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APS NEWS

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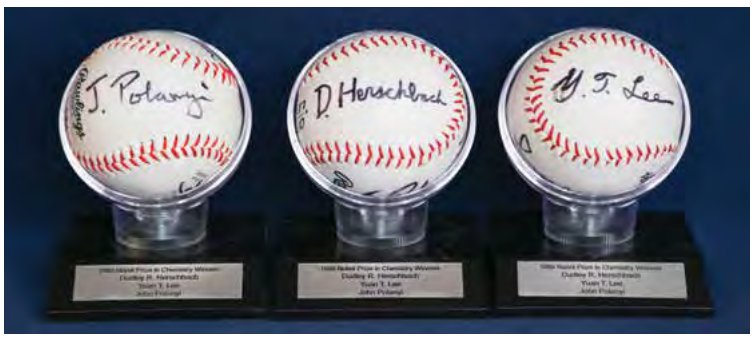
FUNDRAISING

A Novel Pitch to Donors Hits Fundraising Goal

BY DAVID VOSS

Since 2015, the APS Division of Chemical Physics (DCP) has had a doctoral dissertation award given annually to a young researcher with the best PhD thesis in the field. The name of the award was changed shortly after its inauguration to honor Justin Jankunas, a brilliant and accomplished scientist who died in a motorcycle accident. But the Division had a problem: funding for the award was mostly coming in small donations, not enough to fully endow the prize and make it self-sustaining. The solution: baseballs.

"The way this works at APS is you can start an award like this and initially pay for it out of Division funds," said David Chandler (Sandia National Laboratories), who was chair of DCP at the time. "But then you have to endow the award so that it is self-sustaining. People liked the idea, and we were confident we could raise the money, but it turned out to be a lot harder than we thought."



Generous donors to the APS Division of Chemical Physics Justin Jankunas Doctoral Dissertation Award fund receive one of these baseballs autographed by Nobel laureates. CREDIT: DAVID OSBORN

Jankunas finished his doctorate in chemistry from Stanford in 2013 and joined Sandia following postdoctoral work at the École polytechnique fédérale de Lausanne (EPFL), in Lausanne, Switzerland. His thesis advisor, Richard Zare, made an initial large contribution to the award fund.

"He was a wizard in the laboratory working indefatigably on understanding in detail the simplest of all chemical reactions, $H + D_2 \rightarrow HD + H$, " wrote Zare. "He went way beyond the call of duty to provide teaching support to a number of courses, being a teaching assistant in 10 different courses ... When he graduated he received the Linus Pauling teaching award from my Department as well as an award given to the top physical chemistry PhD."

DONORS CONTINUED ON PAGE 7

MEETINGS

Future of Physics Days Events Helps Students Connect Virtually

BY LEAH POFFENBERGER

Both the APS March and April Meetings have a tradition of hosting events designed for the Society's early career members, with offerings from undergraduate-only speaker sessions to career coaching events. Many of these events are part of Future of Physics Days (FPD), a collaboration between APS and the Society of Physics Students (SPS) to help undergraduates get the most out of their conference experience.

The virtual 2021 March and April Meetings continued the FPD tradition, holding online workshops, graduate school fairs, and networking events for students, most of whom may have been experiencing an APS meeting for the first time. With over 800 undergraduate student attendees across the March and April Meetings, FPD included events with innovative new formats to help students connect to the broader physics community.

Both meetings featured FPD activities that included special undergraduate speaker and poster sessions, grad school fairs, and career workshops. The March Meeting career workshop connected attendees with celebrated career coach Peter Fiske, who spoke on ways for students to improve their job search. The April career workshop featured APS Head of Careers Crystal Bailey, who shared her insights on topics from self-assessment to resume building.

A highlight of both meetings was a brand-new event called

FPD CONTINUED ON PAGE 5

GOVERNMENT AFFAIRS

APS Congressional Science Fellow Stephanie Mack

BY TAWANDA W. JOHNSON

Stephanie Mack's interest in science policy blossomed three years ago owing to a workshop sponsored by the American Association for the Advancement of Science (AAAS) titled "Catalyzing Advocacy in Science and Engineering (CASE)."

"Hearing issues framed within the context of science policy strongly resonated with me," she recalled. Mack longed to translate what she had learned on her college campus, but to her dismay, there was no science policy group at the University of California, Berkeley.

With three other like-minded people, she started the Science Policy Group at UC Berkeley (SPG), serving first as the group's Vice President of Campus Affairs and later its President. The group took off like wildfire, with membership growing to more than 200 during a two-year period.

Stephanie Mack

"I organized crowdfunding campaigns that raised thousands of dollars, and we sent members (of SPG) to advocate in Sacramento and DC, including through the CASE workshop," she remembered.

Her strong background in science policy will undoubtedly

MACK CONTINUED ON PAGE 5

PROGRAMS

Inside APS Programs in Careers, Diversity, Education, and Public Engagement

BY RENEE MICHELLE GOERTZEN

Among the many benefits it provides to the physics community, APS offers a wide range of programs in careers, diversity, education, and public engagement. These programs are directed by dedicated professionals, some of whom have recently taken the helm of their respective departments. So that members may better understand the work of those behind the scenes at APS, here is a brief introduction to each of the program heads.

Geraldine Cochran, Acting Head of Diversity Programs

Geraldine L. Cochran is an Assistant Professor of Professional Practice in the School of Arts and Sciences and the Department of Physics and Astronomy at Rutgers University. She is a physics education researcher and teaches large enrollment, introductory physics courses for engineering students. She supports STEM education research and outreach projects and equity and social justice efforts in physics and STEM education. She was named a Fellow of the American Physical Society for "for scholarly advocacy around equitable access that pushes the boundaries of physics education, especially for Black women and women from other minoritized and marginalized ethnicities, for advancing research on racial justice in physics education, leading to deeper understanding of structures of power."

"I am very excited about Geraldine's role as the new Acting Head of Diversity," said Monica Plisch, APS Director of Programs. "Dr. Cochran is an APS Fellow who brings considerable expertise to the department, including as a former chair of the Committee on Minorities, a leader with the Inclusive Graduate Education Network (IGEN) project, a physics education researcher specializing in equity, diversity, and inclusion, and a mentor to many students at Rutgers, to name a few relevant accomplishments. She will help us define the new role of Head of Diversity in the Programs department and recruit for the permanent position. As our diversity programs have expanded over the past few years, it is critical to bring expert leadership to this important program area."

Michael Wittmann, Head of Education Programs

Michael Wittmann will be taking a leave of absence from his position as a Professor of Physics at the University of Maine, where he has been since 2001. He received his bachelor's degree in physics from Duke University in 1993 and his MS and PhD from the University of Maryland, specializing in physics education research. Wittmann has served as the editor of the Physics Education Research Section of the *American Journal of Physics* and was first chair of the PER Leadership and Organizing Council, the decision-making body for the PER Topical Group in the American Association of Physics Teachers.

In the area of teacher development and professional learning, he is a founding member of the Maine Center for Research in STEM Education, where he helped design the Master of Science in Teaching program.

"Michael brings a high level of expertise in physics education to the new role of Head of Education as a national leader in the physics education research community, a full professor and former department chair," said Plisch. "Dr. Wittmann is an APS Fellow who led a professional development project for physical science teachers across the state of Maine, co-founded the biannual conference Foundations and Frontiers of Physics Education Research, and developed tutorials for use in mechanics and quantum physics courses."

Claudia Fracchiolla, Head of Public Engagement

Claudia Fracchiolla is a Venezuelan native and Physics

PROGRAMS CONTINUED ON PAGE 6

OBITUARY

Joseph Serene 1947 - 2021

BY DAVID VOSS

Joseph Serene, 74, Professor Emeritus of Physics at Georgetown University and former Treasurer/Publisher of APS, passed away on May 1, 2021 in Park Ridge, Illinois. He was an APS Fellow, a Fellow of the American Association for the Advancement of Science, and recipient of the President's Medal of Georgetown University in 2001.

"I was on the Search Committee that recommended Joe's appointment as APS Treasurer/Publisher in 2003," said Kate Kirby, former Chief Executive Officer of APS. "Little did I realize then that I would have the pleasure of working closely with him six years later when I was appointed APS Executive Officer in 2009. Joe was a brilliant physicist, a warm and kind individual; he contributed significantly to the financial stability and well-being of APS during his time as Treasurer/Publisher. When Joe left APS in 2014, he was greatly looking forward to teaching physics once again at Georgetown. Our physics community has lost a wonderful colleague."

Joseph W. Serene was born on April 4, 1947, in Indiana, PA. He received an AB degree in physics in 1969 from Dartmouth College and a PhD in 1974 from Cornell University, where his thesis was on the physics of superfluid helium. Following his PhD work, Serene was a postdoctoral fellow at Stanford University, a NORDITA Guest Professor at Helsinki University of Technology (now Aalto University), assistant professor at Stony Brook University, and assistant and associate professor at Yale University.

In 1984 Serene moved to Washington, DC, where he held positions at the National Science Foundation (1984-1987) and Naval Research Laboratory (1987-1993). In 1993 Serene joined Georgetown University as Professor and Chair of the Department of Physics. He subsequently served as Dean of the Graduate School of Arts and Sciences, as a member of the interim Executive of the Georgetown

Joseph Serene

Medical Center, and as Acting Director of Music and Dance. He was named the inaugural holder of the Davis Family Distinguished Professorship in 2004.

In 2006 Serene became the Treasurer/Publisher of APS, where his responsibilities included managing the operating budget, an endowment of $130M, and APS policies on subscription, open access, and copyright for eleven journals. In 2014 he returned to teaching and research at Georgetown, as the Davis Family Distinguished Professor Emeritus.

"Although Joe was soft spoken, he was deep in his convictions and articulate in his expression of them," said Gene Sprouse, APS Editor in Chief Emeritus and Distinguished Professor of Physics, Emeritus, Stony Brook University. "As Treasurer/Publisher of APS, he carried this dual role with distinction. Joe worked hard on the fundamental problem of making the journals sustainable but open, and he was one of the founders of CHORUS, an initiative that is dedicated to doing this. One of the ideas of which Joe was most proud, and rightly so, was making the APS journals FREE to any PUBLIC library, an initiative that helps support the great institution of public libraries and aligns perfectly with APS's goal of "advancing and diffusing the knowledge of physics. Joe Serene was a wonderful colleague and teacher, thoughtful and patient, and he will be missed."

MEMBERSHIP UNITS

The APS Forum on Graduate Student Affairs

BY ABIGAIL DOVE

The APS Forum on Graduate Student Affairs (FGSA) empowers and provides support to graduate students in the physics community. This support spans from the professional—including networking opportunities, career advice, and funding for conference travel—to the practical, including advocacy around research funding as well as issues of travel and immigration for international students, who make up about 45% of all physics students in the US.

Established in 2001 as a platform for physics graduate students to get more involved with APS and the wider physics community, FGSA now boasts nearly 5,000 members, making it one of the largest forums at APS. This underscores the appetite for this kind of networking and support among graduate students embarking on the next phase of their professional lives.

FGSA is led entirely by graduate students and recent graduates, all of whom were graduate students when they joined the executive committee. The current chair is Delilah Gates, a recent PhD PhD graduate of Harvard University. This spring she defended her thesis on spinning black holes and gravity—specifically the analytic characterization of observational signatures of Kerr black holes using the presence of critical null geodesics and the emergent conformal symmetry of the near horizon region of near extremal black holes.

"In general, graduate students' biggest needs relate to resources for professional development. A major aspect of this is the ability to attend conferences and meetings where you can network, meet colleagues and potential collaborators, and get exposure to new ideas," Gates explained.

To this end, FGSA offers several travel awards to facilitate conference attendance among FGSA members. The FGSA Travel Award for Excellence in Graduate Research recognizes graduate students who have made "noteworthy progress" in their academic careers, providing funds to pay for conference registration fees. (In the COVID-19 era this award is specifically reserved for students attending the March and April Meetings.) Additionally, the newer FGSA Underrepresented Minority Student Award covers the full conference registration fee for 10 students attending the March Meeting and 10 students attending the April Meeting who are members of groups typically underrepresented in the physics community compared to the population at large.

Beyond facilitating students' ability to attend the annual March and April Meetings, FGSA plays an active role in developing the programming at these events, typically hosting at least one session per meeting. This year's lineup included a career development-focused session on the post-doc experi-

Delilah Gates

ence at the March Meeting and a session on data analysis in astrophysics at the April Meeting. FGSA also regularly hosts networking sessions—including virtual ones during the COVID-19 pandemic—to facilitate interactions between graduate students and provide an opportunity for them to learn more about FGSA, its resources, and opportunities to get involved in its governance.

In addition to professional development in the context of conferences and scientific meetings, FGSA is also very invested in supporting graduate students as they transition onto the next phase of their careers. "We work closely with and levy the resources of APS Careers in order to make our members aware of different job opportuni-

FGSA CONTINUED ON PAGE 5

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Editor. . . . . David Voss
Staff Science Writer. . . . . Leah Poffenberger
Contributing Correspondents . . . . . Sophia Chen and Alaina G. Levine
Design and Production . . . . . Meghan White

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PROFILES IN VERSATILITY

From Physics to the Circus

BY ALAINA G. LEVINE

Julia Ruth studied physics and Antarctic and Arctic sea ice. She has expertise in programming and science education. And today, she is flourishing, as she spins gracefully through her career as a circus performer.

Ruth's signature performance apparatus is the "cyr" wheel, an aluminum or steel wheel large enough for her to stand inside and grasp the edges. With seven years of performance experience, she is able to balance, gyroscopically spin, move, and dance with the wheel to the amazement of her audiences, who marvel at her fluid movements. She laughs, because it's her background that has allowed her to be successful in this unconventional career. "I gravitated towards the cyr wheel because it was a clear example of forces and motion and acceleration," she says. "It represents physics."

Julia Ruth

Her circuitous route towards a joyful career began when the family lived in Germany for a year while she was in ninth grade. She had to take a physics course, and even though her German was far from fluent, something clicked. "That's how I knew I loved physics," she says. "I wasn't frustrated by the language barrier and still enjoyed it. I knew I wanted to do more of it." She spent the rest of her education at a STEM magnet school in Maryland and matriculated to the University of Maryland (UMD) as a physics major in 2010, because "if I have to spend four years specializing in one subject [in] college, I'd better study something I like."

Her university experience was prolific: she conducted research on dark matter, wrote code for LIGO, and interned at NASA Goddard Space Flight Center, where she contributed software to analyze Antarctic ice sheet radar data. She also pursued a project on Arctic sea ice change at the NOAA Center for Weather and Climate Prediction. Her analysis of laser altimetry data was part of the prelaunch activities for NASA's ICESat-2 and was published in the *Annals of Glaciology*.

While Ruth was studying the

CIRCUS CONTINUED ON PAGE 7

INDUSTRIAL ENGAGEMENT

APS Plays Leading Role in Growth of Quantum Information Science

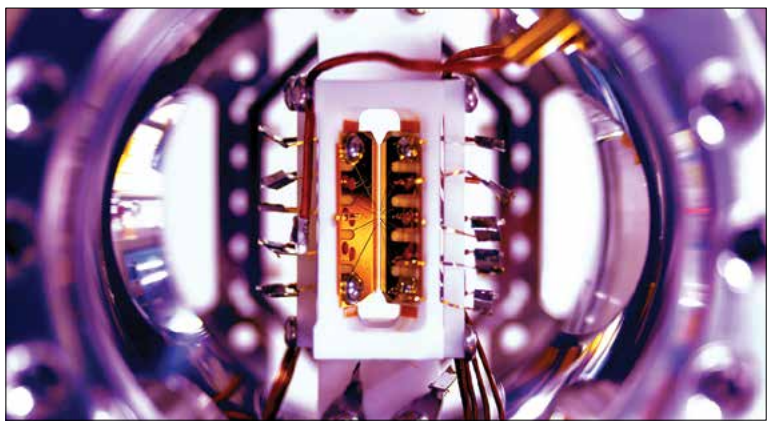
BY TAWANDA W. JOHNSON

APS is a leader in the growth of quantum information science (QIS) by helping found the Quantum Economic Development Consortium (QED-C), supporting the National Quantum Initiative Act (NQI), and in the launching of the APS Division of Quantum Information.

The QED-C is a consortium that aims to enable and grow the US quantum industry. QED-C was established with support from the National Institute of Standards and Technology (NIST) as part of the federal strategy for advancing quantum information science and as called for by the National Quantum Initiative Act enacted in 2018.

"We believe that quantum science is first and foremost a physics phenomenon, and physicists continue to play an important role in the development of quantum systems," said Dan Pisano, Director of Industrial Engagement at APS, who pointed out that the Society is active on the QED-C's Workforce Technical Advisory Committee, which develops strategies to get more physicists involved in quantum information science careers.

Although PhD physicists are in high demand in the QIS field, students with bachelor's degrees are also highly sought after by employers. In multiyear surveys carried out by QED-C's Workforce Technical Advisory Committee,



Quantum devices such as this ion trap developed by the Joint Quantum Institute (a partnership between NIST and the University of Maryland) will be the building blocks of quantum computing in the future. CREDIT: NIST

companies have reported that they need physicists with both bachelor's and master's degrees to build and test development systems. Furthermore, this work is hands-on and best performed by experimental physicists who are comfortable around hardware.

Despite the desire for more physicists to enter the field, employers have struggled to fill positions, mainly because candidates sometimes lack the specialized knowledge necessary to be successful in those positions.

Matthew Versaggi, Senior Director of Artificial Intelligence and Distinguished Engineer at Optum Technology at UnitedHealth Group, who has conducted specialized training courses to help scientists gain the skills needed for QIS careers, said industry needs to boost the levels of competence for employees.

"I absolutely believe that industry will have to train [the workforce because academic institutions will not be] fast enough, nimble enough, cost effective enough, aligned to the proper training timeframes for true capability building, or have the right organizational motivations to produce students to be productive at the time they are hired," said Versaggi.

To prepare PhD students and early career physicists for QIS careers, QED-C is doing its part

QUANTUM CONTINUED ON PAGE 4

MEETINGS

Unraveling the Possibilities of Knitted Materials

BY SOPHIA CHEN

Any knitter knows the vast design potential of a single ball of yarn. By using different knitting techniques, that single long strand can be transformed into a scarf, a sweater, a sock, or any number of other shapes. Researchers want to harness knitting's versatility and incorporate it into new technologies such as soft robotics and wearable electronics. In a session at the 2021 APS March Meeting, researchers shared prototypes, simulations, and theoretical models of knitted objects for investigating the potential role of knitting in technology.

While knitting is an ancient craft, some researchers today are viewing it through a new lens: as a computer algorithm. A knitter follows a prewritten protocol, or pattern, to create a 2D or 3D shape with the desired aesthetic or function. The pattern acts as an algorithm, determining the knitted object's geometry and elasticity.

Building on the idea of patterns-as-algorithms, researchers are using computer code to operate knitting machines. "It's a lot more programming than I ever expected," says Vanessa Sanchez of Harvard University, a fourth-year graduate student who studies textile materials for soft robotics. For her experiments, she uses a knitting machine language called Knitout developed by Carnegie Mellon University.

Knitting could be a useful technique for creating wearable electronics, such as those made of conducting material woven into yarn. Its design advantages are similar to those of 3D printing, in that knitting machines additively create fabrics of composite materials, says Sanchez. Beyond clothing, knitting could also become useful for constructing buildings. In 2018, architecture researchers created a knitted 3D frame that could support 5 tons of concrete.

Knitted fabric has many design advantages over regular fabric. In particular, it can produce a 3D shape without cutting and sewing fabric, eliminating complicated manufacturing steps, thus decreasing the risk of errors. Knitting keeps manufacturing simple, says Sanchez.

Sanchez develops knitted materials for making soft robots, such as clothing that contains a motion-tracking sensor to aid people with mobility impairments. "I want to make garments that help people," says Sanchez.

At the March Meeting, Sanchez presented a sleeve made of knitted yarn, fitted around an inflatable balloon-like pouch, that bends in a desired direction when the balloon inflates. This sleeve could function as an actuator within an assistive

KNITTING CONTINUED ON PAGE 6

MEETINGS

2021 APS April Meeting Featured Nobel Winners in Physics

BY LEAH POFFENBERGER

On October 6, 2020, the Royal Swedish Academy announced the award of the 2020 Nobel Prize in Physics to Roger Penrose (University of Oxford), Reinhard Genzel (Max Planck Institute for Extraterrestrial Physics), and Andrea Ghez (University of California, Los Angeles). Six months later, all three Nobel laureates kicked off the 2021 April Meeting as speakers at the Kavli Foundation Plenary Nobel Prize Session. As the first talks, the session set the tone for the rest of the meeting, celebrating exceptional physics in the theme of "quarks to cosmos."

Genzel and Ghez shared one half of the Nobel Prize for their discovery of a supermassive, compact object—likely a black hole—at the center of our galaxy. In their talks at the plenary session, each of them presented their separate but complementary journeys towards unlocking the secrets at the center of the galaxy. Penrose, who was awarded one half of the Nobel Prize for his discovery that black hole formation is a prediction of general relativity, spoke on his 1965 paper in *Physical Review Letters* that presented his theory, as well as new lessons that may be learned from black holes.

To start the session, Genzel began by discussing the background of the search for black holes, stretching back 100 years

Andrea Ghez

Reinhard Genzel

Roger Penrose

to the first presentation of the theory of general relativity, before describing his own 40-year journey to detecting the likely presence of one at the center of our own galaxy. Early work in infrared imaging of ionized gasses indicated a central object might exist, but with the development of new technologies, Genzel was able to peer closer to the galactic center. By tracing the orbit of a star called S2 over 16 years, from May 2002 to May 2018, and observing behavior consistent with the effects of general relativity, Genzel collected strong evidence for the presence of a supermassive object—most likely a black hole.

Ghez then offered her perspective on the discovery, detailing the technological advances that made it possible, and discussing the questions that remain unanswered about black holes, gravity, and the evolution of galaxies. Development of adaptive optics, which enable telescopes to overcome the blurring effect of the atmosphere, allowed both Ghez and Genzel's groups to track the orbit of S2 and come to complimentary conclusions. The data that can now be collected about the center of the galaxy has solved the initial mystery of what is found there. But according to Ghez, it also raises many other interesting questions, such as behavior of gravity near supermassive black holes and the unexpected presence of young stars in regions surrounding the black hole.

To close the session, Penrose offered a look into his theoretical work on black holes, from his 1965 PRL paper, to some of his newer contributions towards understanding the Big Bang. According to Penrose, his early model of space-time that suggested how something like a black hole might form was met with skepticism. Now that a number of his predictions regarding the formation of black

NOBEL CONTINUED ON PAGE 4

NOBEL CONTINUED FROM PAGE 3

holes have shown to be true, Penrose has turned to using black holes as a means of peering into the past. Penrose discussed his hypothesis that a universe existed before our own, with Planck satellite data collecting signals that appear to be of gravitational waves emitted by black holes colliding in a previous aeon.

The Kavli Foundation Nobel Prize Plenary was made possible in part by the Kavli Foundation, which supports the advancement of science and the increase of public understanding and support for scientists and their work. Each of the talks from this plenary are available on the APS Physics YouTube page: youtube.com/c/apsphysics.

QUANTUM CONTINUED FROM PAGE 3

by hosting three types of events: student research ePoster sessions, webinars, and regular Technical Advisory Committee meetings.

"These sessions will continue, and we hope to see increased participation from [historically Black colleges and universities and Hispanic-serving institutions]," said Dan-Adrian German, Acting Organizing Manager at the Indiana University Quantum Science and Engineering Center. "Connecting industry with talent will remain one of our priorities."

German added, "We have a webinar on July 13 that will bring together students (both at the undergraduate and graduate level) and postdocs with human resource representatives from a wide variety of industrial partners. We've started a collaboration with various quantum companies, and our webinar on June 8 titled 'How to Succeed at Jobs That Don't Exist Yet,' will feature quantum science expert Chris Bishop."

APS's leadership in QIS also extends to the NQI Act. Through APS's annual Congressional Visits Day in 2018, with support from APS Government Affairs, APS members met with congressional staff to advocate for a multi-agency QIS initiative. Ultimately, Congress put forward bipartisan legislation—the NQI Act—which among other things, calls for the National Science Foundation "to carry out a basic research and education program on quantum information science and engineering, and award grants for the establishment of Multidisciplinary Centers for Quantum Research and Education." APS Government Affairs remains actively involved in the appropriation process for NSF, DOE Office of Science, and NIST—all of which fund research in QIS.

There is great potential in the field, and APS members recognize it. According to a *Harvard Business Review* article, quantum information science is expected to be a multibillion dollar industry by 2030. Moreover, the APS Division of Quantum Information has seen the number of members in its unit increase by 15%–20% per year. Its mission: "to promote the advancement and diffusion of knowledge concerning the physics of quantum information, computing, fundamental concepts, and foundations."

"I'm delighted that APS is playing a leadership role as a scientific society in growing the QIS field. It offers tremendous opportunities to expand research and careers for physicists whose skill set make them uniquely qualified to make a tremendous impact within this discipline," said Francis Slakey, Chief External Affairs Officer.

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

INTERNATIONAL AFFAIRS

Focus Groups with International Physicists to Help APS Better Serve Members

BY TAWANDA W. JOHNSON

APS has reached out to young physicists across the globe to better understand their interests and needs. The months-long effort began in February when APS International Affairs partnered with the APS Membership Department to host the first-ever International Young Leaders Forum (IYLF), as part of the 2021 APS Annual Leadership Meeting.

The IYLF gathered 48 young, service-oriented physics leaders from 22 countries spanning six continents. They participated in four focus groups, advising members of the APS Committee on International Scientific Affairs on ways APS could engage with students and early-career physicists in their country.

Following the Society's 2021 March Meeting, APS International Affairs partnered with APS Careers on another set of focus groups for international physicists. More than 70 international students and early career scientists representing 25 countries across five continents signed up for these focus groups to inform program development toward serving international physicists' career interests.

"For this series, we are really looking to go beyond the general career advice that so many resources on our website already cover and do a 'deep dive' into the needs of the international physicist community. These focus groups provided us with some great insights to help plan the series," said Crystal Bailey, Head of Career Programs at APS.

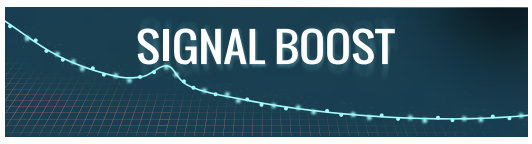
Added Amy Flatten, Director of International Affairs for APS, "I am appreciative of responses we received from young physicists worldwide who were willing to participate in the focus groups that provided APS with important information about how to meet the needs of our members. While we couldn't accommodate everyone who was willing to participate, we plan to have additional focus groups in the future."

Discussions from the focus groups proved insightful, as participants weighed in on matters such as visas and immigration, professional development opportunities, non-academic career paths, international scientific collaboration, and science diplomacy.

Participants noted, for example, that the US government's Optional Practical Training Program (OPT) could be a topic for discussion on APS's Engage platform (engage.aps.org) to help students and job seekers gain a better understanding of the program. The OPT enables highly skilled international students who completed their studies in the United States to gain work experience for a period of time and is used as a recruiting tool by universities, national labs, and high-tech companies. Businesses such as Amazon, Microsoft, and Intel are among numerous tech firms that annually employ thousands of recently graduated international scientists and engineers under the OPT program.

The Society values the importance of OPT. Last fall, APS Government Affairs (GA) ran a successful grassroots campaign that protected OPT from being suspended by a Trump Administration Executive Order. APS GA also

IYLF CONTINUED ON PAGE 5



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

Biden Seeks R&D Spending Surge

BY MITCH AMBROSE

In his first budget request to Congress, President Biden proposes to boost spending on research and development programs across non-defense agencies for fiscal year 2022. The request kicks off the annual appropriations cycle and is separate from the more than $200 billion in R&D spending that Biden has proposed as part of a special, eight-year infrastructure initiative called the American Jobs Plan. Both proposals include a focus on mitigating climate change and better positioning the US to compete globally in key technology sectors.

Within the budget request, Biden seeks a 35% increase in funding across the federal government for "clean energy innovation" as a first step toward quadrupling annual spending in the area over four years. The Department of Energy's budget would increase 10% to $46 billion, with $700 million allocated to standing up a cross-agency ARPA–Climate that would work in concert with the extant ARPA–Energy. Among DOE's other existing programs, the Office of Science budget would increase 5% to $7.4 billion in support of priorities such as climate science, novel materials for clean energy technologies, and advanced computing.

The focus on climate change extends to additional science agencies, such as NASA, the National Science Foundation, and the National Oceanic and Atmospheric Administration. NOAA's budget would jump about 25% to $6.9 billion, largely in support of improving earth observations, forecasting, and climate resilience efforts. NSF's budget would increase 20% to $10.2 billion, of which $500 million of the new funds would go toward expanding research related to climate change and clean energy. NASA's budget would increase 6% to $24.7 billion, with $250 million of the additional funds targeted to developing next-generation Earth observation satellites.

The budget also prioritizes research connected to selected strategic technology areas. For instance, Biden proposes creating a technology directorate in NSF that would work to accelerate progress in domains such as robotics, artificial intelligence, high performance computing, quantum information systems, advanced communications technologies, biotechnology, and cybersecurity. The research budget of the National Institute of Standards and Technology would increase 16% to $916 million in support of a similar set of priority areas.

FYI CONTINUED ON PAGE 7

FPD CONTINUED FROM PAGE 1

Physics Crossing, which used a video-game-style virtual world in the online platform Gather.Town to facilitate networking, tours of physics facilities, and bonding between student attendees. As each attendee entered the virtual space, they were able to move an avatar around to speak to others in the area, as well as enter into specially designed spaces, thanks to national labs and companies who sponsored "tours" of their facilities. Within each tour, students could explore the physics that takes place at the facility and chat with representatives.

"We wanted to plan something fun and interactive to make networking easier—it can be challenging for students to network virtually online," said Midhat Farooq, APS Careers Program Manager. "Having tours in place with staff within the tours provided easy opportunities to start conversations. It made networking more feasible."

The March Meeting event included two companies and four national labs: Google Quantum AI, General Atomics, Oak Ridge National Lab, Princeton Plasma Physics Lab, Sandia National Lab, and the National Institute of Standards and Technology. In April, Oak Ridge, Sandia, and Princeton Plasma Physics Labs returned and were joined by Fermi National Accelerator Laboratory and LIGO, as well as 16 other institutions representing graduate schools for a virtual grad school fair. The March grad fair was held separately with 27 institutions participating.

To help guide students through the Physics Crossing space, attendees also participated in a scavenger hunt for prizes, hunting down clues within facility tours, chatting with facility representatives, or browsing booths on APS Programs. All scavenger hunters received gift cards to the APS store.

The Physics Crossing event used a virtual world called Gather.Town to provide tours of physics facilities.

"One student said this was the first time they had done a scavenger hunt and really had a lot of fun," said Farooq. "An institution representative commented on the great quality of interactions while another recruited two student interns at the event."

Another particularly useful program for undergraduate attendees who were presenting, either in the special undergraduate speaker sessions or a poster session, featured APS Career Mentoringing Fellows providing feedback on every presentation. The Career Mentoring Fellows program enlists physicists working in industry, government, or academia who are interested in mentoring undergraduate students and teaching about diverse career paths available to physicists. By having the Fellows provide feedback on student presentations, it provided much-needed connection between undergraduates and the larger physics community, even at a virtual meeting.

"It might be the first time a student is attending one of these meetings...it's an intimidating experience," said Farooq. "With FPD, we aim to provide a welcoming and supportive environment. It's all exacerbated in a virtual world—if you don't know many other attendees it's ever more jarring to attend a virtual conference. Having some human contact, knowing that someone viewed your presentation and feedback can mean a lot."

FGSA CONTINUED FROM PAGE 2

ties," Gates explained. Importantly, FGSA's support extends not only to graduate students pursuing a traditional trajectory in academia, but also the increasing number interested in joining industry and the private sector.

Beyond the emphasis on career development and network building, FGSA is sharply focused on advocating for the interests of graduate students. "In partnership with APS Government Affairs (APS GA) we levy our collective voice for policies that will be beneficial to graduate students at large," noted Gates. Such efforts have included pushing back against Trump-era executive actions against travel and immigration that have negatively impacted international students in the physics community, as well as advocacy to ensure that physics graduate students could receive financial relief, get US visas processed, and find employment opportunities in the aftermath of COVID-related closures of universities and research facilities (see *APS News* July/August 2020).

Perhaps most notably, APS GA and FGSA spearheaded a grassroots campaign last year to ensure that graduate students, postdocs, and visiting researchers could continue to receive financial support from federal grants during the COVID-19 pandemic. FGSA members sent hundreds of letters to Congress underscoring the importance of these grants and within just days three of the largest funders of physics research—the National Science Foundation, the Department of Energy, and the Department of Defense—confirmed that they would extend grant support during the pandemic.

Looking forward, the FGSA executive committee's biggest aspiration for the forum is to foster an even greater degree of engagement among FGSA members, from establishing volunteer opportunities within the forum to encouraging members to take a leadership role in the unit's subcommittees.

Overall, FGSA stands out as an important entry point into APS for many young scientists and a unit that occupies an important niche for physics graduate students in all their diversity.

More information can be found at the FGSA website: engage.aps.org/fgsa/home.

MACK CONTINUED FROM PAGE 1

serve her well as the 2021-22 APS Congressional Science Fellow.

"I'm eager to get hands-on experience with the nuts and bolts of Congress from preparing memos to communications work to helping develop legislation," said Mack, who earned her PhD in physics from UC Berkeley. "But more broadly, I'm excited to meet new people from a diverse array of backgrounds, work in a fast-paced environment, and be flexible in contributing my scientific perspective to current issues."

Sponsored by APS under the umbrella of the AAAS Science & Technology Fellowships, the aim of the Congressional Science Fellowships is to provide a public service by making scientists available to members of Congress, few of whom have technical backgrounds. In turn, the program enables scientists to broaden their experience through direct involvement with the policymaking process.

Fellowships are for one year, typically running September through August. Following a two-week orientation in Washington, DC, sponsored by AAAS, incoming Fellows become acquainted with their new work environment. After interviews on Capitol Hill, Fellows choose a congressional office or committee where they would like to serve.

"The chance to use my technical background to impact our legislative process and work with true change-makers in a meaningful way cannot be duplicated, and that is why I was eager to submit my application for the fellowship," Mack said.

In addition to her experience with SPG, Mack boasts an extensive research background, with work at Lawrence Berkeley National Lab, UC Santa Barbara, UC Berkeley, SLAC National Accelerator Laboratory, and the University of Ottawa. She has also collaborated with world-renowned researchers to discover novel physics in lithium and improve materials for solar energy capture.

"My work was highly interdisciplinary, covering physics, chemistry, materials science, and computational science to understand and predict properties of quantum materials," she said. "These projects trained me to learn quickly and be open-minded, collaborate productively with people from different technical backgrounds, and develop time-management skills."

Mack's professional activities include serving on UC Santa Barbara's Materials Department Diversity, Equity, and Inclusion (DEI) Committee, during which she contributed to a new DEI strategic plan. Additionally, she has participated in APS's Conference for Undergraduate Women in Physics (CUWiP). Moreover, her accolades are many, including the UC Berkeley Department of Physics Student Service Award and the Molecular Foundry Annual Users' Meeting Best Student Poster Award.

Gina Banks Daly, Director of Federal Relations in the Office of the Chancellor at UC Berkeley, said Mack is an exemplary choice for the fellowship.

"She is uniquely well-qualified, displaying excellent leadership qualities, interpersonal skills, and is driven by scientific curiosity and an eagerness to improve the interaction between science and society," said Daly.

Branden Brough, Deputy Director of the Molecular Foundry at Lawrence Berkeley National Laboratory, echoed Banks' sentiments. "I have seen how Stephanie applies the tools of collaboration—communication, networking, team-building, and group problem-solving—to meet challenges outside of the laboratory," he said.

Added Mark Elsesser, Director of APS Government Affairs, "Stephanie's strong commitment to use her scientific and technical skills to help develop and inform legislation on Capitol Hill will make her an extremely valuable staff member to whichever congressional office or committee she chooses for her fellowship year."

APS remains committed to the Congressional Fellows Program because it enables scientists "to witness and participate in the policymaking process," said Francis Slakey, APS Chief External Affairs Officer. For more information about the APS Congressional Science Fellowship, visit aps.org/policy/fellowships/congressional.cfm.

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

IYLF CONTINUED FROM PAGE 4

released a report titled "How International Students and Researchers Benefit the United States: Their Experiences, Their Stories," highlighting the importance of OPT and J-1 visas programs.

In the area of professional development, focus group participants pointed out the importance of learning networking strategies, including how to approach people formally or informally and how to leverage contacts developed during conferences. Additionally, they said they were eager to get the most out of their mentoring relationships.

To that point, APS recently revamped the APS IMPact Mentoring Program website, which is the Society's resource for connecting early-career physicists with industry mentors, to strengthen connections between students and industry. In a recent *APS News* article, Dan Pisano, Director of Industrial Engagement at APS, said the refreshed site "appears to be fostering some useful mentoring of students and early-career physicists with industry representatives."

Early-career physicists are also interested in finding job opportunities for non-citizens, including possibly at national laboratories or through fellowships. And using physics to benefit society is also an area of interest. According to feedback from the focus groups, they are interested in advocacy training to help them use their voice to make an impact on issues that are important to the physics community. Additionally, they want to make an impact in the area of science diplomacy by working with scientists in other countries to strengthen collaboration among diverse nations.

Flatten said she is eager to continue to work with her APS colleagues to serve APS's international members who comprise a significant portion of the Society's membership. More than 23% of APS members live outside the United States in more than 100 countries, and physicists often cross continents to attend APS meetings. In addition, more than 70% of articles published in APS journals are co-authored by scientists outside of the United States.

Moreover, with APS meetings going virtual due to COVID-19, international physicists have had unprecedented access to APS meetings. In fact, the 2021 APS March Meeting attracted more than 4,481 physicists from outside the United States, accounting for more than 34% of attendees—up from an average of 30% of total attendees during previous March Meetings.

"In the spirit of 'One-APS,' I look forward to working across various departments to address the needs of our international members," said Flatten.

Added Francis Slakey, APS Chief External Affairs Officer, "We take our mission as a membership organization seriously, and that means making sure that both our national and international physicists benefit from their membership in APS."

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

KNITTING CONTINUED FROM PAGE 3

glove that helps the wearer grasp objects. As a proof of concept, said Sanchez, the sleeve shows that it's possible to make an actuator out of knitted garments. "And we can do it all with one yarn," she adds.

To make the actuator bend in the right direction, Sanchez applied stiffer or stretchier patterns to different parts of the sleeve. In her design, she relied on experiments informed by her prior experience working with textiles. But the physics of these knit projects are complex, and researchers struggle to design materials that consistently produce their desired properties.

The geometry of the yarn, such as how each loop locks into the next, as well as the yarn's tensile properties and local friction, can result in surprising properties such as fabric curling. To streamline the design process, researchers are developing more physically precise theoretical models to predict fabric mechanical properties.

Xiaoxiao (Catherine) Ding, a third-year graduate student in applied math at Harvard University, presented theoretical research for predicting a knitted fabric's elasticity. Her group, led by Chris Rycroft at Harvard, has developed a modeling framework that uses yarn properties, such as stiffness and friction, to simulate its characteristics once it is knitted into a fabric.

Ding validated the model by making knitted swatches, performing mechanical tests on them, and comparing their behavior to their simulations. The model can simulate knit patterns made of multiple types of yarn material, such as nylon and plastic. Her group is also working to apply the model in reverse, where it can design a pattern based on a desired material property.

Ding compares knitting to more traditional materials science, in which different chemical combinations yield materials for specific functions. Instead of mixing and matching chemicals, knitters play with geometry to get the material they want, she says.

Knitting can create 3D structures with a wide range of geometries and mechanical properties.
CREDIT: VANESSA SANCHEZ

Some theoretical work discussed in the session applied to materials beyond yarn. Daria Atkinson, a postdoc at the University of Pennsylvania, presented her research on the properties of filament bundles—think a rope consisting of twisted fibers. These geometries occur at scales ranging from DNA strands to spun yarn to steel cables used on suspension bridges.

While a braided rope looks simple, researchers have struggled to theoretically describe how the strands' geometry, as they twist around each other, gives rise to their mechanical properties. In her work, Atkinson found new constraints on the configurations of the strands as of a rope when it is bent or twisted.

The author is a freelance science writer based in Columbus, Ohio.

Video recordings of these and other textile physics presentations will be available on the meeting website (march.aps.org) until June 19, 2021.

PROGRAMS CONTINUED FROM PAGE 1

Education Research (PER) scholar. Her research has focused on assessment of institutional structures and cultural practices to make STEM fields more accessible to women and other underrepresented groups, mainly in non-formal learning environments. She has over a decade of experience in design, facilitation, and assessment of informal physics programs in several different countries. She has conducted research on the impacts participation in informal physics education programs can have on both participants and facilitators. Specifically, some of her recent work has utilized a Community of Practice framework to investigate identity development of facilitators in informal programs.

"Claudia brings a strong background in informal physics education, program design and evaluation, and physics education research," said Plisch. "In her first year as Head of Public Engagement, Dr. Fracchiolla launched a new portfolio of programs to engage and support members in effective outreach. She led a series of very successful WikiScientist courses, which train participants in adding knowledge to Wikipedia on topics including quantum science and biographies of women and minority physicists. Dr. Fracchiola is building a community of practitioners and researchers in public engagement, starting with a series of virtual workshops and webinars this summer to offer professional development and networking opportunities."

Crystal Bailey, Head of Career Programs

Crystal Bailey works on several projects which are geared towards marketing physics and physics career information to high school students, undergraduates, graduate students, and physics professionals. Some of her principal projects include the career events and workshops at APS annual and division meetings, the APS Job Board and Job Fairs, the APS Careers Website, and the recently launched Success in Industry Careers Webinar series. As the principal investigator for the APS PIPELINE project, she also devotes significant time to integrating meaningful workforce development into undergraduate physics education.

Geraldine Cochran

Michael Wittmann

Crystal Bailey

Claudia Fracchiolla

Before coming to APS, Bailey did research in nuclear physics at Indiana University (IU), Bloomington in the area of few-body systems. In 2008 she received the Konopinski Award for Outstanding Graduate Teaching from the IU Physics Department. She graduated with her PhD from IU in 2009.

"With over a decade of experience at APS, Crystal has been a strong leader since stepping into her role as Head of Careers in 2018," said Plisch. "She has been innovative in pivoting to serving our members virtually during the pandemic, launching new webinar series, online career networking events and job fairs, and initiating the Career Mentoring Fellows program to improve student advising."

The author is Assistant Director of APS Programs.

Applications Open for EP3 Departmental Action Leadership Institutes (DALIs)

The Effective Practices for Physics Programs (EP3) Departmental Action Leadership Institutes (DALIs) support departments in addressing challenges or opportunities that they may face. Over the course of a year, two participants from each DALI department will engage in a facilitated process through which they will grow their skills at leading change. They will guide their departments in making sustainable improvements to undergraduate education and a stronger culture of self-reflection and action.

Applications are due June 18 for the DALI cohort scheduled to start in September. For additional information about the DALIs, including the application, please visit ep3guide.org/dali.

FYI CONTINUED FROM PAGE 4

Meanwhile, the infrastructure plan proposes an array of R&D initiatives that would complement or jumpstart proposals from the budget request. These include $50 billion for NSF, $14 billion for NIST, $35 billion for climate-related R&D, and $40 billion for upgrading research infrastructure across universities and federal laboratories. It also seeks $50 billion for the semiconductor manufacturing and R&D initiatives authorized in the CHIPS for America Act.

Any legislation to fund Biden's proposals will require some support from congressional Republicans unless Democrats circumvent the Senate filibuster with the maneuver they used to pass the $1.9 trillion pandemic response bill in March of this year. Republican leaders in the Senate have sharply objected to the scale of Biden's spending ambitions, though they have not singled out the R&D-related provisions for criticism. Some of those provisions do have bipartisan backing, such as the semiconductor initiatives.

In justifying his proposals in recent speeches, Biden has frequently lamented that the share of federal spending on R&D has declined as a share of US gross domestic product in recent decades.

"We're in a competition with China and other countries to win the 21st Century," Biden argued in his first address to Congress. "We will see more technological change in the next 10 years than we saw in the last 50 years. And we're falling behind in that competition. Decades ago we used to invest 2% of our GDP on research and development. Today, we spend less than 1%."

The author is Director of FYI.

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DONORS CONTINUED FROM PAGE 1

Chandler and other members of the DCP executive committee wrote letters asking for contributions, but the fundraising stalled about halfway to the $50,000 endowment goal. "I wrote to anybody associated with DCP over the last 20 or 30 years, but that didn't raise nearly enough to get us over the finish line."

At that point, Robert Gordon, former secretary/treasurer of DCP, Chandler, and the incoming secretary/treasurer David Osborn (Sandia) put their heads together. Why not give something back to people who were generous in meeting the endowment goal?

"My dad ran an antique shop in Texas many years ago," explained Chandler. "And somehow he came across a baseball autographed by Nobel laureate Linus Pauling. He bought it from someone's estate and gave it to me. I thought, well, I know Yuan Lee and Dudley Herschbach, and once I met John Polanyi [the three winners of the 1986 Nobel prize in chemistry], maybe I could get baseballs autographed by them."

As it turned out, Lee and Herschbach were baseball fans and Polanyi was happy to help as well. "You could say that these three laureates are most closely associate with chemical physics in terms of its topical area. For people in chemical physics, this is a really meaningful gift," added Osborn. "Three dozen baseballs were signed by the Nobelists in December 2020. The first ones were sent to donors and now we have about five left, which we hope will garner five more gifts from the community to the endowment. This is what kicked us over the top in terms of fundraising." The endowment campaign reached its goal in March 2021.

"This is a perfect example of how creativity and dedication toward reaching a fundraising goal can make a difference in honoring the legacy of a promising young chemical physicist while supporting the careers of other promising chemical physicists," said Kevin Kase, APS Director of Development.

For more about the Jankunas Dissertation Award and other opportunities to support APS, visit aps.org/about/support/jankunas.cfm.

CIRCUS CONTINUED FROM PAGE 3

physics of Earth systems, she craved a physical activity. She had always wanted to do gymnastics, and UMD had a non-competitive, performance gymnastics troupe. "I love being active in team sports, as it helps me focus, [but] I didn't want to be a performer. I wanted to compete," she says. "I had stage fright." But this troupe did not require an audition and provided training—it welcomed newbies like her.

Her inaugural performance fed her momentum. "The high from the audience's attention and the feeling of being able to captivate them was incredible," she says. "I wanted more. I fell in love." She remained with the troupe the rest of her time at UMD, practicing two to three hours each day, in combination with regular weight lifting for cross training. She graduated with high honors with a bachelor's in physics and meteorology.

As her undergrad education came to a close, she wondered how to continue experiencing the performance high and improve her tumbling, dance, and gymnastics. Ruth, who had been awarded an NSF Graduate Fellowship, enrolled in the PhD program at Scripps Institute of Oceanography in San Diego. She planned on getting her doctorate in geophysics. But the west coast move was strategic for another reason: one of the most prominent circus schools is located in this city, and she had already arranged to train with a leading coach in the circus arts.

Her plan was clear: circus would be a side gig. "I had full intention of finishing my PhD and was going to circus-train on the side to get stronger," she says. And yet, she knew she did not want to be a research physicist, and the longer she put off being a performer, the less opportunity she would have to do it at all. Simultaneously, she was not deriving as much pleasure from physics as she once did. Her geophysics program felt "too removed" from what she liked. "I wasn't happy. . . I realized I wanted to run off and join the circus," she says.

Julia Ruth on the cyr wheel.
CREDIT: SAN DIEGO CIRCUS FESTIVAL 2019, ROB RIINGEN PHOTOGRAPHY

She made the decision to leave grad school with her master's and fully commit to a circus performance career. Her first job was managing events for the circus school, which allowed her to train upwards of six hours each day on core circus performance activities such as dance, flexibility, and handstands. One of her specialties is hand-to-hand, where she holds people in handstands and throws them into flips. Building muscles and developing circus artistry led to her discovering the cyr wheel.

Ruth trained, performed, and networked with circus professionals from around the world, leading to more auditions and jobs. 2019 was her busiest year, where she spent months traveling through Australia, Canada, and the US with various troupes, performing at festivals and other events. Her income was derived from exhibiting her own acts on the cyr wheel as well as performing new acts with different circus clients who hired her. When COVID-19 hit, Ruth didn't let her career take a tumble. Instead, she repositioned herself: she expanded into coaching kids in workout, flexibility, and—physics and astronomy.

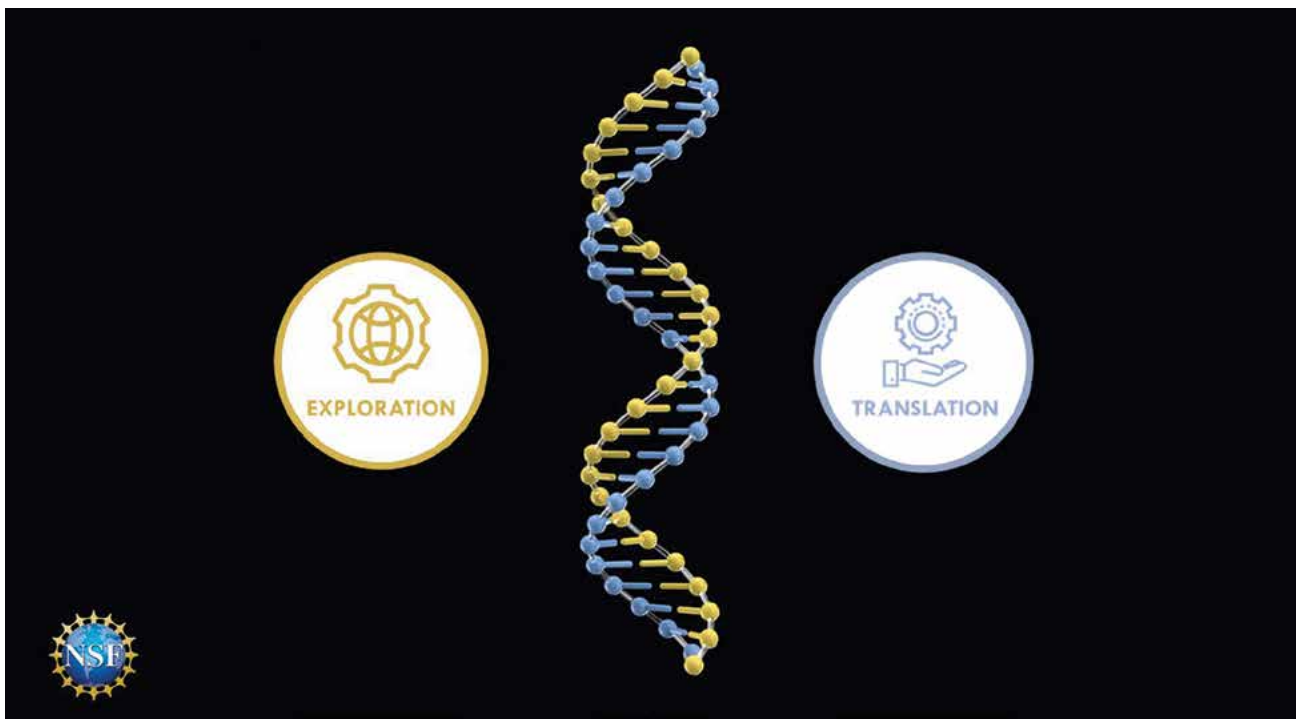
Ruth aims to weave her arts and physics fervor into a novel profession. "I have an idea of creating a one-woman show about string theory to bring to fringe fests," she says. "What's a great representation of particles made of one-dimensional loops? Cyr wheel!"

Cultivating a career at the boundary of science and arts requires bravery, and Ruth is no stranger to courage. It took guts to leave her prestigious fellowship. Her advice for professional success? Believe in and listen to yourself. "The jump can be scary, but once I did that, it made making jumps like that even easier," she says. "I wasn't a fulltime performer right away, but I have full confidence in my abilities."

THE BACK PAGE

Building Stronger Bridges Between Discovery, Innovation, and Prosperity

BY SETHURAMAN PANCHANATHAN



The Biden-Harris administration recently released its budget request to Congress for fiscal year 2022. The discretionary spending request includes $10.17 billion for the US National Science Foundation, which represents a 20% increase over the agency's current budget.

The President's request affirms the importance of the agency's role in advancing the frontiers of science and technological progress and NSF looks forward to working with Congress and other stakeholders to ensure that the United States remains at the forefront of science, engineering, and STEM workforce development.

It is more important now than ever to catalyze innovation, at speed and scale, as the US is looking to the science and engineering community for solutions to some of society's most pressing challenges. We need to rapidly scale our investments and build even stronger bridges between discovery, innovation, and commercialization in order to develop innovative ways to mitigate the pandemic, advance the industries of tomorrow, promote economic recovery, ensure racial equity, address climate resilience, and more.

NSF is poised to drive discovery and innovation along two key axes that undergird the health of our research ecosystem: by training the next generation of STEM leaders and through seeding bold, large-scale foundational and transformative research with meaningful societal and economic impact.

Strengthening STEM pathways

Today's STEM students and researchers are the leaders and innovators of tomorrow. One of my key priorities is realizing the full potential of the American workforce. There is tremendous talent throughout our nation, but only a fraction of it becomes part of the broader STEM community.

US competitiveness depends on reaching that talent, because we need an agile and adaptable workforce that can upskill, reskill and succeed through creative and innovative mindsets. The need is perhaps more urgent now than ever as the pandemic has deeply impacted pathways to STEM education and careers.

As we work to spur recovery and provide relief, we are looking at how we can scale up the reach of the broader STEM community so that anyone—from any background and from any part of the country—who has the aspiration and talent to go into a STEM career is given the opportunity and provided the support to do so.

This will require strengthening pathways into STEM fields and expanding our reach into communities where talent exists. We are going to have to develop new approaches and tailor educational experiences for communities to be more effective at bringing talent into the STEM enterprise.

NSF is also working to develop a diverse workforce capable of driving the industries of the future. For example, we are currently on the cusp of a new quantum revolution and we need a well-trained workforce to accelerate it.

NSF has funded quantum research and education since the 1980s by providing support for thousands of graduate students, post-docs, and early career researchers. Now, the agency is finding new ways to train students in the flexible thinking needed to learn about quantum and to adopt education concepts that could have broad benefits across the country.

Through the National Q-12 Education Partnership, NSF has invested $1 million in linking top industry and academic leaders to build a better-trained, more diverse group of quantum learners, ready one day to enter the quantum workforce.

This effort includes investing in projects such as a University of Illinois Urbana-Champaign and University of Chicago collaboration to create curricula and implement tools that will increase quantum awareness and literacy at the K-12 level—and ultimately for all age groups.

Another project, run by the American Association of Physics Teachers, will host summer workshops for teachers and build a community of educators working to deploy QIS-focused content at schools.

Seeding bold, large-scale foundational and transformative research with meaningful societal and economic impact

By seeding strategic investments, NSF steers the frontiers of discovery and innovation toward breakthroughs that address pressing societal challenges and that places the US at the vanguard of global leadership.

The global pandemic has dramatically underscored the importance and uniqueness of NSF's long-term support for foundational research coupled with use-inspired innovations across the entire spectrum of STEM fields.

NSF rapidly responded to the pandemic by deploying decades of discovery and innovations in support of researchers across all fields of science and engineering working to understand and combat the virus. The results ranged from new designs for vital personal protective equipment and testing devices more easily deployable in the field to new models that advanced our fundamental understanding of the virus's structure and how it functions, to name a few.

Additionally, NSF's early support for projects like CRISPR and the science that led to the creation of the technique polymerase chain reaction have enabled major advancements in our ability to understand the COVID-19 virus and the development of vaccines to slow its spread.

Years of NSF support for dark matter research even resulted in surprising outcomes that facilitated pandemic response efforts. When particle physicists working in Italy on NSF-supported dark matter research were forced to halt their work because of the global pandemic, they quickly shifted focus to look for solutions. Familiar with using and building sensitive detection equipment involving handling and pumping gases, it was a natural transition to adjust focus from the argon used in their dark matter detector to oxygen and lungs instead. Their quick work resulted in an FDA approved ventilator constructed from low cost and easily accessible materials.

These innovations began as exploratory-based research projects aimed at better understanding the world around us. They exemplify the potential benefits of science, technology and engineering solutions that are driven by the unbelievable power of curiosity-driven research.

In other words, NSF supports both fundamental explorations and use-inspired innovations that make possible technological progress and produces solutions to challenges facing society. This is because the scientific pursuit of knowledge and understanding cannot be separated from the development of new technological capabilities.

And, in turn, these new capabilities allow us to pursue new research questions that were once out of our reach, forming a virtuous cycle.

The DNA of NSF

It is this double helix of curiosity-driven, discovery-based explorations in synergy with use-inspired, solutions-focused innovations that makes up the DNA of NSF.

And it is this synergy that NSF is uniquely capable of cultivating that will lead us toward transformational leaps in discovery and innovation.

Consider, for example, the Laser Interferometer Gravitational-wave Observatory. This is a project that was decades in the making at NSF. Early on, there were questions about whether detecting gravitational waves was possible—not as a matter of theory, but as a practical matter of whether it would ever be possible to develop the technology necessary to make those detections.

In 1979, NSF made a grant to Kip Thorne for a new approach to quantum measurement to help bridge that technological gap and bring gravitational wave detection into the realm

Sethuraman Panchanathan, NSF Director CREDIT: NSF/STEPHEN VOSS

of the possible—an unbelievable feat that would happen 3636 years later.

Our pursuit of discovery science—in this case, gravitational waves—was part of a cycle that included innovative technical solutions for quantum sensing. That cycle has continued. Today, we are relying on the culmination of decades of research to peer even deeper into the cosmos to understand the fabric of the universe, and at the same time, we are building on the knowledge we have gained to develop a new generation of quantum sensors that will be critical to technological applications ranging from cutting-edge research to commercial products.

Thanks to strong support from Congress and a team of incredibly talented, hardworking employees, NSF has helped lead the way in American leadership in R&D for decades. As we look to the future, NSF will continue investing in discoveries and discoverers, innovations and innovators who will enable the breakthroughs and advancements that will ensure societal and economic prosperity into the future.

The author is Director of the National Science Foundation, an $8.5B independent federal agency and the only government agency charged with advancing all fields of scientific discovery, technological innovation, and STEM education. Panchanathan was unanimously confirmed as Director by the US Senate on June 18, 2020. He previously served as the executive vice president of the Arizona State University (ASU) Knowledge Enterprise, where he was also chief research and innovation officer. He was also the founder and director of the Center for Cognitive Ubiquitous Computing at ASU. Panchanathan is a fellow of the National Academy of Inventors, where he also served as vice president for strategic initiatives. He is also a fellow of the American Association for the Advancement of Science, the Canadian Academy of Engineering, the Association for Computing Machinery, the Institute of Electrical and Electronics Engineers, and the Society of Optical Engineering.