November 2020 • Vol. 29, No. 10
aps.org/apsnews

APS NEWS

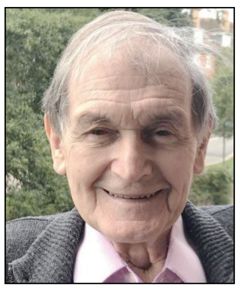
A PUBLICATION OF THE AMERICAN PHYSICAL SOCIETY

HONORS

2020 Nobel Prize in Physics

BY LEAH POFFENBERGER

The Royal Swedish Academy of Sciences has announced the recipients of the 2020 Nobel Prize in Physics, which has been awarded for discoveries about black holes, which are among the most exotic phenomena in the universe. This year's prize is awarded to Roger Penrose (University of Oxford), Reinhard Genzel (Max Planck Institute for Extraterrestrial Physics, and University of California, Berkeley), and Andrea Ghez (University of California, Los Angeles). Genzel and Ghez are both APS Fellows. Ghez is also the fourth woman to receive the Nobel Prize in Physics, joining Marie Curie, Maria Goeppert-Mayer, and Donna Strickland.



Roger Penrose
IMAGE: OXFORD UNIV.

Reinhard Genzel
IMAGE: MPG

Andrea Ghez
IMAGE: UCLA

One half of the Nobel Prize in Physics is awarded to Penrose "for the discovery that black hole formation is a robust prediction of the general theory of relativity." The other half is awarded jointly to Genzel and Ghez "for the discovery of a supermassive compact object at the center of our galaxy." Together, their discoveries were groundbreaking, proving black holes can exist within the framework of Einstein's theory of relativity and that one does exist at the center of the Milky Way.

"This is very exciting news," said APS President Phil Bucksbaum. "Andrea Ghez and Reinhard Genzel lead competing experimental groups that have been tracking the motion of stars near the center of the Milky Way for more than twenty years, making precision tests of General Relativity and particularly predictions based on Roger Penrose's work that there could be a black hole at the galactic center. This work has made pioneering use of adaptive optics on the Keck telescope, and it has led to the understanding that supermassive black holes inhabit the centers of many galaxies. I'm also pleased to see the Swedish academy recognize a fourth woman Nobel Laureate."

The Nobel Committee cited papers published in APS journals

PHYSICS NOBEL CONTINUED ON PAGE 7

COVID-19

New Research Resource Group Brings Physics Expertise to the Coronavirus Pandemic

BY LEAH POFFENBERGER

Since the onset of the COVID-19 pandemic, researchers around the world have been racing to better understand the novel virus. Among them have been physicists, applying expertise in areas from modeling of spread of the virus, to the fluid dynamics of transmission, applying AI to detect the disease in medical images, to the development of ventilators and other technologies.

In order to bring the physicists researching COVID-19 together with medical professionals and epidemiologists, the APS Topical Group on Medical Physics (GMED) and several other APS units have launched the COVID Research and Resources Group (CRRG). The CRRG will facilitate communication, sharing of resources, and other activities to mobilize physicists to help combat an ongoing medical emergency.

"There is no shortage of science that physicists are contributing to COVID—a lot of people don't know that physics is playing an important role," says Robert Jeraj, Past Chair of GMED and chair of the CRRG organizing committee. "CRRG [promotes] physics research towards a broader community…A lot of physicists work behind the scenes, so we want to show the importance of physics in addressing medical problems."

At the onset of the coronavirus pandemic, the GMED executive committee recognized an opportunity to consolidate the efforts of members in different APS Units conducting research to address COVID. The committee submitted a proposal to APS Leadership calling for the creation of CRRG. "This was a new problem for everyone, and there was no real home for it

EXPERTISE CONTINUED ON PAGE 6

EARLY CAREER

APS Launches a New Chapters Pilot Program

BY LEAH POFFENBERGER

To serve its diverse membership, APS provides a variety of units, divisions, and forums that gather individuals into communities with common goals or research interests. And now, APS is launching a new way for members to connect with each other within their own institutions with the advent of the APS Chapters program.

APS Chapters will be small groups, localized within interested universities and national labs, targeted specifically towards graduate students, post-docs, and early-career scientists with the goal of supporting them in their current roles and as future leaders. A pilot program launched in October is paving the way for future APS Chapters to start up next year.

"One of the things the APS is interested in is serving early career folks and connecting with them to find out how APS can support them," says Farah Dawood, APS Chapters Program Manager. "We have many programs to address

Farah Dawood

their needs, and the goal of Chapters is helping those individuals find some kind of home at their institution that has support from the APS."

Each Chapter will have a chance to build its own unique communities, with the ability to communicate directly with APS about their needs and interests. If a particular Chapter expresses

CHAPTERS CONTINUED ON PAGE 7

MEETINGS

APS to Consider Police Conduct in Choice of Meeting Locations

BY DAVID VOSS

APS has updated its criteria for the selection of future venues for its scientific meetings. Cities in which APS meetings might be held will be asked to report demographic statistics on police use of force, policies on strangleholds and other restraint methods, and the status of independent investigations into instances of deaths while in custody, among other issues.

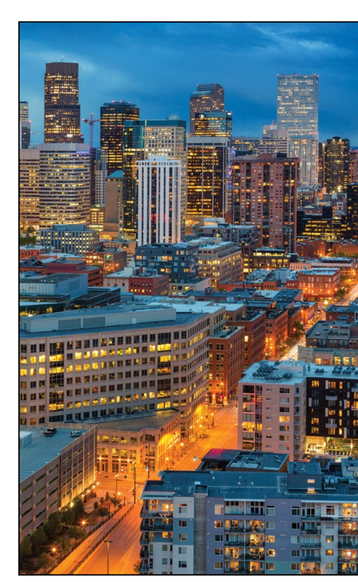
According to Susan Gardner (University of Kentucky), chair of the APS Committee on Scientific Meetings, the change was primarily in response to a proposal to the Committee by Philip Phillips and Michael Weissman (both at the University of Illinois at Urbana-Champaign)—a proposal based on letters they had published in *Science* (June 19, 2020) and *Physics Today* (July 2020). The committee also considered other factors, including discussions at a recent APS webinar "From Passion to Action" hosted by APS President-Elect S. James Gates, Jr.

"We deliberated at length over the proposal and other input during our recent committee meeting," said Gardner. "I would summarize by saying that we became aware that members of our community are vulnerable in ways we had never imagined, and we resolved to act. We voted unanimously to recommend these changes. We want to conduct every APS meeting in a safe environment for our attendees; this is a natural part of our site selection process. These new criteria are a way of broadening the issues to be considered."

On behalf of the committee, Gardner informed the APS Council about the new criteria in a letter, distilled from the Phillips and Weissman proposal:

The Committee on Scientific Meetings has added the following items to consider as part of the future site selection criteria for APS Scientific Meetings. Each city under future consideration should:

- *Have openly available statistics on police-initiated contacts and use of force that include demographic information.*
- *Have an independent investigative body to respond to serious incidents, including deaths in custody and officer-involved shootings.*
- *Have a policy in place that forbids the use of carotid holds, strangleholds, or generally, maneuvers by police officers that cut off blood or oxygen.*
- *Have all police officers trained in de-escalation methods, such as PERF's ICAT (Integrating Communications, Assessment, and Tactics) training.*
- *Have a policy in place where each police officer has the duty to intervene and/or to render medical aid if other officers are using excessive force.*
- *Have performance evaluations/measures that include more criteria than just enforcement statistics (arrests, summonses, stops). The criteria should include officer-involved fatalities or shootings of unarmed persons.*
- *Have a well-defined plan and timetable for improving local policing practices.*



Denver is one of the cities that has responded well to the additional criteria APS will use in choosing meeting venues.

LOCATIONS CONTINUED ON PAGE 6

PROFILE

Jami Valentine Miller Inspires the Next Generation

BY JUSTUS HAWKINS

Jami Valentine Miller

Dr. Jami Valentine Miller's journey to becoming the first Black woman to graduate with a PhD in physics from Johns Hopkins University is a story that will surely inspire the next generation of Black physicists.

She was born in Philadelphia to a family that valued hard work and education, and her family was always near. As early as elementary school, Valentine Miller was identified as gifted and talented. She went on to attend a middle school for gifted and talented students that would give her access to a new world. "While I was there I got into a program called PRIME," she recalled.

PRIME is an acronym for Philadelphia Regional Introduction for Minorities in Engineering. According to Valentine Miller, the program bussed kids from all over the city who were interested in math and science. The program brought the students to college campuses during the summertime to prepare for the classes they were taking in the fall. She said that the PRIME program normalized being a Black geek during the 1980s.

The PRIME program is not the only factor that helped shape Valentine Miller into the person she is today. Eight years before she was identified as a gifted student, her aunt achieved the same distinction, but that opportunity was taken away because of the color of her aunt's skin. According to Valentine Miller, during the 1970s, her aunt was a top math student and had even won a statewide math competition.

Unfortunately during this time, Philadelphia schools were heavily segregated. "The principal did everything he could to get her into that school, and they simply didn't accept her," Valentine Miler said.

As far back as the first grade, she recalls students being bussed into schools. Desegregation bussing in the United States was an effort to add diversity to schools. "[It] wasn't that long ago that we had to deal with these issues," Valentine Miller said.

For all these reasons, the family was adamant that she would be in the gifted and talented middle school. "My mother worked for the school district for 39 years, so education was very important in our home," Valentine Miller said.

Off to university

When it came time to choose a college to attend, Florida Agricultural and Mechanical University (FAMU) found her.

Dr. Leonard Johnson, the president of the FAMU alumni association, was a Philadelphia doctor who insisted that university representatives go to every high school in Philadelphia to recruit students. Students who were merit scholars were distinguished by an armband, but on the day of the visit, she did not wear her armband because she did not want to wrinkle her shirt. After everybody gave their spiel, Johnson said that he wanted to see the class president and the valedictorian.

Valentine Miller questioned why he did not want to see her as well and Johnson asked who she was. To which she proudly replied, "I am Jami Valentine, I have had the highest SAT scores in this school for the last five years going."

Following that meeting, she and sixteen other students were invited to go to FAMU. Valentine Miller recalled them boarding the Amtrak train, getting off in Jacksonville, and boarding a charter bus to get to the FAMU campus. "It was a bonding trip, because once you take a sixteen-hour train ride with high school students, y'all friends now," Valentine Miller said.

Once they reached FAMU, Valentine Miller met with President Humphries. According to Valentine Miller, he asked her what she wanted to major in. "I said physics," Valentine Miller said.

MILLER CONTINUED ON PAGE 4

THIS MONTH IN

Physics History

November 28, 1680: Death of Athanasius Kircher

Athanasius Kircher

The 17th century Jesuit priest and polymath Athanasius Kircher was a contemporary of such scientific luminaries as Isaac Newton, Robert Boyle, Gottfried von Leibniz, and Rene Descartes, and enjoyed considerable public recognition for his scientific investigations—at least until his later years. His prolific writings cover topics ranging from geology, magnetism, and mathematics to astronomy, optics, acoustics, and Egyptian hieroglyphics. Although he has been called the "last Renaissance man," and the "master of a hundred arts," he never achieved the same long-lasting scientific legacy as his contemporaries.

The youngest of nine children, Kircher was born in 1601 or 1602 (even he was unsure) near what is now Hesse, Germany. His father was a magistrate, who ensured the boy attended Jesuit schools, and also learned Hebrew from a local rabbi, inspiring a lifelong love of languages. Young Athanasius was quite accident prone as a child, experiencing many brushes with death.

For instance, after initially being rejected by the Jesuit college in Fulda, a despondent Kircher injured his legs while ice skating, and the wounds festered, with gangrene setting in. During this time, he was accepted as a novitiate at the college in Paderborn, but his condition was so far advanced when he arrived that he was judged to be incurable. In Kircher's telling, he prayed to a statue of the Virgin Mary one night, and when he woke up the next morning his legs had miraculously healed.

Kircher took his vows in 1621, the same year the Duke of Brunswick's troops took over the diocese, forcing Kircher and his fellow priests to flee to a nearby Jesuit college at Neuss. Kircher was swept into the water of the freezing Rhine river during the flight but managed to reach the shore and walk the remaining three miles to rejoin his colleagues. Forced to cross a war zone controlled by Protestant forces while traveling to Heiligenstadt in Saxony, Kircher didn't bother disguising his Jesuit robes. He was stripped and beaten by a group of soldiers, who would have hanged him if it weren't for one soldier who had a change of heart and pleaded for mercy.

Other adventures included being shipwrecked on an island while traveling to Austria and witnessing the eruption of the volcanoes Aetna and Stromboli. On one especially memorable occasion, he lowered himself into the active crater at Mt. Vesuvius. "The whole area was lit up by the fires, and the glowing sulphur and bitumen produced an intolerable vapor," Kircher wrote of the experience. "It was just like hell, only lacking the demons to complete the picture."

Eventually he retired to a quieter life of scholarly contemplation, pursuing his scientific interests with equal passion. For instance, as the bubonic plague ravaged Rome in 1656, Kircher used a microscope to study micro-organisms in hopes of finding a cure, observing "little worms which propagate plague." Given the poor resolution of microscopes at the time, these were more likely red blood cells he was seeing, but it did lead Kircher to suggest a rudimentary germ theory of disease, putting him far ahead of the medical orthodoxy of his time. Robert Hooke and Antonie van Leeuwenhoek would eventually reveal the microscopic world in even greater detail.

Kircher taught mathematics and tried to decipher Egyptian hieroglyphics; he was considered one of the leading Egyptologists of the time. His interpretation wasn't correct—and the Rosetta Stone would not be discovered for another 100 years—but he correctly deduced that the Coptic language was crucial to unlocking the mystery. Another of his experiments disproved speculation that the Sun was a giant magnet whose rotation around its axis caused the Earth and the planets to stay in their orbits. His 1641 treatise on magnets may contain the very mention of the term "electro-magnetism."

Indulging a mechanical bent, he built several pneumatic, hydraulic, and magnetic machines, including a magnetic clock. He even devised a Mathematical Organ (an example of which is preserved in the Museo Galileo in Florence, Italy) to provide answers to mathematical problems, although it required memorizing long poems in Latin (provided in an 850-page instruc-

KIRCHER CONTINUED ON PAGE 3

APS NEWS

Series II, Vol. 29, No. 10
November 2020
© 2020 American Physical Society

Editor . . . . **David Voss**
Staff Science Writer . . . . **Leah Poffenberger**
Contributing Correspondents . . . . **Sophia Chen and Alaina G. Levine**
Design and Production . . . . **Nancy Bennett-Karasik**

APS News (ISSN: 1058-8132) is published monthly, except for a combined July-August issue, 11 times per year, by the American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, (301) 209-3200. It contains news of the Society and of its Divisions, Topical Groups, Sections, and Forums; advance information on meetings of the Society; and reports to the Society by its committees and task forces, as well as opinions.

Letters to the editor are welcomed from the membership. Letters must be signed and should include an address and daytime telephone number. APS reserves the right to select and to edit for length and clarity. All correspondence regarding *APS News* should be directed to: Editor, APS News, One Physics Ellipse, College Park, MD 20740-3844, Email: letters@aps.org.

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

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

Coden: ANWSEN ISSN: 1058-8132

KIRCHER CONTINUED FROM PAGE 2

tion manual) even to perform the most elementary functions. He maintained a large collection of unusual artifacts, including a stuffed aardvark and an automaton he called his *Kircherianum*—essentially an elaborate *wunderkammer* ("cabinet of curiosities").

Kircher retreated to the Roman countryside when his health deteriorated. His reputation lost its luster as he grew old and gradually succumbed to a "second childhood." He died on November 28, 1680. At his request, his heart was buried at an old church he had helped restore in the mountains outside Rome.

Kircher languished in historical obscurity for centuries, in part because his interests were so varied, but also because of his misguided efforts to unite Biblical historicism with science. A follower of the hermetic tradition, he wrote highly speculative treatises on Noah's Ark (including a floor plan) and the Tower of Babel, for instance—the latter a natural (albeit scientifically sketchy) outgrowth of his long-standing interest in linguistics. He also invented a divination device he called "magnetic hydromancy."

But in recent years, Kircher has inspired renewed appreciation for his uniquely eccentric gifts. The Los Angeles-based Museum of Jurassic Technology maintains a permanent exhibition on Kircher.

Further Reading

Findler, Paula. *Athanasius Kircher: The Last Man Who Knew Everything.* New York: Routledge, 2004.

Fletcher, John Edward. *A Study of the Life and Works of Athanasius Kircher, 'Germanus Incredibilis.'* Amsterdam: Brill Publications, 2011.

Glassie, John. *A Man of Misconceptions: The Life of an Eccentric in an Age of Change.* New York: Riverhead, 2012.

MEMBERSHIP UNITS

The APS Topical Group on Magnetism and its Applications

BY ABIGAIL DOVE

With nearly 1,300 members, the Topical Group on Magnetism and its Applications (GMAG) is a home for physicists interested in the fundamental physical phenomenon of magnetism, which can be found in a variety of materials ranging from elements, molecules and clusters, to nanoparticles, filaments, films, and crystals.

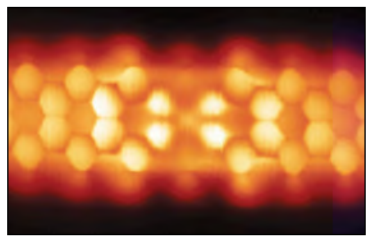
As GMAG chair Geoff Beach (MIT) put it, the study of magnetism involves a "symphony of different disciplines" from physics to materials science, chemistry, engineering, and even biomedicine. "What brings everything together is the need to understand the physics of spin, how spins interact, and how they couple to materials to give rise to collective behavior," he explained.

Some of the topics of current interest in magnetism, according to GMAG vice chair Marcelo Jaime (Los Alamos National Laboratory), are the search for a 'spin-liquid' state predicted in geometrically frustrated magnetic lattices, magnetic-field induced magnetism in paramagnets, the anomalous quantum Hall effect in topological semimetals, the interactions between magnetic and non-magnetic states of matters, and fermiology, or the study of electronic band structure by observing the response of electrons to external magnetic fields.

Magnetism also has wide-ranging practical applications. In the clean energy sector, magnets enable turbines to convert flowing wind and water into electricity and are critical to the functioning of electric car motors. As for information technology, the vast majority of the world's information is stored in magnetic grains on hard disks, and the advent of these materials that are capable of storing data at a stable scale and recalling it efficiently has brought about the information age. In biomedicine, magnetic nanoparticles (MNPs) are used for targeted drug delivery, as contrast agents for magnetic resonance imaging (MRI), and even to target tumors for cancer therapy. In metrology, two-dimensional electronic gases in a magnetic field are used to define the practical standard for electrical resistance by means of quantized Hall effect resistance plateaus, precise to one part in a billion.

Magnetism researchers themselves are as diverse as this array of topics – pursuing theoretical, experimental, and applied work and spanning academia, industry, and national labs.

A point of pride for GMAG is its large presence at the APS March Meeting. Typically, the group sponsors eight focus topics and co-sponsors three. GMAG's 2021 lineup includes sessions such as Magnetic Nanostructures: Materials and Phenomena, Spin Transport and Magnetization Dynamics in Metals-Based Systems, Spin-Dependent Phenomena in Semiconductors, and Magnetism in Biomedicine. APS has announced that the 2021 March Meeting will be virtual (see the meeting website at march.aps.org).



Magnetism plays a role in many areas of physics. This image from the cover of *Physical Review Letters* shows a graphene nanoribbon in which doping by boron creates a net magnetic moment. IMAGE: N. FRIEDRICH ET AL. PHYS. REV. LETT. **125**, 146801 (2020).

As a testament to the enthusiasm of this topical group, GMAG chair-elect Julie Borchers (NIST) pointed out that GMAG-organized sessions drew approximately 8% of all submitted abstracts at the 2020 and 2019 March Meetings—certainly impressive for a unit of its comparatively modest size.

According to Jaime, the impact of magnetism at the APS meetings could be viewed as being even

GMAG CONTINUED ON PAGE 6

EDUCATION

STEP UP Social Hours

BY LEAH POFFENBERGER

STEP UP is a national community of physics teachers, researchers, and professional societies with the mission of empowering educators, creating cultural change, and inspiring young women to pursue physics in college. Starting in April, in response to the COVID-19 pandemic, STEP UP began an effort to help connect its nearly 2400 members through virtual social hours. While most of the events offered opportunities to discuss topics like distance learning strategies or the STEP UP project, six of the social hours featured distinguished guests—including four Nobel Laureates.

The STEP UP Social Hours were all informal gatherings, even those featuring prominent special guests, giving attendees a unique space to connect with each other and big names in physics. Jocelyn Bell Burnell, Donna Strickland, Carl Wieman, Jim Gates, Bill Philips, and Barry Barish each joined a social hour to discuss anything from how to inspire physics students to favorite hobbies.

"It was fun to connect with our distinguished guests over Zoom in this way because they have great stories and info to share with the people who come to our social hours, but they're also just people with hobbies and ideas," says Anne Kornahrens, STEP UP project manager. "All of these social hours have been great in part because of these amazing people who have spent an hour with us."

STEP UP Social Hours were originally conceived to reach physics teachers, who can feel isolated during the pandemic, but the events quickly grew to include other members of the STEP UP community.

"Our goal at the beginning was: COVID is happening, our community is isolated, we have the capacity to get everyone together on Zoom. Let's make an event for teachers," says Kornahrens. "We've had some good attendance by teachers, but the STEP UP community also has a lot of faculty, undergrad students, other educational specialists...We now have a gathering to bring the community together."

The Social Hours began as a purely social gathering, but in order to create a valuable experience for attendees, the events expanded to topical discussions, virtual events like tours of the National High Magnetic Field Lab, and special events with distinguished physicists. With special guests like Bell Burnell, Gates, and Strickland, event attendees had opportunities to ask questions, share experiences, and just chat. "There were always moments where you would see smiles on peoples' faces, realizing that this speaker is a nerd or has unique passions, just like me," says Kornahrens.

Physics teacher Sara LeMar (North Shore Schools) shared her experience of attending a social hour and getting to chat with Strickland.

"To meet someone at the top of their field is an incredible experience and this social hour was no exception. The open question format made the virtual experience more comfortable," says LeMar. "Not only did I walk away with an understanding of Dr. Strickland's research, but also a clearer perspective of the path she followed throughout her career. Her transparency made the conversation authentic and I hope to share her story with my students. While her accomplishments in the physics world are impressive, Dr. Strickland's journey to her success was really the takeaway from this meeting. I hope to attend more

STEP UP CONTINUED ON PAGE 5

CAREERS

Emails Help Members "Shape Up" Their Career Goals

BY LEAH POFFENBERGER

The APS Careers team has been hard at work, supplying students and early career members with resources aimed at exploring options and opportunities for physics careers. Following a successful and extremely popular Summer Webinar Series, two new webinar series are running this fall, titled "Success in Industry Careers" and "Physics Career Exploration." In addition to webinars, APS Careers is launching the Shape Up email series—a brand-new tool to help early career members meet their goals.

The Shape Up email series, which launched at the end of October, allows members to opt in for a guided six- to eight-week "challenge" designed to help with achieving career goals. Participants will receive a weekly email with a short task to complete, breaking up big career goals into small, surmountable steps. Currently, there are five topics to choose from: Boost My Grad School Application, Shape Up My Career Exploration, Shape Up My Job Search, Shape Up for the Interview Process, and Shape Up My Professional Image.

"We have so many great career resources, but a lot of people might not know they exist. Shape Up came about to give people better access to these resources," says Midhat Farooq, APS Careers Program Manager. "Our goal in APS Careers is to help guide students and early career physicists through their career journey. Shape Up is a way of accomplishing this by tailoring each series topic to meet a specific audience goal."

This summer, the Career Shape Up email series underwent a soft-launch alongside the Summer Webinar Series, featuring three topics: Boost My Grad School Application, Shape Up My Career Exploration, and Shape Up My Job Search.

"We decided on these specific topics based on conversations with students and early career members, and a survey conducted by Farah Dawood, APS Chapters Program Manager, that was conducted to guide the Chapters program (see article on p. 1) as well as the Summer Webinar Series," says Farooq. "Additionally, some of the topics that are being launched, including ideas for future topics, came directly from feedback given by attendees of the Summer Webinar series—people told us what webinars they want to see, which gave us a better idea of our audience's career goals."

While the soft-launch was aimed at undergraduate students applying to graduate school or seeking advice on career trajectory, the official Shape Up content will be broader, including the two new topics—interview and negotiation skills, and professional image—that appeal to members further along in their careers as well as undergraduates. Anyone can sign up for multiple Shape Up emails if they'd like, though APS Careers recommends doing one challenge at a time.

"As a Shape Up recipient, you can choose your career goal and based on that goal we will send you five to six emails that will be regular challenges or tasks: did you continue searching for grad schools this week, have you worked on your resume recently, have you applied to more jobs this week?" says Farooq. "It's a month to a month and a half commitment—the idea is to have a short-term challenge that's both helpful and also easy to complete, like a seven-day health challenge."

With its wealth of resources for job seekers, APS Careers is employing the Shape Up emails to get the relevant and timely information to those looking to meet specific goals.

"APS Careers is focusing on audience needs—right now we have a lot of career resources, and we're working to get these to our different audiences," says Farooq. "This is what we're doing for webinars as well—we have launched a new series on Physics Career Exploration and one on Success in Industry Careers, both aiming to meet specific needs of our attendees."

To opt-in to Career Shape Up e-mails, visit info.aps.org/careers/shape-up. Other career resources, as well as past and current webinar series can be accessed at aps.org/careers/.

MILLER CONTINUED FROM PAGE 2

Humphries asked her how she would like a full-ride—tuition, room, and board all paid for—and an opportunity to intern in California every summer at the Lawrence Livermore National Lab as a part of the Life Gets Better scholar program.

"That sounds great, where do I sign?" Valentine Miller asked.

Valentine Miller remembers this being a unique time at FAMU because of President Humphries. He was a charismatic man who made it his mission to recruit the top merit scholars in the country. She recalls the story of how he convinced her husband's parents to allow him to go to FAMU. Humphries sat on his mother's couch and talked his parents out of sending him to Florida State University.

"They just kind of want him, we really want him," President Johnson said.

Valentine Miller recalls that when she got to FAMU she wasn't the only Black physics major. Even at her internship at Livermore in California, she was surrounded by students from various Historically Black Colleges and Universities (HBCUs). "Usually it's like I'm the only physics major," Valentine Miller said.

Valentine Miller said that at FAMU there were so many tech majors that you didn't feel like it was weird to be in science. She also noted that you didn't get a big head about being a physics major. "It was very normal to be about your science and your business," she said.

Graduate school trials and triumphs

After completing her program at FAMU, Valentine Miller attended Brown University for graduate studies. She was advised to continue her studies at Vanderbilt University, but she was set on going to Brown because it was a top Ivy League research institution.

"The social aspect was a bit of a challenge for me, but I did ok in my classes," Valentine Miller said.

In the end, Valentine Miller was unable to pass her qualifying exam, which meant that she could not advance to PhD candidacy. Valentine's research advisor, James Valles, assured her that she could be a great scientist and that he would write her a letter of recommendation.

For this next move, Valentine Miller would be more careful about where she would attend. According to Valentine Miller, she realized she did not want to live in a cold place that lacked diversity and she wanted to be near a national airport.

Her search to find the right university brought her to the National Society of Black Physicists. Valentine Miller had a plan to go to recruiting tables for schools that wanted Black students. With her resume printed on high-quality paper, she told each table that she did not pass her graduate qualifying exam and that her advisor would write her a letter of recommendation.

"The students at the Hopkins recruiting table were so energetic and happy, they didn't seem like miserable grad students at all," Valentine Miller said.

She remembered that the professor at the table told her that if she sent him her letters of recommendation, he would make sure that they were reviewed. Valentine Miller found Hopkins to be a better fit for her. Valentine Miller also noted that being near Morgan State University gave her additional support.

"Grad school is hard no matter where you go, but it was a better fit for me," Valentine said.

In 2006, Valentine successfully defended her dissertation "Spin Polarization Measurements of Rare Earth Thin Films." Her research journey included sleeping near the lab and working sixteen-hour days. "The work ethic is different, and it's much more intense," Valentine Miller said.

When it comes to the current generation of scientists, Valentine Miller is encouraged by the young Black scientists who are making waves. She is excited about what she sees on Twitter about young Black scientists.

"I look forward to the day when we won't need to amplify these accomplishments," Valentine Miller said.

African American Women in Physics

Valentine Miller is currently working as a patent examiner at The United States Patent and Trademark Office and founded aawip.com, a website that features African American women in physics.

Valentine Miller created the website in 2005 while she was conducting her graduate studies at Johns Hopkins. According to Valentine Miller, the site came into being during a time when she felt isolated in her department.

The goal of the website is to honor the women who paved the way to inspire future physicists and connect with allies interested in promoting diversity in physics and other STEM fields.

According to Valentine Miller, the website has opened a new side career of studying African American Women in Physics.

The website currently features over 100 women starting from 1940 to current graduate students. The list begins with Katherine Johnson, who was portrayed by Taraji P. Henson in the 2016 film "Hidden Figures." This year Jami Valentine Miller plans on celebrating 100 Black women with PhDs in Physics on the website.

The author is currently studying Strategic Communication at Morgan State University. To date, he has created pieces for the Online News Association, the Baltimore Times, *and The Society of Professional Journalists. After graduation, he plans to work in the field of public relations as data analyst and content creator.*

GOVERNMENT AFFAIRS

Supporting Early-Career Physicists Through COVID-19

BY TAWANDA W. JOHNSON

APS strongly supports bipartisan legislation recently introduced by members of the House Science Committee to enable early-career researchers to strengthen their skills and maintain continuity in their careers as they grapple with obstacles due to the COVID-19 health crisis.

Co-sponsored by both Democrats and Republicans, the Supporting Early-Career Researchers Act calls for the director of the National Science Foundation to establish a two-year pilot program to award grants to highly qualified, early-career investigators to carry out independent research.

In a letter to House Science Committee Chair Eddie Bernice Johnson (D-TX) outlining the Society's support for the legislation, APS President Phil Bucksbaum wrote, "The severe financial stress in our universities means that new opportunities in academia are not likely to return to pre-pandemic levels for some time. It is essential that we maintain our capacity to prepare new members of our R&D workforce for a broad set of career options, including research positions outside of academia. By providing recent PhD graduates and postdocs opportunities to further develop their independent research skills, they will become more competitive candidates regardless of career choice and even stronger contributors to our nation's research enterprise."

Bucksbaum's letter offered two suggestions to the bill for clarity and to broaden its impact:

- clearly define the groups eligible for the award and distinguish it from the current NSF Faculty Early Career Development Program (CAREER), which supports researchers who already hold career positions in academia; and,
- allow the awardees to partner, as appropriate, with research labs located outside of an institution of higher education. These partnerships would broaden the program's reach and allow for all sectors of the US R&D enterprise to participate.

Supporters of the bill also acknowledge that it would make awardees better scientists as they are afforded more opportunities to conduct independent research, allowing them to improve or augment their research skills. Additionally, the researchers will continue to hone their qualitative and communication skills, among many others, that will make them more prepared and competitive, whether they go on to work in academia, industry, or a national laboratory.

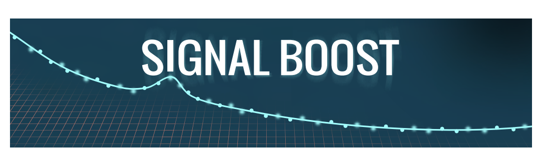
"The COVID-19 global pandemic has presented unique challenges for early-career scientists due to its health and economic impacts. For a research scientist working for academia, a national laboratory,

Ben Ueland

or industry, their investigations and collaborations immediately after obtaining their degree distinguish them from their advisor and sets their course for advancement," said Ben Ueland, Associate Scientist at Ames Laboratory and chair of the APS Forum for Early Career Scientists. "Passage of the bipartisan Supporting Early-Career Researchers Act would go far in assisting early-career scientists in preparing them for success in their careers during a difficult time in our nation and ensuring that the United States stays at the forefront of scientific and technological advancement."

Added Dan Pisano, APS Director of Industrial Engagement, about the legislation: "This bill is critical to avoid a break in the US pipeline of

EARLY-CAREER CONTINUED ON PAGE 7



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.**

FYI: SCIENCE POLICY NEWS FROM AIP

US Builds Out Architecture of National Quantum Initiative

BY MITCH AMBROSE

The US Department of Energy (DOE) and National Science Foundation (NSF) established an array of research centers this summer focused on complementary facets of quantum information science (QIS), fulfilling a centerpiece of the National Quantum Initiative Act. Enacted in late 2018, the law reflects the view that concentrations of multidisciplinary teams are needed to accelerate development of sensors, computers, and communication methods that capitalize on the subtle quantum behaviors of matter at the atomic scale.

DOE announced in August it is funding five QIS centers at $115 million each over five years. Each is led by a DOE national lab and together have attracted participation from dozens of universities and companies, which have committed an additional $340 million in total.

Over the same period, NSF's Quantum Leap Challenge Institutes program is splitting $75 million evenly across three centers led by the University of Colorado Boulder, University of Illinois at Urbana-Champaign, and University of California, Berkeley. NSF also is awarding $26 million over five years through its Engineering Research Centers program to establish a Center for Quantum Networks at the University of Arizona.

One of the DOE centers, Q-NEXT, led by Argonne National Lab in Illinois, will establish two "national foundries" for standardized quantum materials and devices in partnership with SLAC National Accelerator Lab in California. In an interview, Q-NEXT Director David Awschalom said the national labs are a natural place to host such capabilities.

"You need exquisite characterization techniques to know your materials are pristine, because we're talking about building an atom-scale technology. You need synchrotrons to do atomic scale imaging and look at electronic structure. You might need massive computational facilities to calculate the electronic band structure for a particular design," Awschalom said. "The national labs in the US are often the stewards of these technologies."

Another focus of Q-NEXT is to create quantum communication links, which have unique security advantages and could be used to create networks of quantum sensors and computers. Argonne has already established a 52-mile quantum link with the University of Chicago using an existing fiber optic cable, with plans to connect to nearby Fermilab next year. But longer terrestrial links will require an as-yet uninvented device known as a quantum repeater to boost the signal along the way.

DOE announced this summer it plans to eventually connect all 17 of its national laboratories as nodes in a national "quantum internet." University of Oregon physicist Michael Raymer, who is a part of NSF's Center for Quantum

INITIATIVE CONTINUED ON PAGE 7

STEP UP CONTINUED FROM PAGE 3

STEP UP social hours in the future because the community they are building is so important."

According to Kornahrens, as the school year has been picking up, STEP UP Social Hours will be less frequent, but virtual events are still in the works. One future activity will be to train STEP UP teachers virtually in the lessons included in the STEP UP program designed to inspire high school students, especially high school girls, to pursue physics in college.

"We would be open to continue connecting prominent figures to physics teachers, and we're open to ideas on how to make this happen," says Kornahrens. "The other big thing we want to offer is to bring physics teachers together to learn about and take the STEP UP lessons—we want to be supportive and meet the community members where they are, but at the same time we know getting the STEP UP lessons into their hands and inspiring and connecting students is what matters."

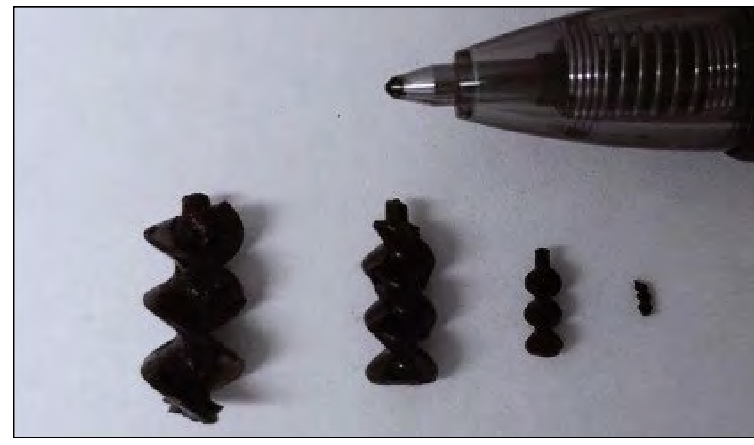
STEP UP is sponsored by the National Science Foundation, the STEM Transformation Institute at Florida International University, the American Association of Physics Teachers, Texas A&M Commerce, and APS. For more information, visit the STEP UP community on APS Engage at engage.aps.org/stepup.

MEETINGS

Small-Scale Robots Benefit Environmental and Medical Research

BY ABIGAIL EISENSTADT

Robotics research benefits many scientific disciplines: autonomous underwater vehicles gather samples from the deep seafloor, while surface rovers collect data from Mars. But smaller robots can also play important roles in research, like tracking the movements of ocean animals, monitoring microscopic changes in the body, and tracing the genetic evolution of communities.



Biohybrid micro-robots in different sizes. IMAGE: ELIZABETH HUNTER

Among the robophysics researchers who were planning to present work at the cancelled 2020 APS March Meeting, Brooke Flammang, Elizabeth Hunter, and Robert Austin are creating new technology ranging from physical robots that operate using only forces like friction to biohybrid and analog-digital robots.

Purely physical robots lack control circuits or an internal power source, making them a useful tool when studying the biomechanical evolution of unique animals like remoras. Remoras are a species of fish with an adhesive disc evolved from a dorsal fin, a structure that lets the fish attach to most sea animals, no matter how slippery their skin or how quickly they swim.

"A problem with automated design for evolution studies is that you start to introduce other things. A motor-driven system will add power to do the thing you ask it to do. A physics-driven system is only going to operate within certain physical, and therefore biological, limits. Those [can mimic] the limits in which the remora has had to evolve," said Flammang, a biologist at the New Jersey Institute of Technology.

The remora's adhesive disc has a fleshy sucker that encircles structures called lamellae, which have hundreds of tiny spinules that grab onto the host animal. However, suction alone does not explain how remora can attach to extremely fast fish like marlins, which reach speeds of 80 kilometers per hour.

By studying live remoras and using computer models of the discs, Flammang and collaborators found that friction is what helps the remoras stay attached to other fish: the spinules generate enough friction to counteract the drag force by a factor of ten.

Flammang's student, Kaelyn Gamel, tested these results with a physical robot. She created a robotic adhesive disc and attached it to four different surfaces with varying degrees of roughness. For example, one surface was smooth like dolphin skin, while another was gritty like shark skin.

"[It] shows that adhesive performance increases with lamellae, and thus spinule, number. We know that remoras evolved more lamellae over time, and these results suggest that was driven by performance-based selection," said Flammang, "We never would have been able to test this without physical robotics."

Now, she and her laboratory are combining their robots with tracking devices to help marine scientists monitor whales and other sea creatures. "This offers a huge opportunity for a new technology where we can have better long term ecological and health biomonitoring of organisms with less of a health risk incurred to them," said Flammang.

While robots driven by purely physical forces can help scientists understand biomechanical processes, so-called analog robots can help scientists learn more about biological evolution.

"Analog systems are not precise, but they are robust. They can find solutions to complex situations," said Austin, a biophysicist at Princeton University working with physics graduate student Trung V. Phan.

Austin's colleagues, led by biophysicist Liyu Liu and physics graduate student Gao Wang at Chongqing University, used analog technology to determine how a robot community behaves in a resource-limited landscape. They placed 50 silver-dollar-sized robots on a multicolored light board. The LED board was roughly the size of a stadium scoreboard and emitted colored light made from different combinations of green, blue and red. Analog cameras helped the robots sense colors and resources beneath them. Wang programmed the robots' "genotypes" to favor green, blue, or red light. For example, blue-dominant robots preferred areas on the board with high intensity blue light: since they are "genetically" sensitive to blue, they derived more "resources" from higher intensities of the color.

Austin and Liu designed the robots to be genetically selfish, meaning each robot wanted to mutate as little as possible to preserve its evolutionary fitness. Some robots had genotypes that demanded all three colors in high intensities.

If a robot stayed too long in one area, it depleted the resources in that area. The robot died, and the board dimmed. Although robots largely avoided their dying neighbors, they would sometimes

ROBOTS CONTINUED ON PAGE 6

EXPERTISE CONTINUED FROM PAGE 1

[within APS]," says Jeraj.

CRRG currently has around 130 members connecting regularly through the APS Engage networking platform. While the group promotes collaboration among different areas of physics, a broader goal is to involve disciplines outside of physics.

"The CRRG is something that started in APS, but we want to make it broader for anyone who interacts with physics, for example, engineering, computer science, operations research, modeling, and chemistry," says Jeraj. "We are reaching out to other communities as well. We hope this will also create partnerships that haven't existed yet. COVID is not a single discipline problem—physics plays a role but not the only role—so these partnerships need to happen."

CRRG also hopes to connect with physics societies outside the United States. "We see this as an initiative to link with other physics societies within Latin America, Europe, and India—we are continuing to bring the international community together. COVID is not limited to North America, but is global, so the fight and the science that contributes is global," Jeraj adds.

The first phase of CRRG activities kicked off with a webinar series, featuring the latest COVID research by leading experts. The purpose of these webinars, according to Jeraj, is to present problems that physicists have the ability to address and spark discussion among CRRG members.

"This led us to selecting Dr. Marc Lipsitch (Harvard T.H. Chan School of Public Health), for the first webinar, particularly because we wanted to have a leading epidemiologist explaining the problem in a way that physics can play a role. We wanted to have a broader, high level view of the problem and bring the physics perspective into it," says Jeraj. "For the following webinars, we've picked some of the most significant topics, ranging from modeling to understanding the evolution of viruses to understanding the transmission of viruses."

Beyond the webinars and discussion groups on APS Engage, CRRG is working on creating a comprehensive webpage with resources for COVID researchers. The group is also forming a partnership with the Johns Hopkins University Novel Coronavirus Research Compendium, lending additional expertise for literature review. Another activity CRRG is considering for the future is working with educators to create educational resources about COVID for students at a variety of levels.

As CRRG grows and takes on new activities and plans new webinars, Jeraj hopes the group's efforts will be community driven, and that the work that comes out of CRRG continues long after COVID.

"COVID [has] brought together people that didn't interact before. What we hope is that there will be a long-lasting impact with new collaborations and new partnerships that will go far beyond COVID." says Jeraj. "The community will continue [to focus] on medical and society related problems. By building this collaboration, we hope and anticipate that this will have reach well beyond the COVID-specific challenge."

To join the COVID Research and Resources Group, visit engage.aps.org. To register for future webinars, visit aps.org/membership/units/crrg.cfm.

ROBOTS CONTINUED FROM PAGE 5

accidentally brush up against them, triggering a digital exchange of genes. This revived the dead robots by changing their genotype and allowing them to gather resources from other color intensities across the board.

Although the robots have some digital components, Austin and Liu are working to transition them to pure analog. They are collaborating with oncologist Ken Pienta at Johns Hopkins Medicine to develop a robotic model for cancer cell communities. "We're hoping that we might learn more about how cancer maintains its robustness in this kind of system. I don't think you can replicate it on a computer. You really have to let it do its thing," said Austin.

A different kind of robot—a biohybrid—can expand medical professionals' ability to learn more about biological systems. These robots are very small, ranging from 'millimeters to microns in size, small enough to one day be used for medical purposes.

According to Elizabeth Hunter, a mechanical engineer at the University of Pennsylvania, there are three main challenges to developing these robots: fabricating the robot, controlling its movements and developing effective sensors to make the micro-robots smarter. "[These robots] have exciting applications, but the challenge [of] making them really lies in developing new locomotion measurement and information processing techniques and mechanisms to interconnect these components at small scales," said Hunter.

To overcome these obstacles, Hunter built helical micro-robots ranging from one millimeter to 10 millimeters in size. She combined iron oxide with nontoxic, organic hydrogels to create "cell-friendly" robots. Since iron oxide is a magnetic material, Hunter was able to use an external rotating magnetic field to drive the "corkscrew" robots through fluids with different viscosities. She also equipped the robots with biosensors by decorating their surfaces with genetically engineered E. coli. The bacteria naturally produced fluorescent green protein signals. This engineered signaling protein could be modified to respond to signals like proteins, light, or chemicals.

Currently, Hunter's team is developing new geometrical designs for her robots to test how they move across petri dishes and engineering new biosensing bacteria. "Essentially, we might be able to imagine these robots rolling across petri dishes and swimming in tubes performing automated laboratory experiments and probing different cells with high spatial and temporal resolution," said Hunter.

The author is a Communications Assistant at the Smithsonian National Museum of Natural History and a former Science Communications Intern at APS.

GMAG CONTINUED FROM PAGE 3

broader: "Magnetic properties or behavior are omnipresent in virtually all aspects of physics that take place at the March and April Meetings, often discussed in sessions devoted to correlated electron systems, superconductivity, semiconductors, optics, topological materials, and even astrophysics."

Within the March Meeting, GMAG holds an annual Business Meeting where GMAG Fellows and GMAG Student Travel Award winners are recognized and where members can network and socialize.

GMAG also makes efforts to engage younger scientists at the March Meeting, holding student-facing membership drives and networking lunches, and providing a platform for students to interact with more senior members of the GMAG community. Notably, at approximately 50%, GMAG ranks among the top APS membership units in terms of student involvement—"a healthy indicator of the status of the magnetism field," according to Beach.

Looking forward, the GMAG executive committee's goals for the topical group are two-fold: On one hand, continuing to highlight the diversity that exists within the group in terms of research; on the other hand, working to promote diversity and representation among the group's membership base.

On the former, the executive committee members underscored the success GMAG has seen to date in bringing researchers together across disciplines. "Through the years GMAG has proven to be very effective in bringing together scientists and engineers with complementary interests in magnetism and shared goals of advancing and disseminating their discoveries," explained Borchers. Added Beach, "We have a good track record of growth and a good track record of bringing students into the field and highlighting the diversity of areas where we work. My aspiration is to see that grow."

On the latter, Jaime underscored the lack of diversity in the magnetism field, explaining that there is a need in GMAG for "initiatives with special emphasis on diversity that encourage the active participation of under-represented members of the community as well as the scientist 'research-force' of the future." Indeed, GMAG's membership currently stands at just over 15% female.

Promoting the importance of magnetism research at the policy level is another major priority for the group. As Borchers put it, "My aspiration is that GMAG expands opportunities for identifying concerns and needs of the magnetism community and then communicating them to policymakers and funding agencies to secure the support and resources necessary to maintain the high level of achievement that is characteristic of this creative field."

Overall, GMAG stands out as a vibrant and enthusiastic group, promoting research and exchange of ideas at the forefront of a buzzing and interdisciplinary area of physics. More information on this unit can be found at the GMAG website at aps.org/units/gmag.

The author is a science writer based in Stockholm, Sweden.

LOCATIONS CONTINUED FROM PAGE 1

We anticipate that the set of criteria will evolve over time and be updated periodically.

Conference arrangements are organized by the APS Meetings Department, with guidance from the Committee on Scientific Meetings, explained APS Meetings Director Hunter Clemens. It is a complex process that depends on the venue capacity in a given location and the environmental sustainability of the venue. Contracts have to be finalized six or seven years in advance and cancelling a meeting can potentially involve several million dollars in penalties, depending on circumstances. And in the midst of the pandemic, even virtual meetings are very expensive.

"When we presented the committee with the Phillips and Weissman proposal, they said 'we need to do something about this right away,'" said Clemens. "We've reached out to the cities where we plan to meet in the future and asked them to respond to these concerns, and we've gotten some responses back. Each city is in a different place with regard to the criteria, but the one that impressed me the most was Denver in terms of how far along they are with each of the issues."

APS CEO Kate Kirby notes that the added criteria build upon a statement adopted by the APS Council in November 2000, in which "The Council of the American Physical Society affirms the commitment of the Society to the protection of the rights of all people, including freedom from discrimination based on race, gender, ethnic origin, religion or sexual orientation. This principle will guide the Society in the conduct of its affairs, including the selection of sites of meetings of the APS."

"The challenge is going to be how many cities have this information available," said Kirby. "And if they haven't collected these statistics, they should start now. It's a way of having these locations realize that there are economic and business implications in terms of how they respond."

Kirby also has begun communicating with other scientific societies to gather wider support. "I brought this up with a working group of science society CEOs that meets informally," she says. "The reaction was very positive, and people acknowledged that it is really important to start asking these questions so that cities and convention bureaus know that these are criteria we will be looking at."

Andrea Liu (University of Pennsylvania), Speaker of the APS Council, says that APS President-Elect S. James Gates has drawn a useful analogy between the new criteria and the Sullivan Principles, developed by Rev. Leon Sullivan, during the last years of apartheid in South Africa. "Some corporations adopted these principles to protect their employees there by using their economic leverage to put pressure on the country. That's the idea—APS brings a lot of money with these conferences and we should not invest in cities that have a problem with police violence that endangers our members."

Gardner acknowledges that some APS members may disagree with the Society taking these steps.

"There are some who might be dismayed that we take this up—that this somehow makes us political," she says. "I resist that. I think that we are a physics organization, but we function in a society. It is part of our charge and is our goal to keep our members and conference meeting attendees safe."

Additional information

APS Webinar: "From Passion to Action: Levers and Tools for Making Physics Inclusive and Equitable," aps.org/programs/minorities/webinars/passiontoaction.cfm.

APS Webinar: "Removing Barriers: Physics in HBCU, MSI, and PBI Communities," aps.org/programs/minorities/webinars/removebarriers.cfm.

P. Phillips and M. B. Weissman, "Academic societies' role in curbing police brutality," *Science* **368**, 1322 (2020); doi.org/10.1126/science.abd1932.

P. Phillips and M. B. Weissman, "A proposal for APS action on police brutality," *Physics Today* **73**, 7, 12 (2020); doi.org/10.1063/PT.3.4514.

CHAPTERS CONTINUED FROM PAGE 1

a need for a careers workshop or interest in science policy, the Chapter members can be directed to the appropriate APS resources.

"We really want to make sure that these chapters represent the different types of institutions—research intensive R1 universities, Master's granting universities, Historically Black Colleges and Universities, Hispanic Serving Institutions, and national labs" says Dawood. "Each chapter is probably going to look very different, and we want to recognize that each chapter will likely have a unique identity."

A main goal of the pilot program, which has just completed its application process, is to work with a small group of institutions and assess what resources Chapters could benefit from the most. Each Chapter that has been selected for the pilot will first elect Chapter officers this fall, and in December they will submit an activity interest form to APS, laying out what resources or events they need.

Another draw of APS Chapters beyond individualized resources is a chance for students and early career members to grow their leadership skills. A small group at one institution provides a training ground for future leaders in physics to find their voices.

"We want to provide opportunities to empower individuals. The local groups really give individuals the opportunity to rise to the occasion and rise to leadership positions," says Dawood. "The other big thing is that we want to make sure these are equitable, inclusive communities—anyone who wants to be a part of them can join. We want to support everyone, especially those from underrepresented groups."

APS Chapters are open to anyone at their respective institutions, with the only requirement being that at least five Chapter members are also members of APS. One faculty or staff advisor will also be required for each Chapter to provide a sense of continuity as new students join the Chapter and take on leadership roles. However, anyone—graduate student, post-doc, faculty, or staff member—will be able to apply to start a Chapter at their institution.

While the pilot program has just kicked off, anyone interested in starting an APS Chapter at their institution can fill out an interest form on the Chapters website (aps.org/membership/chapters.cfm) to be alerted when Chapter applications open up next fall.

"What's exciting about this program is that it is connected to many APS activities, in particular those run by the APS Membership, Career Programs, and International Affairs offices," says Dawood. "Navigating your career early on isn't easy, so we at APS want to do what we can to help and build a sense of community while supporting these individuals."

EARLY-CAREER CONTINUED FROM PAGE 4

new physics talent, especially in the more rapidly growing segments of the field, such as quantum information science, where the demand far exceeds current supply in both industry and academia."

Francis Slakey, Chief External Affairs Officer for APS, said the legislation is an excellent step toward ensuring that newly graduated physics PhDs and postdocs are ready for whatever career path they choose.

"We know that early-career researchers are confronting numerous challenges during the beginning stages of their careers right now, and this bill would help maintain the continuity needed in their careers as they pursue various job opportunities," said Slakey.

The author is Senior Press Secretary in the APS Office of Government Affairs.

INITIATIVE CONTINUED FROM PAGE 4

Networks, said in an interview that connecting the DOE labs is a daunting task, estimating it will take at least 20 years, but he expects the initiative will benefit from the collective efforts of the new QIS centers.

"There's the theoretical protocol layer. There's the building of the fiber infrastructure, assuming you have a repeater, then there's actually building a repeater. And then the other end of it is what do you connect to the internet," Raymer said. "I think the community has decided to work on all these layers in parallel [because] these are hard problems. ... That's really what these centers are all about."

Raymer was among a small group of scientists that conceived of the idea to appeal to Congress for the centers through an advocacy coalition called the National Photonics Initiative (lightourfuture.org), which was established in 2013 to support efforts that use optics and photonics as enabling technologies. "The main selling point that we all came up with was that individual researchers — whether they be in universities or in industry or even government labs — in small teams are not capable of creating quantum technology. It's too complicated," he said.

The author is Acting Director of FYI.

Published by the American Institute of Physics since 1989, FYI is a trusted source of science policy news that is read by congressional staff, federal agency heads, and leading figures in the scientific community. Sign up for free FYI emails at aip.org/fyi.

PHYSICS NOBEL CONTINUED FROM PAGE 1

in their announcement, including two papers in *Physical Review Letters* (PRL), and one in *Reviews of Modern Physics*. This marks the tenth consecutive year that a PRL article coauthored by one of the recipients has been cited in the Scientific Background of the Physics or Chemistry award.

"APS congratulates the 2020 Nobel Laureates for their outstanding contributions to astrophysics, and the understanding of our universe," said APS CEO Kate Kirby. "I sincerely hope that this award will inspire the next generation of physicists, especially young women, whom we are committed to supporting at every level."

Penrose receives half of the Nobel Prize in Physics for his use of mathematical methods to show that black holes are a direct consequence of the theory of general relativity. Albert Einstein had not believed black holes existed, but in 1965, ten years after Einstein's death, Penrose published a groundbreaking article describing black holes and their formation. Penrose showed that the theory of relativity accounts for the formation of black holes, despite containing a singularity at which the known laws of nature cease to apply. His contributions to general relativity also earned Penrose the 1971 Dannie Heineman Prize for Mathematical Physics, jointly awarded by APS and the American Institute of Physics.

Genzel and Ghez share half of the Nobel Prize for their separate but complementary efforts to study a region called Sagittarius A*, located at the center of our galaxy. "I'm thrilled that the Nobel Committee has recognized the critical importance of the work of Genzel and Ghez, which established beyond a doubt the existence of a supermassive black hole at the center of the Milky Way, and the work of Penrose with Stephen Hawking, predicting the existence of black holes," said Glennys Farrar, Professor of Physics at New York University and Chair of the APS Division of Astrophysics.

Beginning in the early 1990s, Genzel and Ghez each led groups of researchers mapping the orbits of bright stars close to the center of the galaxy. Based on their measurements, both groups found that the movement of these stars is affected by an extremely heavy, invisible object—most likely a four million solar-mass black hole. Both Genzel and Ghez have given talks at recent APS April meetings, Genzel in 2020 and Ghez in 2019, and Ghez received the Maria Goeppert-Mayer Award from APS in 1999.

"I hope I can inspire other young women into the field. It's a field that has so many pleasures, and if you are passionate about the science, there's so much that can be done," said Ghez by phone during the Nobel announcement in Stockholm.

The Nobel Prize, first awarded in 1901, is widely considered the highest honor in science, economics, and literature. The 2020 Nobel Laureates will be awarded medals separately in their home countries, and they will receive 10 million Swedish krona (just over $US 1.1 million), half of which goes to Penrose, and the other half to Genzel and Ghez. All three laureates will be honored at the 2021 Nobel Banquet owing to the cancellation of the 2020 ceremonies.

Articles Cited by the Nobel Committee

The following articles have been made free-to-read by APS:

R. Penrose, "Asymptotic Properties of Fields and Space-Times," *Phys. Rev. Lett.* **10**, 66 (1963).

R. Penrose, "Gravitational Collapse and Space-Time Singularities," *Phys. Rev. Lett.* **14**, 57 (1965).

R. Genzel, F. Eisenhauer, and S. Gillessen, "The Galactic Center massive black hole and nuclear star cluster," *Rev. Mod. Phys.* **82**, 3121(2010).

Related Articles

The following articles have been made free-to-read by APS:

T. Johannsen et al., "Testing General Relativity with the Shadow Size of Sgr A*," Phys. Rev. Lett. 116, 031101 (2016).

A. Hees et al., "Testing General Relativity with Stellar Orbits around the Supermassive Black Hole in Our Galactic Center," *Phys. Rev. Lett.* **118**, 211101 (2017).

A. Amorim et al. (GRAVITY Collaboration), "Test of the Einstein Equivalence Principle near the Galactic Center Supermassive Black Hole," *Phys. Rev. Lett.* **122**, 101102 (2019).

A. Hees et al. "Search for a Variation of the Fine Structure Constant around the Supermassive Black Hole in Our Galactic Center," *Phys. Rev. Lett.* **124**, 081101 (2020).

THE BACK PAGE

A Changing Dichotomy: The Conception of the "Macroscopic" and "Microscopic" Worlds in the History of Physics

BY ZHIXIN WANG

Note: This article is adapted from the winning entry in the third annual essay contest sponsored by the APS Forum on the History of Physics. The full essay is available at aps.org/units/fhp.

"Two kinds of intellectual activity, both equally instinctive, have played a prominent part in the progress of physical science," Jean Perrin wrote at the opening of his *Les Atomes* (1913) [1]. The tradition of induction is represented by Galileo and Carnot, who were capable of establishing physical laws through the direct observations and generalizations of experience. The inquiries guided by intuition include the works of Dalton and Boltzmann, which inspect the "hidden gears" of the empirical world and seek to "explain the complications of the visible in terms of invisible simplicity" [1]. The temporary success of one method, as Perrin opined, cannot deny the necessity of the other. Furthermore, he envisaged the day when the two approaches would merge into one—a time when individual atoms would be as visible as microorganisms.

Les Atomes, viewed by many as the manifesto for the reality of atomic hypothesis, was published at a critical point in the history of modern science. In modern vocabulary, Perrin's dichotomy between the "inductive" and "intuitive" inquiries can be rephrased as the classification of physics research according to the scale of the physical objects being studied. However, few physicists of the following generations would fully accept Perrin's criterion— visibility—as the most sensible standard to distinguish macroscopic phenomena from microscopic ones. In fact, given the progress of modern physics since the quantum revolution, one might find this borderline increasingly hard to draw.

17th Century: Visibility to the Unassisted Eye

It would not be easy for modern minds to imagine a time when the study of the basic entities of matter was not only absent in scientific practice, but as some schools of thought claimed, should even be excluded from rational thinking. In Renaissance natural philosophy, "qualities"—the Aristotelian term for the causes of properties and natural effects—is divided into the "manifest" and the "occult," depending on whether they are perceptible to human senses [2]. Magnetism, chemistry, and medicine are all "occult," which appeared to be insensible and unexplainable, as inappropriate topics for rational philosophy. Such a doctrine was challenged during the Scientific Revolution. As René Descartes asserted, mechanical explanations will be found for all "occult qualities," which are therefore within the scope of scientific reasoning [3]. Moreover, he believed all perceptible effects are essentially generated by those hidden mechanisms. Meanwhile, pioneers of experimentation demonstrated that human senses can be extended through the assistance of scientific instruments. A remarkable example is the microscope, which had a major impact on both academic research and popular culture.

The infant microscope marked the arrival of an age when miniature structures, previously invisible, could form an extended vision for the sake of scientific observation and experimentation. Those objects that are obscure to the unassisted eye but visible with optical equipment comprise the early modern conception of the "microscopic world."

Fin de siècle: The Struggle of the Atomic Hypothesis

Owing to the fast diffusion of the microscope as a gadget for research and leisure, by the late 17th century, its magnified image was deprived of the privilege of being a "new world" but absorbed into humans' natural sensation. In the meantime, the early modern period witnessed the renaissance of the ancient atomism—the belief that all matter is composed of undividable fundamental entities. Notably, Descartes, Boyle, and Newton all employed the model of "corpuscles" to explain astronomical motion, chemical reactions, and light, respectively. The reality of microscopic particles was eventually to be revealed thanks to the advances of statistical physics and electromagnetism in the second half of the 19th century. However, without direct experimental evidence, the true existence of these particles beyond a convenient hypothesis remained a matter of belief. For example, Ernst Mach, a firm positivist, would question whoever spoke to him of atoms: "Have you seen one?" [4].

Zhixin Wang

One could hardly reply with a definite "yes" before Perrin's systematic study of the Brownian motion and reliable measurements of the Avogadro number in 1907–1909 [5].

Around the same decade, various charged particles were observed and measured in cathode rays, cloud chambers, and falling drops, where particles are isolated from the bulk. Then came the prominence of reductionism in the practice of science: a complex phenomenon should be understood from the properties and configurations of its components. What was exactly opposite to the dominant philosophy before the Scientific Revolution almost became the new doctrine in the 20th century.

Considering these backgrounds, especially the struggle to validate atomic reality among fin-de-siècle physicists and chemists, Perrin's criterion to differentiate between macro- and microphysics seems fairly reasonable. But unlike its meaning at the time of Huygens and Hooke, the "visibility" of scientific atomists does not refer to the resolution of the eye, but the very limit of experimental methods. This new notion, however, was soon to be modified when the foundation of physical science was rewritten by quantum mechanics.

Mid-20th Century Afterwards: Quantumness and More

Since the turn of the 20th century, physicists have been questing for the "most fundamental" building blocks of nature. Particles more elementary than atoms were discovered by methods that followed stringent standards. Moreover, Perrin's prospect of seeing atoms under the microscope has indeed been realized. Invisibility is thus no longer the distinctive feature of the atomic world. "Microscopic" objects are thereafter not characterized primarily by their spatial scale, but through the physical laws they obey: being "microscopic" means their behavior has to be described using the formalism of quantum mechanics.

Different as it may sound from its predecessor, in practice this new criterion requires very few objects to be reclassified. For a long time, "microscopic," "atomic," and "quantum mechanical" more or less denote the same regime. However, this de facto correspondence has no solid basis: nothing in the current version of quantum theory forbids it from describing larger objects or more complicated systems.

This already came into the mind of Erwin Schrödinger as early as 1935, when he raised the "cat paradox" trying to present the absurdity of applying the quantum formalism to macroscopic things and living beings [6]. This paradox has nevertheless sparked the interest among contemporary physicists to study the quantum effects of objects much larger than atoms and molecules. In particular, certain types of solid-state device, once sufficiently isolated from the environment, possess a quantized energy-level structure and can be prepared to a state containing no more than a few excitation quanta, and even to a coherent superposition of different low-excitation states. Given the name "artificial atoms," they are the basic components of the quantum machines, whose macroscopic degrees of freedom for control and measurement are intrinsically quantum mechanical [7].

Those systems containing a large number of particles and thus "macroscopic" in spatial scale but exhibiting quantum coherence lie in the scope of mesoscopic physics, in which the "macro–micro" borderline is separated from the "classical–quantum" boundary. In these cases, the breakdown of the one-to-one correspondence between "atomic" and "quantum mechanical" forces us to rethink the essence of the old two-world dichotomy.

Why does there have to be a dichotomy? In fact, more than a century ago, Perrin already conceived the merge of the two methods of inquiry. What we have been searching for is a universal set of basic principles, a consistent way of perception, that is applicable to all physical systems regardless of their spatial size or particle number. We are halfway toward this goal: On the one hand, the grand success of quantum mechanics grants us the confidence that the theory may also work at a larger scale. On the other hand, no one has ever found a "Schrödinger's cat," namely, an everyday object in a quantum superposition of classical states that are macroscopically distinct. Further explorations in mesoscopic physics might provide more insightful solutions to this dilemma.

Conclusion

After sketching a few key episodes in the history of physics, we find the conception of the "macroscopic" and "microscopic" worlds is by no means constant over time. Instead, it has been actively reflecting our limit of experimentation, perception, and comprehension regarding the composition and behavior of matter. Besides the development in theory and philosophy, the evolution of instrumentation plays an essential role in this odyssey. Interestingly, the reality of atomic hypothesis was verified through the study of the Brownian motion of granules under the microscope, and the operation of a quantum machine is based on the precise control and measurement of natural or artificial atoms. This three-stage relay is emblematic of the scientists' growing capability of observing and manipulating the subtle structures of nature throughout the ages.

The author is a graduate student in the Department of Applied Physics and the Yale Quantum Institute at Yale University.

References

1. J. Perrin, Atoms, translated by D. Ll. Hammick from the 4th revised edition of Les Atomes (New York, D. Van Nostrand, 1916).
2. K. Hutchison, "What Happened to Occult Qualities in the Scientific Revolution?" Isis 73, 233 (1982).
3. C. Wilson, "Visual Surface and Visual Symbol: The Microscope and the Occult in Early Modern Science," Journal of the History of Ideas 49, 85 (1988).
4. S. G. Brush, "Mach and Atomism," Synthese 18, 192 (1968).
5. J. Perrin, Brownian Movement and Molecular Reality, translated by F. Soddy from the Annales de chimie et de physique, 8me series, September 1909 (London, Taylor & Francis, 1910).
6. E. Schrödinger, "Die gegenwärtige Situation in der Quantenmechanik," Naturwissenschaften 23, 807 (1935)
7. S. M. Girvin, "Circuit QED: superconducting qubits coupled to microwave photons," in Quantum Machines: Measurement and Control of Engineered Quantum Systems, Lecture Notes of the Les Houches Summer School, Session XCVI, eds. M. Devoret, B. Huard, R. Schoelkopf, and L. F. Cugliandolo (Oxford, Oxford Univ. Press, 2014), pp. 113–255.