicists at the very beginning of the nuclear era argued for nuclear arms control, during the 1960s when their message of the ineffectiveness of ballistic missile defense laid the basis for the 1972 Anti-Ballistic Missile (ABM) Treaty, and during the 1980s, when the citizen movement, calling for a freeze to the arms race, helped achieve the basis for the Intermediate Nuclear Force and START Treaties."

This hard-won treaty-based structure of nuclear restraint and progress toward disarmament is being undone, however, said Prager.

"With the US withdrawal from the ABM Treaty (in 2002) and the Intermediate Nuclear Forces Treaty (2019), the only remaining treaty providing a constraint on Russian and US nuclear arsenals is the New START Treaty which, if not renewed, will expire in February 2021. The world is slipping toward a new and complex nuclear arms race, involving China, as well as the US and Russia," he said.

Given the complex issues surrounding the reduction of nuclear threats, a multi-pronged approach is needed to effectively address the matter.

"There are many such steps—extension of the New START Treaty, abandonment of a launch-on-warning policy, and implementation of a no-first-use policy, to name a few," said Prager.

Francis Slakey, APS Chief Government Affairs Officer, said the coalition is doing important work that could make a lasting impact on the legacy of nuclear arms control.

"This is another opportunity for APS OGA to support our members in advocating for an issue that not only affects the lives of Americans, but of those throughout the world," he said.

The author is the APS Senior Press Secretary.

PANDEMIC CONTINUED FROM PAGE 4

and the agency had not announced any plans to resume the center's operations as of mid-April.

Beyond imaging facilities, several DOE labs have lent their supercomputers to the effort, participating in the COVID-19 High Performance Computing Consortium launched by the White House on March 23. The consortium triages requests for computing resources at DOE, NASA, the National Science Foundation, and several private companies. Among the first projects, the NSF-funded Frontera supercomputer at the Texas Advanced Computer Center is running detailed simulations of the virus' surface to identify potential vulnerabilities, and Oak Ridge's Summit supercomputer has modeled molecular interactions between the virus and thousands of drug compounds.

In support of such efforts, Congress included supplemental appropriations for research in the phase three coronavirus response legislation signed into law on March 27. Beyond providing billions to public health agencies, the measure provides smaller amounts to a broad set of science agencies, including $100 million for DOE to support access to its user facilities, $75 million for NSF grants, and $66 million for measurement science and manufacturing programs at NIST.

The author is Acting Director of FYI.

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Scientists Must Intensify Their Commitment to Research Integrity

BY THE APS PRESIDENTIAL LINE: PHILIP H. BUCKSBAUM (PRESIDENT), S. JAMES GATES JR. (PRESIDENT-ELECT), FRANCES HELLMAN (VICE PRESIDENT), AND DAVID J. GROSS (PAST PRESIDENT)

A few months ago, a prominent APS Fellow was led out of his office in handcuffs and charged with fraud for lucrative research contracts with China that he allegedly failed to report to the National Institutes of Health. At a time when the US government is increasingly concerned about foreign influence, particularly from China, the lesson of those handcuffs on a leading US scientist at one of our flagship universities couldn't be clearer: scientists must recommit to the core principles of research conduct.

Recent Reports and Reaction by Congress and the Executive Branch

This incident is just one recent example of the US government's response to growing concerns about foreign influence, espionage, and IP theft. A recent US Senate report [1] largely critical of the scientific community states that some countries "seek to exploit America's openness to advance their own national interests."

Furthermore, that Senate report, titled "Threats to the US Research Enterprise: China's Talent Recruitment Plan," notes: "This report exposes how American taxpayer-funded research has contributed to China's global rise over the last 20 years." It states that members of China's Talent Recruitment Program—scientists engaged in research in the US who transfer their work to China in exchange for high salaries, lab space and other incentives—have downloaded sensitive electronic research files, submitted false information when applying for grant money, and willfully failed to disclose the receipt of money from China on their US grant applications.

That report was just one of many recent examinations of the extent and impact of foreign influence, from China in particular, on the US scientific enterprise. Other reports that have also circulated widely among policymakers in DC offer other views on this issue.

China's tactics also came under fire in a report [2] last fall by Strider, a Maryland-based intelligence company, that alleges that China has gone from a "laggard in quantum science and technology to a global leader" by taking advantage of the scientific openness of the United States and European nations, as well as their funding mechanisms. The report goes into considerable detail describing a network spanning four continents, operated by a scientist in China. "For over a decade" according to the report this leading scientist at one of China's premier research universities, "in collaboration with PRC (People's Republic of China) government stakeholders, has executed an intentional strategy to exploit Western government funding to train Chinese quantum scientists at Western research institutes and relied on both 'unwritten agreements' and monetary incentives through PRC government talent programs to then bring those Western-trained quantum scientists back to China."

Together, these two reports tell a chilling story that calls into question our principles of open science, and also the integrity of the scientists themselves, who are characterized as at best naïve, and at worst, greedy and complicit in unethical contracts and deep conflicts of commitment.

These report conclusions, however, discount the very values that are intrinsic to progress in fundamental science, and even encourage new policies that could override those values, hamper the US role in worldwide scientific research, and thus diminish our nation's scientific enterprise. This real danger was displayed by a recent APS study, where 32 percent of international physics students who chose not to study in the US, say the country is "unwelcoming to foreigners."The National Science Foundation (NSF) is rightly concerned about this issue, so the agency commissioned a report [3] on fundamental research security that was carried out last fall by JASON, the highly acclaimed group of distinguished US scientists with a long history of consultation for the government on security and science questions. According to NSF, four main themes emerge from the JASON document:

- The value of, and need for, foreign scientific talent in the United States
- The significant negative impacts of placing new restrictions on access to fundamental research
- The need to extend our notion of research integrity to include disclosures of commitments and potential conflicts of interest
- The need for a common understanding between academia and US government agencies about how to best protect US interests in fundamental research while maintaining openness and successfully competing in the global marketplace for STEM talent


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The Director of the White House Office of Science and Technology Policy and current Acting Director of the National Science Foundation, Kelvin Droegemeier, is quoted in an NSF statement on the report, "The integrity of our research enterprise rests upon core principles and values of transparency, openness, and merit-based competition. Principled international collaboration and foreign scientific talent in the United States are critical to the success of the US research enterprise." Dr. Droegemeier is accurate in his assessment, which is a sensible conclusion to draw from the various reports that have been issued regarding foreign influence on U.S. science.

If scientists don't engage in the open, transparent and ethical behavior expected of us, our largely self-policed scientific enterprise will understandably invite new regulations from the federal government. And some of the regulations already proposed—including bans on foreign scientists or restrictions on their participation in subfields of research—could risk the very qualities that have made fundamental research an engine for U.S. scientific innovation and economic growth.

The Value of Collaboration to the US Scientific Enterprise and Global Science

Fundamental research transcends national boundaries, and open, international contact is essential for progress in basic science research. Vital research projects would not have reached fruition without open, international scientific collaboration including LIGO, CERN, or the US network of accelerator-based user facilities, just to name a few.

Some view the scientific relationship of the United States with China as zero-sum—if China gains, the United States loses. In reality, both countries can gain from research collaboration. A study [4] of scientific co-publications published last year in *Higher Education* indicates just how beneficial collaboration is to the United States, particularly with China. Collaboration has enabled the United States to increase its scientific influence, leverage its resources, and recruit world-class talent. By examining co-publications, the authors determined that US research article publications would be in decline without co-authorship with China. The authors conclude, "regardless of whether US agencies and organizations espouse a positive or zero-sum view of scientific research, both interests would be served in research collaboration with China."

APS Board Statement and a Commitment to Research Principles

There is clearly a need to balance national security concerns such as economic espionage against the research requirements and considerable national benefits of open science. APS believes this balance is best achieved through adherence by scientists, their employers and the US federal government to core principles, which our APS Board of Directors laid out in a Statement on Open Science and a Recommitment to Research Principles [5]. APS leaders are now discussing the path forward in meetings with leadership in the State Department, Department of Defense, Department of Energy, Department of Commerce, and the White House as well as relevant committees in Congress.

In the APS Board's view, first and foremost, scientists must commit to research integrity: objectivity, honesty, openness, accountability, fairness, disclosure and stewardship. Research integrity imposes expectations on behavior of individual scientists, and it imposes expectations on how scientists interact with each other and with their employers. There must be reciprocity in the global exchange of research information between scientists. There must be full disclosure to employers and federal funders of potential conflicts of commitment. And there must be responsible handling of research information, particularly prior to publication. All of these expectations must apply globally, whether a scientist is in the United States or Europe, Canada or China.

Is it realistic, for example, to expect scientists in China to adhere to research principles? From our experience, and those of our colleagues, the answer is yes. In our discussions with leading scientists in China, they emphatically endorsed these principles, knowing as we do that disregarding them will jeopardize the open scientific exchanges that propel fundamental research.

Adherence by scientists to these principles should, in turn, support the commitment of Congress and the Administration to the principles that have successfully guided our nation's research enterprise since 1985. During the height of the Cold War, President Reagan considered whether to impose restrictions on fundamental research in order to limit Soviet intrusion and influence. He concluded that the benefits of an open scientific enterprise far outweighed the risks. In national security decision directive NSDD-189, Reagan stated that "to the maximum extent possible, the products of fundamental research should remain unrestricted." In addition, most importantly, the directive clarified that the means of control of fundamental research for national security is the mechanism of classification.

Scientists and the government must now recommit to these research principles in order to, as Reagan recognized, sustain a research enterprise that generates the greatest benefit to the US. Those who choose to ignore these ethical guidelines, rare outliers in our opinion, should be shunned by our research community. Setting the example, the American Physical Society is now establishing policies that require adherence to these principles in order to receive or retain an honor, award, or fellowship.

The health of the fundamental research enterprise and the needs of national security can both be satisfied by strict adherence to these principles of openness coupled with responsible stewardship. With that understanding, we can ensure that science will continue to advance, and the scientific enterprise can be held in the highest regard.

References

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