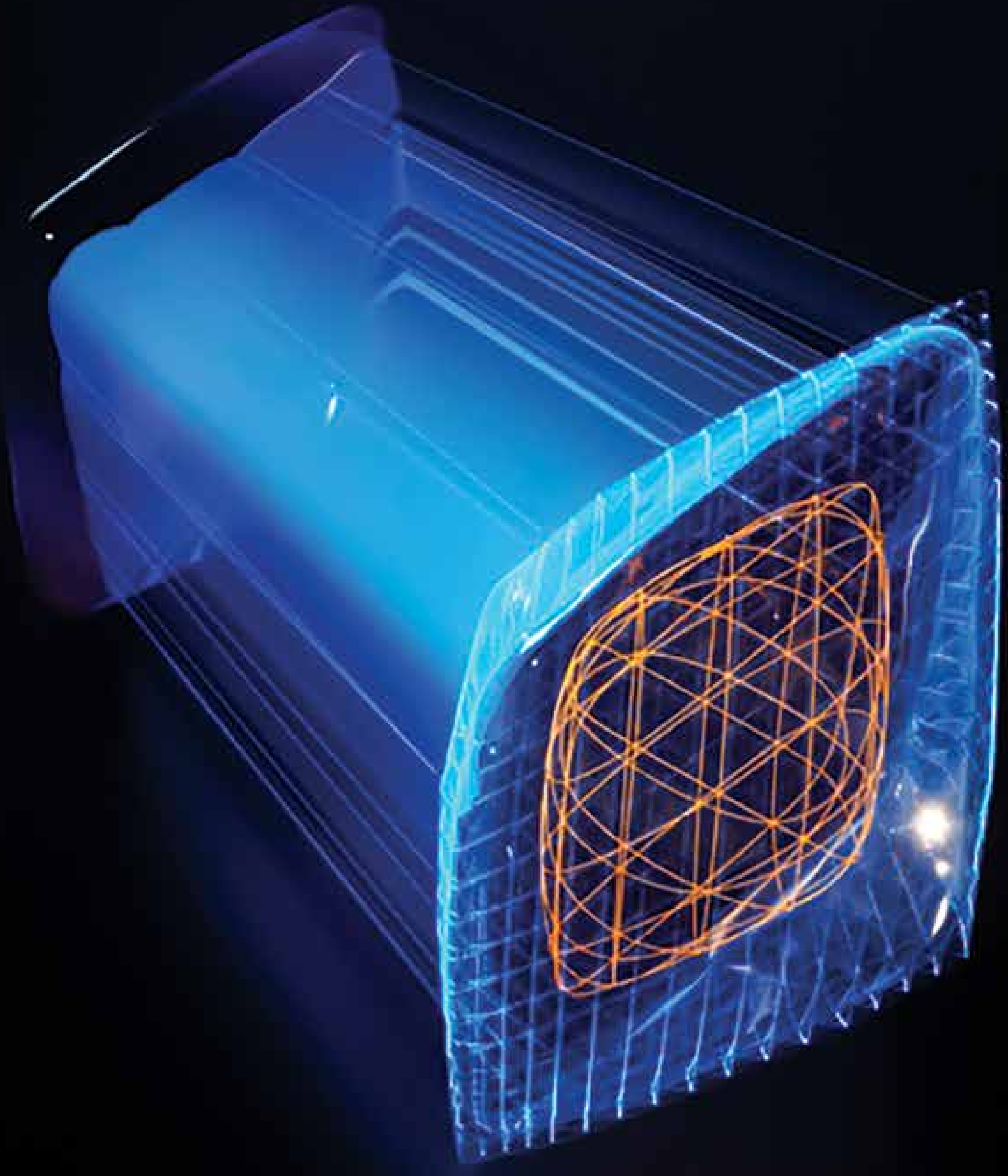
the SPS Observer

Volume LVI, Issue 1

SPRING 2022



+ Machine Learning, Physics, and Your Future
+ Dive into Machine Learning
+ Machine Learning at Work
+ Suggestions for Summer
+ Seeing the Invisible at NIST
+ The DIY Demonstration Box Project: A Shift in Outreach Strategy
+ James Webb Space Telescope: Looking to the Past for the Future

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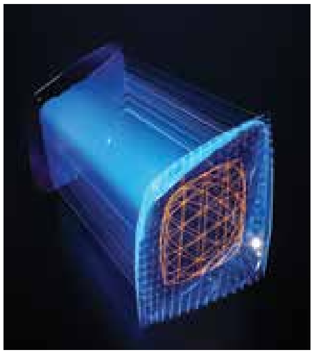
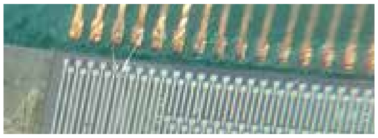


ON THE COVER

In a collaboration between Stanford University, Lawrence Berkeley National Laboratory, MIT, and other institutions, researchers are using AI to better understand why batteries wear out. This is an artist's rendition of a particle analyzed by a combination of machine learning, X-ray images, and electron microscopy. For details on this research, see doi.org/10.1038/s41563-021-01191-0. Image by Ella Maru Studio.



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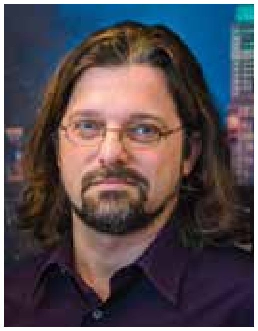
Advice for a Successful Summer: #HowtoREU

by Kiril A. Streletzky, President, Society of Physics Students

It's the time of year when many physics and astronomy students are looking forward to finishing the semester and beginning a summer research experience or a summer research internship. If that's you, congratulations! As an REU Site program director at Cleveland State University and an undergraduate research advisor, I'd like to share some advice for making the most of your experiences, this summer and beyond. If the idea of a summer research experience is new to you, keep reading anyway—hopefully you'll be inspired to try one next summer.



LEFT: Kiril A. Streletzky. Photo courtesy of Toni Carter, CSU.

Summer research opportunities are unique and rewarding experiences. They can be critical for helping you figure out what you want to do in the future. A summer research experience can help you determine if a research-based graduate program or job is a good fit for you. REUs and other summer research opportunities are a great chance to try research while being paid and without any real danger of failing, a chance to discover whether research in general, and the specific type of research you're doing, excites you. It's fine if it isn't a good fit. The point is that you can figure this out now during the summer as opposed to after starting graduate school. It's a great way to test drive a career with a research component.

Research experiences are also vital opportunities to create a network of friends and colleagues, connect to your peers in the program, and build a network of research mentors—graduate students, faculty, research scientists, and postdocs. These networks can be extremely important for your future career. Peer networks can offer support and help with navigating scholarship applications, graduate school, and beyond. And when you're applying for jobs or grad school, your summer research mentors can be your strongest references and recommenders.

To make the most of your summer, start preparing now. If you are heading to an internship or REU, you probably have a project description. If not, reach out to the program director or your research advisor and find out what you'll be working on and how you can prepare. Then dive into the topic by working with corresponding literature suggestions. Research advisors appreciate new students coming into the lab with specific questions about the project, since it shows that they've already thought about what they'll be working on. Knowing the basics will also help you be more productive in the lab and benefit more from your 10-week-long summer research experience.

Once you're in your summer program, really treasure the experience and get as much as you can out of it. Have fun and learn new skills. Never be afraid to ask questions. Spend time reflecting on how well this research suits you, and start building your network. Don't hesitate to reach out for help if you encounter any problems. If your mentor is unable to give you the attention you need, talk to other members of your lab and/or program administrators and directors. They are invested in your success and can help facilitate the best possible experience for you.

Securing an REU or an internship is a significant achievement already. You should be proud of yourself. Expect to have the time of your life, learn a ton, and have a great summer! //

WHAT'S AN REU?

The National Science Foundation (NSF) funds research opportunities for undergraduate students in various disciplines through its REU Sites program. REU stands for research experiences for undergraduates. An REU Site consists of a group of 10 or so undergraduates who work in the research programs of the host institution. Each student has a specific research project and works closely with faculty and other researchers. Students receive stipends and, in many cases, assistance with housing and travel. REUs are commonly 10-week summer programs. Not all summer research opportunities in astronomy and physics are REUs, but many of those that aren't have a similar program model.

To learn more and search REU Sites, visit nsf.gov/crssprgm/reu/.

#HOWTOREU

To learn more about REUs, summer experiences, and how you can set yourself up for success this summer, watch *#HowToREU with Brad Conrad and Kiril Streletzky* on YouTube. While you're there, be sure to check out the other awesome videos from SPS National!

Suggestions for Summer

We asked SPS members on social media what advice they have for students entering summer research or other positions, and these are their responses! Some have been edited for clarity.

@shoukav
Spend spring break educating yourself more about the position you've gotten. Talk to your advisor and other mentors. If it's possible, reach out to your summer mentor(s) and discuss your role, focusing on any particular skills you need to develop before you start.

@sylphrenna
The sooner you can do it, the better!

@sweiss567
You'll have more free time than you realize—check out the area, walk around town, enjoy it.

@jackdmoody
Don't be afraid to ask your summer mentor about background readings and other ways to prepare prior to starting!

@WrightPhysicsHop
Be EAGER!

@love_drea3
Save yourself a lot of time and ask questions when you're stuck.

@dalton_phys
Ask as many questions as possible. Learn something and be happy doing it.

@mcyike
Never ever ever be afraid to ask for help! Asking questions is a part of the process.

@bradrconrad
Make business cards with your LinkedIn profile, QR code, and permanent email address.

@janessvrs
Don't be afraid to ask your advisor questions. Stay consistent, but your mental health comes first!

@supersparticle
Talk to everyone about what they do and why they like it, or what they'd want to change.

@ashley__lieber
Have a growth mindset! You're there to learn, not perform! Talk to everyone and stay in touch.

@jennadance_
Don't be afraid to try something brand new, even if you feel underqualified. You can learn!

@carboncapturequeen
Be on time so you can chat with peers and network while you wait for others to join.

@kayladenee_
Participate in any professional development your organization offers. NETWORK NETWORK NETWORK!

BELOW LEFT: 2019 SPS summer interns enjoy the congressional baseball game together.

BELOW RIGHT: 2019 SPS summer interns show off their new fashionable bucket hats after their Closing Symposium. Photos courtesy of SPS National.

Elon's Story:

A path shaped by conferences, community, and mentoring

by Elon Price, 2018 SPS Summer Intern and PhD Student, Auburn University

When I started working toward an undergrad degree in physics, I wasn't sure what I was in for. My family and I didn't know much about astrophysics as a career, and we didn't know of any Black, female astrophysicists at the time either. My dad told me it would probably be a White- and male-dominated field. My parents warned me that I might feel isolated sometimes and experience discrimination, but that made me only more determined.

After a few years of working toward a physics bachelor's degree, I started to feel constantly overwhelmed by the various stressors in my life—including more responsibilities at work and harder courses. One day I got an email from a professor about a conference of the National Society of Black Physicists (NSBP) that offered free travel and lodging to students who wanted to attend. I had no idea this kind of thing even existed or that there were many Black physicists out there. I decided to attend.

During that NSBP conference I experienced the value of networking and connecting to the broader physics community. I finally started to feel a sense of belonging in physics. Other conferences presented unique opportunities too. One even led me to a Society of Physics Students summer internship. Participating in that internship taught me a lot about physics professional societies and the myriad of physics careers and research areas.

During my undergrad years, I also found time to serve as a mentor. I volunteered for many summer sessions with Imhotep Academy, a program that teaches elementary and middle school students from underrepresented groups about careers in STEM. As an alumna, it meant a lot to me to give back to the program that first exposed me to laboratory research. My experiences with Imhotep over the years taught me the importance of mentor–mentee relationships and the impact they can have on a student's education and career.

When the time came for me to apply to graduate schools, I had a lot of resources but was still nervous. I was knowledgeable about physics and had a clear picture of my career goals, but I also knew about the increased underrepresentation of minority students in physics at the graduate school level. And I understood the importance of belonging and effective mentoring. As I learned more about the many bridge programs that support underrepresented minority students in the transition from undergraduate degree to physics PhD program, I was inspired to apply.

Ultimately, I enrolled in the Fisk University–Vanderbilt University Master's-to-PhD Bridge Program and completed a master's degree at Fisk. The experience only reinforced my career goals. The support I received boosted my confidence and affirmed my physics identity, and in the positive, encouraging environment, my coursework and overall understanding of physics improved. The skills I gained have prepared me well for obtaining a physics PhD, which I'm doing now at Auburn University.

ABOVE: Elon Price. Photo by Auburn Photographic Services.

My advice to students planning their physics career is to use networking to your advantage. Obstacles will arise, and it's reassuring to have an established network you can rely on for guidance. Mentoring is important, and mentors can come from many places, including conferences, internships, research experiences, and department faculty, among others. Ultimately, your mentors and community can help you make solid career choices that align with your interests. //

This story was originally published in the 2021 edition of GradSchoolShopper magazine.

To learn about the National Society of Black Physicists, visit the NSBP website at nsbp.org.

Student members of the Society of Physics Students are eligible for free membership in NSBP; for details, see spsnational.org/about/partnerships/nsbp.

Fall 2021 SPS Chapter Awards

Congratulations to the winners of the Fall 2021 SPS Chapter Awards. These awards are made possible in part by generous contributions from Sigma Pi Sigma alumni. For examples of past award-winning projects, visit spsnational.org/awards/chapter-awards.

FUTURE FACES OF PHYSICS

Future Faces of Physics Awards are made to SPS chapters to support projects designed to promote physics across cultures. The goal of the Future Faces of Physics Award is to promote the recruitment and retention of people from groups historically underrepresented in physics.

Stony Brook University
SPS Peer Mentorship and Physics Café Initiative
Sara Kurdi (Leader)
Robert McCarthy (Advisor)

Texas Lutheran University
TLU Afterschool Special
Maximillian Schaar (Leader)
Toni Sauncy (Advisor)

University of Central Florida
James Webb Space Telescope and Elevating Muted Voices
Rajib Chowdhury (Leader)
Costas Efthimiou (Advisor)

University of Texas at Dallas
Physics HALO
Victoria Catlett (Leader)
Jason Slinker (Advisor)

University of the Sciences
Falling for Physics!
Dan Fauni (Leader)
Roberto Ramos (Advisor)

MARSH W. WHITE

Marsh W. White Awards are made to SPS chapters to support projects designed to promote interest in physics among students and the general public. The Marsh W. White Award dates back to 1975 and is named in honor of Dr. Marsh W. White for his many years of service to Sigma Pi Sigma and the community.

Adelphi University
Lab for Kids
Shalauni Patel (Leader)
Matthew Wright (Advisor)

Cleveland State University
Fabulous Light Waves and their Applications
Andrew Scherer (Leader)
Kiril Streletzky (Advisor)

Henderson State University
Science Olympics
Timothy Wooten (Leader)
Shannon Clardy (Advisor)

Missouri Southern State University
Launching Physics Outreach with a Trebuchet
Rebekah Sweyko (Leader)
Jency Sundararajan (Advisor)

Rhodes College
Rhodes College Egg Drop
Olivia Kaufmann (Leader)
Brent Hoffmeister (Advisor)

Tuskegee University
STOMP: Science Tutorials on Mechanics in Physics
Taylor Jones (Leader)
Walter Malone (Advisor)

University of Central Florida
Invigorating Young Minds Through Physics Solution Videos
Madisyn Brooks (Leader)
Costas Efthimiou (Advisor)

University of the Sciences
Trickery of the Eye: The Physics of Optical Illusions
Nell Grabowski (Leader)
Roberto Ramos (Advisor)

Wofford College
Physics Interests Community Outreach
Caleb Hames (Leader)
Rudrajit Banerjee (Advisor)

SIGMA PI SIGMA CHAPTER PROJECT

The Sigma Pi Sigma Chapter Project Award provides funding of up to $500 for chapter inductions and events.

Missouri Southern State University
An Event of Great Magnitude
Joshua Numata (Leader)
Jency Sundararajan (Advisor)

University of Central Arkansas
Sigma Pi Sigma @ UCA Induction Ceremony
Hypatia Berry (Leader)
Jeremy Lusk (Advisor)

University of Central Florida
Sigma Pi Sigma Induction Ceremony
Spencer Tamagni (Leader)
Costas Efthimiou (Advisor)

University of Tennessee - Knoxville
Awards Banquet
Jesse Farr (Leader)
Maxim Lavrentovich (Advisor)

University of the Sciences
USciences Future Physicists
Ryan Hess (Leader)
Roberto Ramos (Advisor)

Worcester Polytechnic Institute
Induction for Growing Sigma Pi Sigma
Brigitte Lefebvre (Leader)
Doug Petkie (Advisor)

SPS CHAPTER RESEARCH

The SPS Chapter Research Award program provides calendar-year grants to support local chapter activities that are deemed imaginative and likely to contribute to the strengthening of the SPS program.

Louisiana Tech University
Tiny Dancers with Moves Like Jagger: Principal Component Analysis of Anthropomorphic Organic Molecules
Caden Edwards (Leader)
Tom Bishop (Advisor)

McMurry University
BAJA SAE 2023 Phase One
Austin Bridwell (Leader)
Tikhon Bykov (Advisor)

Missouri Southern State University
The Minute Differences in Production
Joshua Numata (Leader)
Jency Sundararajan (Advisor)

Rhodes College
Finding the Sun: Developing a Sun Sensor for Use on a 1U CubeSat
Olivia Kaufmann (Leader)
Brent Hoffmeister (Advisor)

The George Washington University
Characterizing Atmospheric Muon Concentration Using a High Altitude Balloon-Based Detector
Caden Gobat (Leader)
Gary White (Advisor)

Suffolk University
Neutron Energy Distribution of an AmBe Source at the MGH Proton Center
Alexandra Leeming (Leader)
Walter Johnson (Advisor)

Universidad Autónoma de Ciudad Juárez
Construction of a Low-Cost Muon Detector
Jose Barraza Villaverde (Leader)
Hectro Alejandro Trejo Mandujano (Advisor)

University of Tennessee at Chattanooga
A LEGO Watt Balance: An apparatus to determine the SI unit of kilogram using the fundamental Planck's constants
Ivy Cartwright (Leader)
Tatiana Allen (Advisor)

SPS FALL AWARD APPLICATIONS DUE NOVEMBER 15

Have an idea for an event, outreach, or research project and need funding? Let SPS National help you get there! Applications and advisor sign-offs are due Tuesday, November 15, 2022.

Future Faces of Physics Award: $500 maximum
Outreach award to promote the recruitment and retention of people from historically underrepresented groups in physics and astronomy

Marsh W. White Award: $500 maximum
Outreach award to chapters for programs with grades K–12 and the general public

Sigma Pi Sigma Chapter Project Award: $500 maximum
Engagement award for funding events that aim to include alumni, help with chapter inductions, or expand recognition

SPS Chapter Research Award: $2,000 maximum
Research award to chapters for imaginative physics and astronomy projects

For more information about these award opportunities, including proposal templates, visit spsnational.org/awards.
If you have any questions regarding applications, please contact sps-programs@aip.org.

Does İdeal Baseball Mean No Air Resistance?!

by Brad Conrad, Director of SPS and Sigma Pi Sigma

As most readers well know, in introductory physics we talk ad nauseum about projectile motion. It's a never-ending stream of firing cannon balls straight up, throwing rocks at arbitrary angles, and even watching the occasional space ship move in all kinds of strange ways. Luckily, at least in first-year physics courses, we get to start the discussion with the heartwarming phrase "assuming no air resistance . . . ."[1] Those four words make things so much easier.

As we thaw into spring in the Northern Hemisphere, many countries welcome the beginning of baseball season (which is super different from cricket but still involves a bat and ball), and this got me thinking. If baseball existed in an ideal world, would this lead to a totally different game? Or would we hardly notice a difference? Let's find out.

To start things off, **if there was no air resistance, how much larger would we need to make baseball fields?**

There are many ways to look at this, but a little background first.

1) In baseball, one player throws a ball really fast at a person with a wooden bat. These pitched balls can reach speeds in excess of 150 km/hr! The fastest recorded pitch was about 166 km/hr.[2]
2) As you might imagine, a baseball field is very well defined in the game rules. It needs to be flat with 90 ft (27.4 m) between the diamond bases and separated from fences by a minimum distance of 290 ft (97 m) and 400 ft (133 m), as shown in my crude drawing, see Fig. 2. If a ball is hit over the fence, it's a home run!

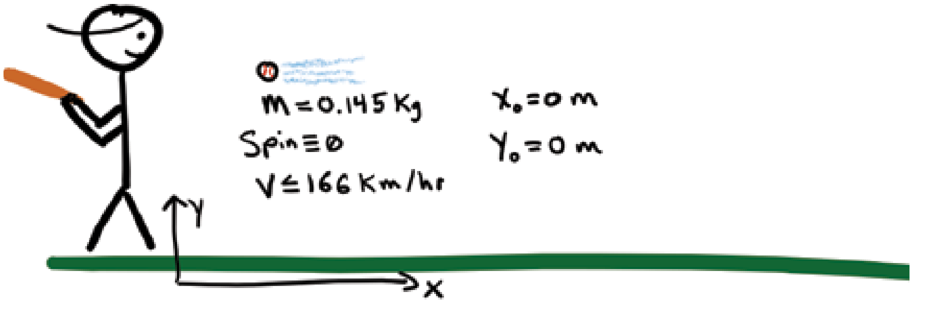


Figure 1. An illustration of a stick person at bat. For reference, a baseball has a mass of roughly 0.145 kg and is about 75 mm in diameter.[2] Aside: Official baseballs can have a mass variance of ½ ounce (14 g) and a radius variance of ¼ inch (6 mm)—so there is significant variance). All images by the author.

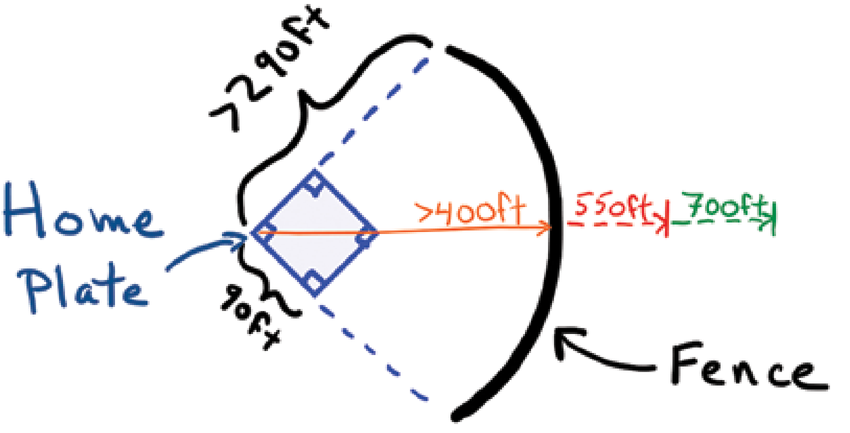


Figure 2. A crude illustration of a baseball diamond and the distance to the back fence, which marks a home run. The farthest home run ever hit (and properly measured) was roughly 582 ft.

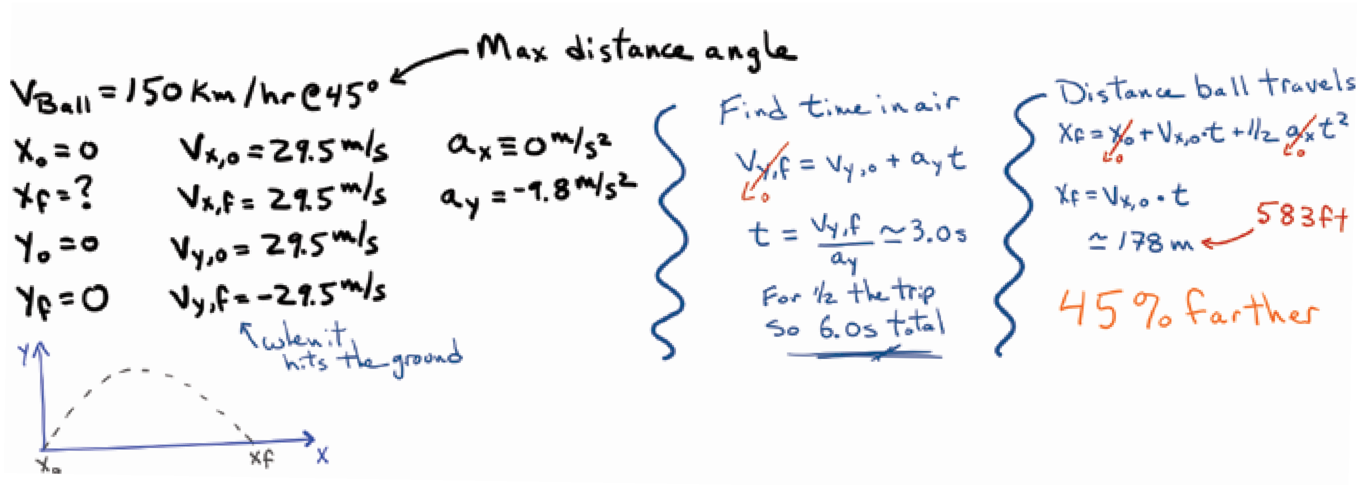


Figure 3. A handwritten solution for a baseball hit in a vacuum using kinematics.

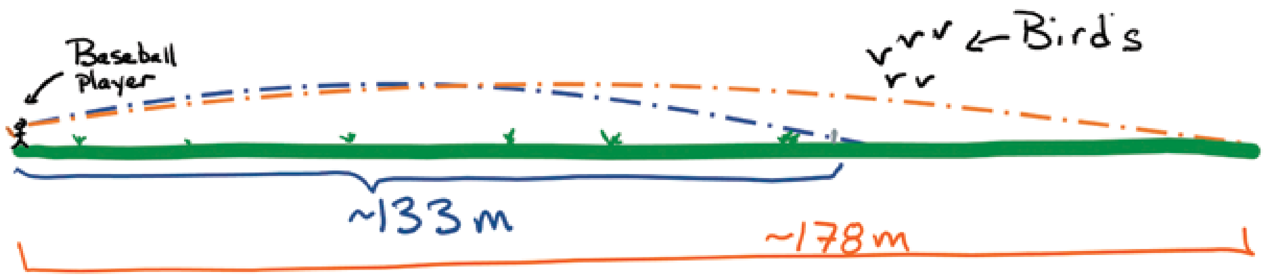


Figure 4. A sketch comparing the projectile motion curves for a home run (blue) and the ideal case (orange).

Using these numbers, we can address the question of how large to make a baseball field with no air resistance. I think it's fair to assume that if a player hits a standard fast ball perfectly, at a 45° angle, it should land at the back fence. So, in my ideal baseball game, how far would that perfectly hit ball go?

From kinematics and being extra careful with units, we get 178 m (or 583 ft), which is substantially longer than a standard field—about 45% longer. This means air resistance has a huge impact on baseball. If we kept the field the same, baseballs hit at a wide variance in angle would be home runs, driving up the scores A LOT! If we wanted to keep the scoring roughly the same, we'd need to move the back fence 44 m farther out (145 ft). And to carry the calculation through, if we hit the fastest baseball ever recorded it would travel 217 m (or 711 ft).

THIS LEADS TO THIS ISSUE'S PUZZLER! GIVEN THE INFORMATION IN THIS ARTICLE AND ANYTHING YOU CAN ESTIMATE, CONSIDER THIS:

Often a ball will be hit to the fence and passed toward home plate. If the outfield fence was, in fact, 183 feet farther out and a batter hit a ground ball all the way to the fence, how much **extra time** would it give a player to run around the baseball diamond to try and score? Would we even notice the time difference?

And if you are looking for an additional challenge, you can examine the relative effects of air drag and ball spin.[3] I challenge you to examine whether ball spin increases or decreases how far a hit ball will travel.

If you would like to share your work and answers on social media, please tag @SPSNational and we will repost you! //

Notes:

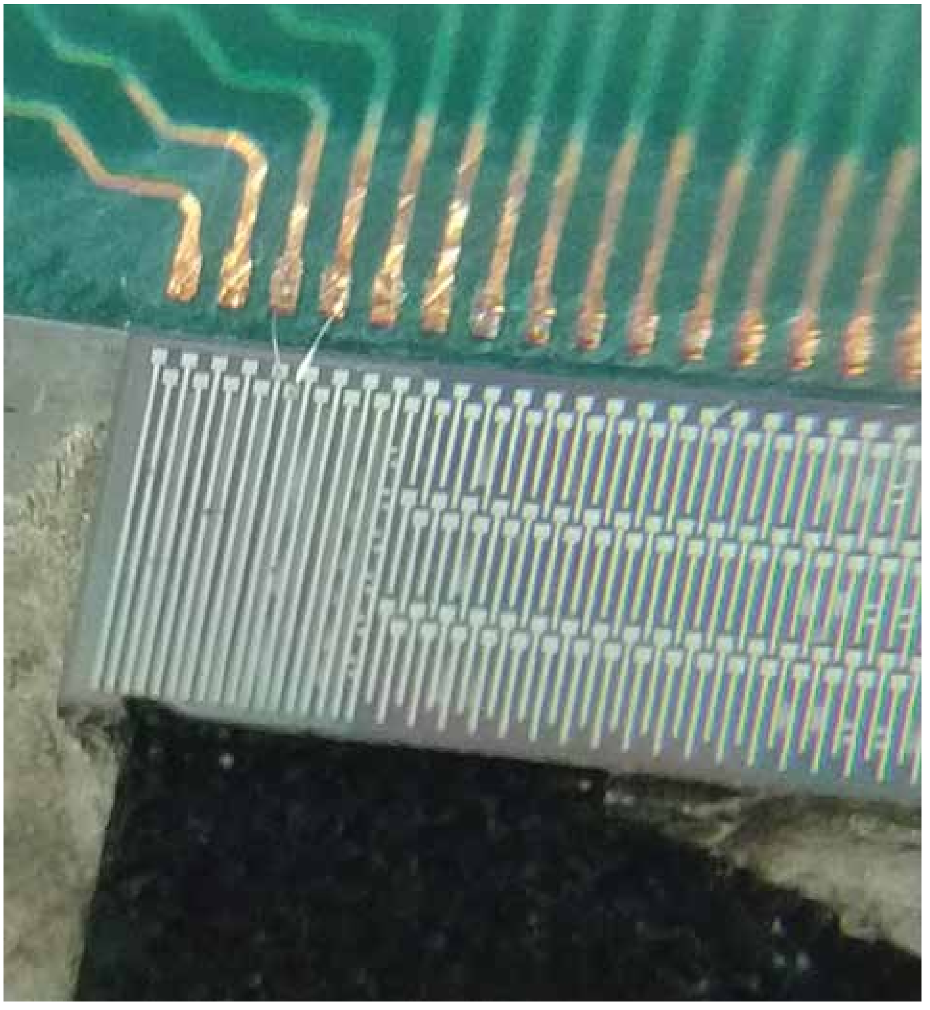
1. I say "heartwarming" because anytime I can avoid a complicated differential equation, my students say it's a good day.
2. Robert K. Adair, *The Physics of Baseball*, 3rd ed., Revised, Updated, and Expanded (New York: Harper & Row, 2002).
3. See either Robert K. Adair's book, or "The Effect of Air on Baseball Pitches," the webpage of Michael Richmond, accessed March 6, 2022, spiff.rit.edu/richmond/baseball/traj/traj.html.

Seeing the Invisible at NIST

by Joseph Tibbs, 2019 SPS Summer Intern and PhD Student, University of Illinois Urbana-Champaign

How do we know what we know? In philosophy, this question is addressed in a field of study called epistemology. In the sciences, the nearest approximation of this would be metrology. Every measurement has inherent imprecision and bias, and metrologists seek to understand these errors and improve measurement technology. Microscopy overlaps heavily with these ideals and specifically seeks to create images of things that were previously invisible. My desire to learn about biological molecules at greater precision than ever before, and my background in physics and biochemistry, means I end up doing a lot of microscopy.

In the summer of 2019, I found myself immersed in a unique research environment in which metrology was the starting point and focus, with every other field of physics (and science as a whole) stemming from that perspective. The campus of the National Institute of Standards and Technology (NIST) is located just outside of Washington, DC, and I was stationed there as part of the SPS summer internship program. Other members of my cohort were exploring science policy on Capitol Hill, science communication at *Physics Today*, library science at the Niels Bohr Library & Archives, and engineering at NASA. Meanwhile, I was at NIST, a place where seeing the invisible is an everyday occurrence.



LEFT: Joseph Tibbs. Photo courtesy of SPS National.

ABOVE: A sample chip which was used in taking the calibration measurements. Photo courtesy of the author.

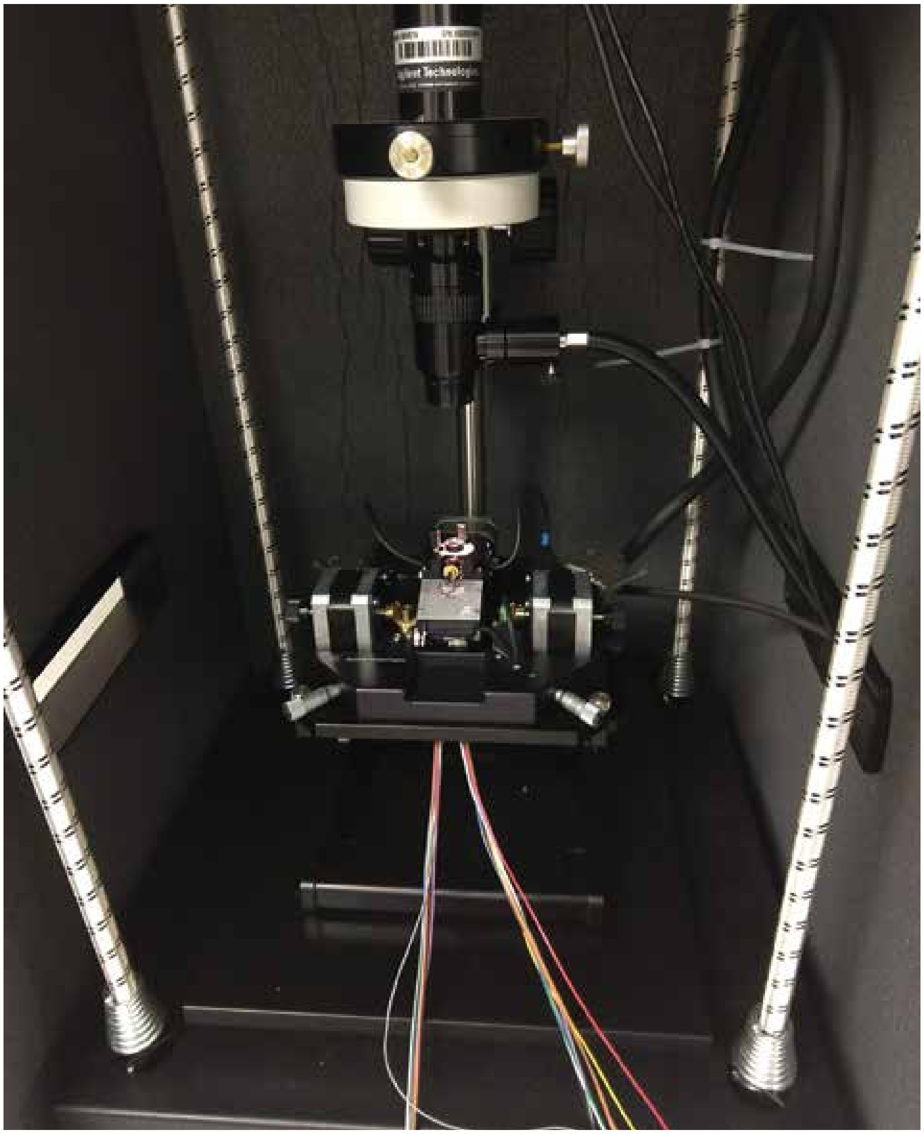
At NIST the goal of creating cutting-edge measurement technology mingles with the practical concern of ensuring that business runs smoothly and with well-defined and rigorously implemented standards. Standards underlie everything from civil engineering to the design of semiconductor chips. How do you ensure that building codes adequately protect against deadly fires? By studying the physics of fire using advanced simulations. How do you conduct quality control on computer chips? By finding defects before they get placed into devices.

For those of us researching under Joe Kopanski, the leader of the Nanoscale Imaging Group at NIST, this meant working on a technology called electrostatic force microscopy (EFM). In most scanning-probe microscopy techniques, a vibrating cantilever with an atomically sharp tip scans over a surface at a distance of mere nanometers. The forces on the tip, resulting from miniscule changes in topography or surface properties, lead to a shift in resonant frequency that can be measured by sensitive electronics. Because the measurement is based on near-field interactions, subnanometer resolution is the result.

Specifically, our group wanted to adapt this technology to search for defects in embedded wiring in layered integrated circuit devices. Although these wires are covered by insulating material, electrostatic forces from applied voltages can still propagate a short distance and be picked up by the tip of the EFM machine. In the process of characterizing this machine, I learned about the physics of probe microscopy through both hands-on interactions with the machine and by building software simulations of the system.

It's hard to collect a complete data set during a 10-week internship. Some would see this as a downside—if I didn't publish a paper or generate visible results, what was the point? But if working at NIST taught me anything, it's that what isn't visible can be just as impactful. My senior thesis, which I completed the following year, relied on data taken on a scanning-probe microscope that just happened to be identical to the one used at NIST. The simulation tool I learned to use during the internship is commonly used in my current lab to help design new photonic materials.

At NIST I also had a long conversation with John Kasianowicz, a biophysicist, about science career paths and what it means to find your field. He encouraged me to never think of myself as being tied to a single field; he started in electrical engineering before working with biomolecules. When I took my qualifying exam last year as part of my PhD program, I had to give a presentation on two research papers, one of which was about a technology called nanopore sequencing. When I looked at the references of this paper, one entry stood out—a paper that provided the first experimental evidence of nanopore sequencing. The author: J. Kasianowicz.



ABOVE: The scanning-probe microscope used to collect data. Photo courtesy of the author.

Internships provide skills and experience relevant to your field of study, but they also broaden your horizons. All of science is interconnected, to much the same degree as the fields of microscopy and metrology are. The more connections you can make, both between pieces of information and between collaborators, the better. And, as in an integrated circuit, just because the connections are invisible doesn't mean they aren't important. //

BE AN SPS SUMMER INTERN!

The SPS summer internship program offers 10-week positions for undergraduate physics students in science research, education, and policy with various organizations in the Washington, DC, area. All internships include paid housing, a competitive stipend, support to attend a national physics meeting in the year following the internship, and transportation to and from Washington, DC.
To learn more, visit spsnational.org/programs/internships. Mark your calendar for summer 2023! The application deadline is January 16.

The DIY Demonstration Box Project: A Shift in Outreach Strategy

by Molly Griston, SPS Chapter Social Chair and Past President, Fiona Gaffney, SPS Chapter Business Manager, and Vashisth Tiwari, SPS Chapter President, University of Rochester

In 2020 we witnessed a new sociopolitical awakening through Black Lives Matter protests around the country. For our chapter it was a time of reflection. We realized that simply supporting the protests and condemning racism, white nationalism, and police brutality were not enough. Given that physics remains one of the least inclusive academic fields, our chapter decided to make intentional changes so that we can play our part in making physics a more diverse and inclusive space.

One of these changes involved adjusting our outreach strategy, which previously relied on K–12 students coming to us for on-campus events. We recognized that this strategy had helped to reinforce the systemic disadvantages faced by underprivileged students while favoring students with the resources to visit our campus. In order to address this, we decided to work with nearby schools, especially those in the Rochester City School District (RCSD), where the population is majority low-income students of color.

Due to COVID-19, however, it was impossible to implement traditional outreach efforts such as school visits, and we had to find another way to engage with these students. So, with the support of an SPS Marsh White Award, we created the DIY Demonstration Box Project. The project was the brainchild of Fiona Gaffney, then our chapter's outreach committee chair, and other Executive Board members. Each box contained the materials for three do-it-yourself physics demonstrations: a popsicle stick catapult, a constellation circuit made of conducting tape and LED lights, and a diffraction grating.

We designed the boxes so that students could engage with physics in an enjoyable way while learning about projectile motion, electricity, and the nature of light. For each activity we included written instructions and brief video lessons highlighting relevant physics concepts. We made 175 student boxes and delivered them to RCSD teachers who expressed interest in participating.

Because the students assembled the demonstrations themselves, the project promoted physics in a hands-on, creative way. In addition, the activities were COVID-safe and accessible to more students—participation wasn't limited to classes with the means to visit our campus.

We're still collecting feedback from teachers and students on the activities and related physics concepts, but the initial responses have been encouraging. Hopefully, the excitement of the boxes will spread beyond the students as they share the demonstrations with their family and friends.

Through the activity planning, box creation, and common goal of sharing our love of physics, this project brought our chapter members at the University of Rochester closer to each other and to our goal of promoting a more diverse and inclusive physics community. The DIY boxes mark the beginning of our reformed outreach approach. We hope to continue working more closely with RCSD schools and playing our part in making physics a more inclusive and accessible community. //

TOP: Some of the 175 student boxes waiting to be filled.

ABOVE: University of Rochester SPS members pack the DIY demonstration boxes. Images courtesy of the chapter.

GET MONEY FOR CHAPTER OUTREACH EVENTS!

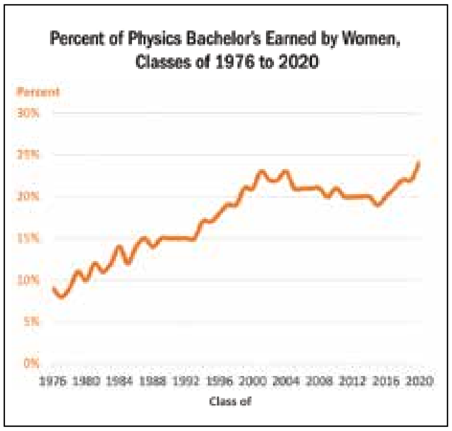
The University of Rochester received an SPS Marsh White Award to help support this project. SPS Marsh White Awards provide up to $500 in funding to support SPS chapter projects designed to promote interest in physics and astronomy among students and the general public. They are funded by the generous donations of Sigma Pi Sigma members and friends of SPS. Applications are due November 15 each year. For details visit spsnational.org/awards/marsh-white.

A HALO of Opportunity for Women Interested in Physics

by Victoria Catlett, SPS President, University of Texas at Dallas, with Kendra Redmond, Editor

In the United States, women are half of the population but only a fifth of the physicists. Hoping to increase the number of women who go into physics in a small way, last year our SPS chapter at the University of Texas at Dallas hosted a two-day virtual boot camp. Called the Physics High-School Advanced Learning Opportunity (HALO), our event included Python programming workshops, talks from professional physicists, a panel discussion of undergraduate women in physics, and informational sessions on getting involved in research and outreach.

We designed this event to provide women in our community with a physics foundation and to inspire them to study physics. Eight high school students attended—fewer than we'd anticipated, but given the outcomes, we hope to make this a recurring event.



TOP RIGHT: Image courtesy of the University of Texas at Dallas SPS chapter.

ABOVE: Women make up less than 25 percent of those earning physics bachelor's degrees in the United States. This drops below 20 percent at the PhD level. Image by the Statistical Research Center of the American Institute of Physics. www.aip.org/statistics/undergraduate.

The two days were packed with activities, including talks on condensed matter physics, machine learning, pulsar stars, and STEP UP, an American Physical Society initiative to increase the number of women in physics. We taught the attendees some Python, worked together on physics problems, and had a panel of undergraduate women from four different universities. The program featured several women physicists, demonstrating that women can and do become successful in the field. And we encouraged attendees to connect with us via LinkedIn or other platforms and stay connected throughout their careers, as we want them to feel like members of the physics community.

Here's some of the feedback we got from attendees.

- I loved all the discussions from the speakers and how informational they were. Not only did they offer a great general introduction to their various fields, but they discussed actual content [from their research], which I thought was super cool.
- I got a really great glimpse into what I plan on pursuing in the future. I gained a lot of insight through all the talks, which I will definitely use to guide me as I prepare for college as well as undergrad research in physics or astronomy!
- I learned a great variety of computer programming skills that I will be implementing in the future . . . There were so many great resources introduced to me this weekend that I will for sure be taking advantage of. All in all, I got a nice introduction to the physics world that has only heightened my desire to learn more.

A lot of preparation went into making this boot camp happen. We designed a two-part Python workshop, created an entire website for hosting program information and the application form, came up with fun physics problems, and finally—with everyone's permission—recorded most of the sessions so that attendees could reference them in the future.

HALO had a deep impact on our SPS members. We sharpened our public speaking skills and learned how to break down scientific concepts. The men among us became more aware of the struggles faced by women in STEM, and the women learned how to better overcome some of the gender-based obstacles we face. All of us are more ready than ever to make the field more equitable. And finally, the event brought home the value of outreach. Being able to tangibly change the community in a positive way acted as powerful motivation. As a chapter, we're planning to increase our focus on external outreach now that we've seen the profound impact we can have. //

GET MONEY FOR INCLUSIVE CHAPTER EVENTS!

The University of Texas at Dallas received an SPS Future Faces of Physics Award to help support this project. Future Faces of Physics Awards provide up to $500 in funding to support SPS chapter projects designed to promote physics and astronomy across cultures. They are funded by the generous donations of Sigma Pi Sigma members and friends of SPS. Applications are due November 15 each year. For details visit spsnational.org/awards/future-faces.

Tackling Challenges One Coffee at a Time

by Korena Di Roma Howley, Contributing Editor

When Calvin University reopened following COVID-19 shutdowns, student and SPS president Willem Hoogendam realized that some undergraduates—particularly first-year international students—had missed out on a key element of campus life: getting to know other students. This sparked his idea to start a mentorship program that would pair first-year physics and astronomy majors with upper-level students for meaningful one-on-one coffee chats. Hoogendam also wanted to encourage camaraderie by subsidizing the cost of department quarter-zip sweaters for interested students.

In response to his proposal for the program, the Calvin University SPS chapter received a 2021 Future Faces of Physics Award of $500 to cover coffee vouchers and department attire. The awards are made annually to SPS chapters whose proposed projects aim to promote physics and astronomy across cultures and support students from groups historically underrepresented in the field.

ABOVE: Students meet for coffee as part of a mentorship program made possible by a Future Faces of Physics Award. Photo courtesy of the Calvin University SPS chapter.

Among the goals for the chapter's mentorship program was providing the chance for students of all backgrounds to thrive at the university, and in particular, to support those students who were transitioning to campus life while facing the additional challenges of cultural transition.

Hoogendam, who oversaw the program, explained that mentors and mentees were paired based on interests. For instance, new astronomy majors met with third- or fourth-year astronomy majors, and women were paired with women. The one-on-one coffee meetings promoted in-person gatherings that followed the university's COVID guidelines, which prohibited large in-person meetings. Coffee vouchers provided students with additional incentives for meeting up.

"We wanted to find a way to connect with each other despite COVID," Hoogendam says. The coffee meetings, he says, stimulated conversation and helped students build relationships with each other when they might otherwise have faced isolation. These relationships also gave new students someone to turn to with questions and concerns. "It's easier to ask a friend for help than it is to ask a stranger," Hoogendam says.

According to Hoogendam, about 85 percent of students in the department participated in the program. They reported stronger relationships within the department and that they enjoyed the chance to meet with other physics majors face-to-face, an opportunity normally taken for granted.

Most importantly, first-year students and students from underrepresented groups were welcomed into the department. This helped them overcome some of the obstacles and barriers that might have prevented them from successfully pursuing physics and astronomy. In addition, the women appreciated having strong female role models to turn to for advice, inspiration, and support.

Hoogendam says the coffee meetups caught on and have continued, with students largely arranging them on their own now. And those who were first- and second-year mentees when the program began now find themselves in a mentoring role. "It's kind of gone full circle," he says.

There have also been secondary benefits. One of the coffee chats led to the creation of a Discord server, which now includes both students and alumni. And the department quarter zips that have helped to unify physics and astronomy majors on campus will serve the same purpose at meetings and conferences.

Hoogendam says one of the program's biggest challenges was communication between students. When it comes to connecting, he says, it's important to take initiative. "People are definitely willing to connect and willing to be with each other, but sometimes there's confusion about where to begin, so if you provide that initial nudge of, 'Maybe we should begin here,' people will jump on that." //

Melissa Schmitz

BA in Physics and BS in Chemistry, Le Moyne College

ABOVE: Melissa Schmitz works with a VR simulator. Photo by Herb Vasquez.

What she does

I am an R&D engineer creating new product prototypes for the material handling industry, with a general focus on making use of the most cutting-edge technology available. In particular, my projects tend to focus on machine learning, vehicle automation, and extended realities (XR).

The lifecycle of these commercial R&D projects is significantly shorter than research projects in academia, so innovation happens at a comparatively fast pace. As someone who always found herself going on tangents with new ideas, an environment where these tangents are at the very least seen as valuable exercises—if not the next big thing—turned out to be a better fit for me than the hyperspecificity of the slower-paced academic research process.

How she got there

I prefer the small school environment, so I studied at a private school in Syracuse, New York, called Le Moyne College, where I graduated with a dual bachelor's in physics and chemistry. I actually started out on a premed track as a biochemistry major. I was always generally interested in STEM, and while taking my first physics class with the incredible Dr. David Craig, I discovered how deeply interesting physics could be (especially quantum mechanics!).

My whole life I had been interested in getting to the root of scientific phenomena, but it just never dawned on me how crucial physics was to that fundamental understanding. Especially for young girls, physics is typically presented as dry and boring math, or with a focus on things like rockets and cars. I was never particularly interested in those things, so I ended up focusing a lot on psychology and human anatomy to understand my own experiences.

However, learning more about physics and math unlocked a deeper connection to the world around me as I became acquainted with the bottom-up thought process you typically apply in physics. I don't come from a family with STEM or academic careers at all, so this took me some time to figure out, but I'm certainly glad I did!

Bringing a unique perspective

As it turns out, my background is very different from those of my colleagues, who all graduated with traditional engineering degrees. At first there was a big adjustment period, because I had to learn general engineering principles on the job. However, it actually turned out to be a positive, as I'm able to come up with fresh ideas because of my unique perspective and extensive academic research background. I might end up asking a question about something that at first seems obvious to most engineers but was actually overlooked.

Advice to physics students

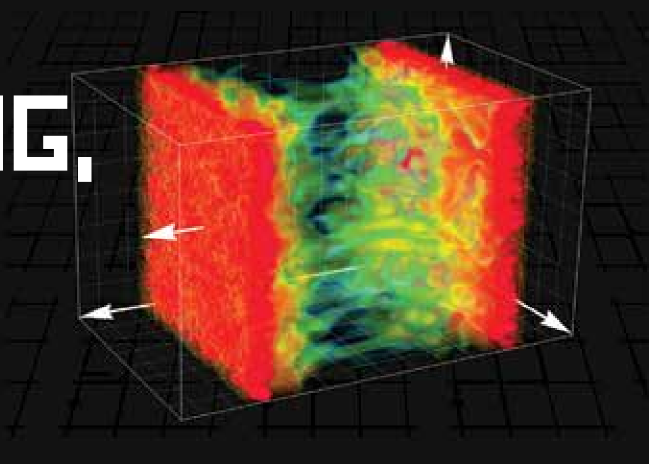
Explore your career options in earnest. Even if you feel dead-set on pursuing physics or astronomy in graduate school or more generally as your career, it's important to have a clear view of what's out there so you can be confident in your decision. After all, it's a big one that involves a lot of time and money!

While unintentional, being in a university setting biases you toward the bubble of academia. When you ask professors for advice, they may be inadvertently directing you to follow the same path they did.

So whether it's taking an internship, participating in outside events like hackathons, attending career talks, or pursuing your own personal projects, I think it's important that while you're still learning who you want to be in college you give various things a chance. After all, even if you find a particular class exciting, you may hate the work of applying it (or vice versa). You can research your options all you want, but nothing compares to lived experiences when you're trying to figure out how you want to spend the next several years of your life!

I didn't end up pursuing academic physics like I thought I would, but I still got a lot of value out of my degree and my research experience, both of which have helped me grow in my career. //

MACHINE LEARNING, PHYSICS, AND YOUR FUTURE



by Kendra Redmond, Editor

We live in a data-driven world. When you buy coffee, retweet, binge watch, search, or walk near a security camera, your behaviors and choices become part of the data landscape. You know that already, and you also know that data is valuable. But you may not know that all this data, in combination with advances in semiconductor computation devices, has given physicists and astronomers the opportunity to make a big impact on society in the form of machine learning.

Machine learning is a tool for making sense of data, and it lies at the intersection of physics and astronomy skills, job opportunities, and change-the-world potential. It's what's under the hood of today's photo filters, autonomous cars, online fraud detection programs, and language translation software. It's powering cutting-edge research on disease detection and treatment, extreme weather prediction, and other big challenges facing society.

MACHINE LEARNING 101

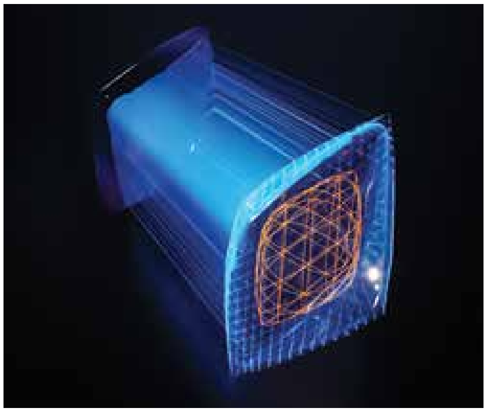
A subset of artificial intelligence (AI), machine learning describes a system in which an algorithm, or set of algorithms, learns from data and adapts.

Physicists and astronomers traditionally use their knowledge of a system to build a model. By running simulations and comparing the results with real data, they uncover what's happening in the physical system. Machine learning flips that approach, says Michelle Kuchera, a computational physicist and assistant professor at Davidson College. The machine learning approach says, "I'm not going to make assumptions about the model. I'm going to learn from the data, let it tell me something," she says.

In practice, this involves starting with an algorithm or set of algorithms appropriate for the task. Next comes training the model with lots of existing data. As the model learns, the algorithm evolves to better accomplish its task when it meets new data.

For example, if you want to identify cats and dogs in pictures, you start with a classification algorithm. You train the algorithm with lots of pictures of cats and dogs, telling it which is which. Through this process the algorithm learns the difference between cats and dogs and, in response, self-adapts to distinguish between them. A well-trained system can then accurately classify the subjects of new pictures as cats or dogs——even though you never defined the difference.

You can think of machine learning as pattern matching, says Vijay Janapa Reddi, an associate professor of engineering and applied science at Harvard University. With a machine learning system, you "implicitly let it learn the pattern that's inherently in the data, rather than explicitly code rules to identify a pattern that you may not even be aware exists," he says.



TOP: Theoretical physicists at Vienna Institute of Technology (TU Wien) have shown how neural networks can help us study the quark-gluon plasma and other computationally complex particle physics environments. This image shows a quark gluon plasma after the collision of two heavy nuclei. For details on this research, see doi.org/10.1103/PhysRevLett.128.032003. Image courtesy of TU Wien.

ABOVE: In a collaboration between Stanford University, Lawrence Berkeley National Laboratory, MIT, and other institutions, researchers are using AI to better understand why batteries wear out. This is an artist's rendition of a particle analyzed by a combination of machine learning, X-ray images, and electron microscopy. For details on this research, see doi.org/10.1038/s41563-021-01191-0. Image by Ella Maru Studio.

WHAT DOES THAT HAVE TO DO WITH PHYSICS AND ASTRONOMY?

Machine learning is a powerful tool for physics and astronomy research. Browse a journal like *Applied Physics Letters* or *Astrophysical Journal Letters* and you'll find physicists and astronomers applying machine learning to tasks such as predicting the characteristics of new materials, fabricating qubits, identifying stellar objects, and finding anomalies in massive data sets.

"If you look at the Large Hadron Collider, or any such scientific instrument, there's a lot of fine-tuning that needs to happen in real time to precisely control them. It's great to be able to do that using machine learning . . . you'll be able to infer very complex control patterns much more easily," says Janapa Reddi.

If you choose a career in physics and astronomy research, you'll probably be applying machine learning or collaborating with someone who is before too long. It's not magic, but machine learning can handle many situations that are difficult for conventional methods. It's another tool in the physicist's toolbox.

"Machine learning is really great for cases where you don't have an algorithm with explicit rules on how to accomplish a certain task," says Kuchera. She says it's also great for discovery—looking for patterns, outliers, or unexpected behavior in data, and for making fast theoretical predictions.

Machine learning is essential for physics and astronomy research in other ways too. In its early days, machine learning was done at large-scale data centers, but now the technology has moved into our phones and homes—think Alexa and Siri. It's not cost effective, energy efficient, or at times even practical to move all this data into the cloud for processing. As a result, the machine learning community is pushing to the edge, moving the data processing or computation as close as possible to the actual data.

At the forefront of machine learning research is something called tiny machine learning, or tinyML. It's the concept of running machine learning models at the point of data collection using ultralow power. This enables always-on sensors or other devices that can operate for years without recharging. And when it comes to next-generation particle accelerators and other huge scientific instruments that will operate in real time with many moving parts, we'll need this technology. "There is absolutely no way you can stream this data to some cloud computing model," says Janapa Reddi. It won't even be possible to move the data off the device, because the real-time latencies will interfere with the integrity of the data, he says.

If you're thinking about a future in industry, machine learning is worth considering. According to Sandeep Giri, a staff project manager at Google, there are all kinds of technical and nontechnical career paths in the machine learning and AI space, from software engineering to hardware design, systems engineering, supply chain, operations, product and project management, sales and business development, and beyond. People with a physics and astronomy background can and do grow into all these careers, he says. You don't need a graduate degree, and there are tons of jobs. "I believe that every tinyML company, large Fortune 500 or startup, involved in energy-efficient machine learning is hiring like crazy," says Evgeni Gousev, senior director at Qualcomm Technologies, Inc.

ABOVE LEFT: Evgeni Gousev is senior director at Qualcomm Technologies, Inc., and chairman of the board of directors of the tinyML Foundation, www.tinyML.org. He has a PhD in solid state physics. Photo courtesy of Gousev.

ABOVE RIGHT: Sandeep Giri is a staff project manager at Google, cloud.google.com/tpu, and on AIP Foundation's board of trustees. He has a BS in physics and an MS in materials science and engineering. Photo courtesy of Giri.

I'M NOT QUALIFIED FOR THAT. AM I?

Physics students and academic physicists often tell Gousev that they'd like to work in industry, but they don't see themselves as qualified. This is just a "perceived barrier," says Gousev. He says most physics and astronomy undergrads can pick up the basics of machine learning in a matter of months. That's because they already have the math background, real-world data experience, training in logical problem-solving, and the ability to look at the world and connect the dots.

Physicists are also good at asking critical questions, and that's especially needed in this emerging field, says Giri. What and where is the problem? What are possible solutions? Should we even be solving this problem? Who else might utilize this solution? What biases and inequities might emerge if this method is used on other data sets, like data on people?

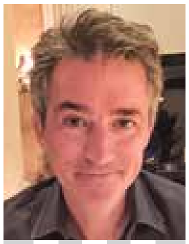
If you're interested in pursuing machine learning, the first step is to develop confidence in yourself and your background, says Sean Grullon, lead AI scientist at Proscia. Then, he suggests reading machine learning blogs to get a feel for the vocabulary and what researchers are working on. "If that kind of stuff excites you, then it's a good indication that you should investigate it further," Grullon says. From there, he suggests learning basic Python, if you haven't already, and then exploring project examples and online classes.

Janapa Reddi notes that it's also important to learn all you can about data collection, data engineering, and evaluating results. He says that system architecting is one of the biggest challenges in industry today and the reason many startups fail. A good model is worthless if you don't understand how it works in the field. "It's one thing to get a nice accuracy number on a chart in your notebook; it's a whole different thing when you put it into practice in the real world," he says.

As a community that only loves cows when they're spherical, that's definitely something all physicists know. //

This article is adapted in part from "A Physicist's Guide to Machine Learning and Its Opportunities," which appeared in the Spring 2022 issue of Radiations.

MACHINE LEARNING AT WORK



JOHN BURKEY, FOUNDER, CEO, AND CTO OF BRIGHTEN AI

BS in Physics, History, and Computer Science

A few years ago, I was looking for something new to do and I called my buddies at Apple. They told me that Siri was super interesting, but they were kind of stuck. I joined the Siri team and have been in voice recognition since. Along the way I realized that people had bolted together a bunch of components but didn't really understand how any of them worked. So I founded Brighten Ai, which takes a physicists' approach to voice recognition. We've broken everything down to first principles, looked at all the components, and reassembled them with the end goal in mind.

A big part of our work is in architecting things. When we listen to a person talk, we get a lattice of possibilities for every 10-millisecond frame, where any one of several phonemes could exist. It's like we have a ball of probabilities of sounds and words. We compile this for all the frames and explore what the person is trying to say with grammar, vocabulary, and knowledge structures that all work together. This generates more probabilities, and the system picks the most likely one based on context—that's another *n*-dimensional space. We call it dialogue.

Our goal is to provide companies with a platform on which they can build a product. In this new phase of the high-tech industry, there's more room for suppliers and smaller shops to participate in the bigger ecosystem. It's a place where scientists can have a high degree of impact.

SEAN GRULLON, LEAD AI SCIENTIST AT PROSCIA

BS, MS, and PhD in Physics

I am the lead AI research scientist for Proscia, a medical imaging startup company. We research machine learning algorithms for computer vision in order to analyze medical images. If you get a tissue biopsy that needs to be screened for cancer, a pathologist examines it under an optical microscope to look for evidence of a cancerous tumor. This is time-intensive and difficult. We're developing tools to help pathologists diagnose and triage cancer faster. We're focused on melanoma, the deadliest form of skin cancer.

On a day-to-day basis, I work with algorithms that we're researching in-house or that have worked well in other domains to see how well they work for medical imaging. We don't have a product on the market yet, but we published some good results from our AI algorithm last October.

I worked with machine learning a couple of times during my physics PhD research, but it was just one of many different techniques I dabbled with to get results. Machine learning started to take off when I graduated, and I've been applying it in the healthcare or pharmaceutical space ever since. I've found my path rewarding, very interesting, and very impactful. It's gratifying to see the clinical impact of your work.

ALL: Photos courtesy of the subject.

HELEN JACKSON, MACHINE LEARNING RESEARCHER

BS, MS, and PhD in Physics

I knew at the age of 12 that I wanted to be a physicist, but it was a convoluted pathway. After many curves I made it to physics graduate school at Fisk University and then at Vanderbilt. But Vanderbilt didn't allow graduate students to work, and I needed an income to support my family. I eventually accepted an invitation to work at the Air Force Research Lab, studying radiation effects on electronics, and simultaneously completed my PhD at the Air Force Institute of Technology as a civilian. It was a long path, but I made it.

I became a visiting physics professor for a while and taught myself machine learning during my free time. Eventually, I was offered a data science contract job. The job was my first introduction to machine learning as a physicist—using computer vision to detect threats in the cluttered airport environment via X-ray scanning. I also worked on predicting failures in airport equipment. It was fascinating.

During my next position, I leveraged multidomain machine learning for an array of military applications, from differentiating the signatures of bombs from earthquakes, to bio applications such as biotechnology and bioterrorism. Next, I continued as a government contractor, combining computer vision with natural language processing for complex document understanding, among other projects. Recently, I was retained as a consultant to apply machine learning and data analytics to epidemiology data. Once you grasp machine learning and have a core knowledge of the basic sciences—biology, chemistry, physics—you're prepared to work in many applications.

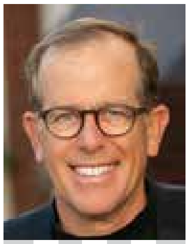
MICHELLE KUCHERA, ASSISTANT PROFESSOR OF PHYSICS AT DAVIDSON COLLEGE

BS and MS in Physics, MS and PhD in Computational Science

I'm a professor and principal investigator of the Algorithms for Learning and Physics Applications (ALPhA) group at Davidson College. We collaborate with physicists at various facilities across the country and world to help them develop AI solutions for nuclear and particle physics tasks. This includes data processing, data analysis, and making theoretical predictions.

For example, we use machine learning methods to help detector physicists and experimental physicists select out interesting particle interactions for further study in their experiments. We also use machine learning to make fast predictions. In some cases, the calculations for a theoretical prediction would take an extremely long time, but with machine learning we can build a surrogate model that does them much faster.

Machine learning isn't the solution to every challenge. If you have a solid understanding of the physics and the explicit mathematical rules to accomplish a task that you're interested in, then that is the preferred method, unless there's some challenge with implementation. However, machine learning has the potential to advance scientific discovery in areas where there are computational challenges.



CHRIS ROWEN, VP OF ENGINEERING FOR WEBEX COLLABORATION AI AT CISCO

BA in Physics, PhD in Electrical Engineering

My team works on the machine learning and AI building blocks that become key components of how our video conference calling platform, WebEx, works. For example, we extract different elements of an audio stream—voices, noise, reverberations, commands, keywords—and rearrange them to do things like eliminate noise, reduce reverberations, and identify keywords to act on. We do this in real time with a latency of roughly 20 milliseconds, which is virtually undetectable.

Similarly, we decompose complex video streams into important elements. Where are your hands? Where's your face? What gestures are you making? We can do a three-dimensional model extraction of your face and enhance it. We can change the lighting and give you a haircut. We are increasingly able to do things like track a person's gaze to see what they're paying attention to.

We're also doing a lot in natural language processing, such as taking transcripts of meetings and extracting out important events, comments, or commitments. And then we're doing deep analytics, looking at interactions within an organization. Who spends time talking to whom? Who is this person falling out of touch with? What do these things mean about professional relationships? From these deep analytics and machine learning, we improve the clarity and intuitiveness of the system's response. //

DIVE INTO MACHINE LEARNING

by Kendra Redmond, Editor

ADVICE FROM THE EXPERTS

We live in the age of open data sources, in other words, free data platforms and free data. Download those free platforms and use them to develop the code.
- Helen Jackson

Have confidence. Most employers in this field want to hire smart people who can work independently and think quickly. There is a vocabulary difference between the private sector and what you learn in school, but it's just vocabulary.
- Sean Grullon

ABOVE: Credit: XKCD, xkcd.com/1838/.

Garbage in, garbage out. Learn about the whole life cycle—data collection, data engineering, machine learning models, training the models, and evaluating models properly and in context. **- Vijay Janapa Reddi**

It takes a while to become acquainted with computing, but it's a linear task. Get online, try projects, and mess with the data to see what changes the output. **- John Burkey**

If you're interested in machine learning, also be interested in all the other computational methods and gain familiarity with them. **- Michelle Kuchera**

There are four or five major skills in computing: programming, debugging, using the tools, performance profiling, and testing/analytical understanding of when your products are ready. For each of those things it's important to think about how you can get real experience. **- Chris Rowen**

RESOURCES FOR GETTING UP TO SPEED

There are many widely available, internet-based resources on machine learning. This list is compiled from recommendations from the sources in *Machine Learning, Physics, and Your Future* and *Machine Learning at Work*.

Learning Python

- Machine learning is done in Python. Google's Python Class and Microsoft's Introduction to Python are good free online classes.

Blogs and background

- To get a sense of machine learning, its vocabulary, and what's happening in the field, check out blogs like *Google AI, Facebook AI, Berkeley AI Research*, and *Stanford AI Lab*.
- *Towards Data Science* is another great blog if you're just getting started. They have a lot of introductory articles that explain machine learning and deep learning algorithms and how to get started.

Setting up your system

- Scikit has a package for Python for machine learning with a good overview of machine learning algorithms and how to incorporate them in Python.
- Environments like TensorFlow (Google) and PyTorch (Facebook) allow you to quickly build models for whatever kind of data you have.

Online courses

- Platforms like edX, Coursera, Udemy, and Udacity have free or low-cost Python classes and machine learning classes with projects that you can complete and show a prospective employer. Andrew Ng's machine learning course out of Stanford is very popular, and it's free on Coursera.
- HarvardX's Tiny Machine Learning (TinyML) and Google are collaborating on a series of courses focused on TinyML. The courses cover topics from the fundamentals of machine learning to collecting data, designing and optimizing machine learning models, and assessing their outputs. The first three courses are available now on edX, tinyml.seas.harvard.edu/courses/.
- The Google Cloud AI Platform has tools, videos, and documentation for data science and machine learning, developers.google.com/learn/topics/datascience. The following resources may be especially helpful:
  - o Google's codelab "TensorFlow, Keras and deep learning, without a PhD"
  - o Online learning channel, youtube.com/user/googlecloudplatform
  - o Product documentation, cloud.google.com/docs
- fast.ai has courses, tools, and articles for people interested in getting into machine learning.

Getting data

- Don't have data? There are public domain data repositories with data on almost anything you could want, and most machine learning courses will direct you to them. Kaggle has lots of public datasets. //

SPECIAL FEATURE

GW SPS Chapter – Your Local Host for the Celebration of the Century

by Davie Loria, SPS Chapter Officer, Alexander van der Horst, Associate Professor of Physics and Deputy Chair, and Gary White, Adjunct Professor of Physics, The George Washington University

Our SPS chapter at The George Washington University (GW) is the local host of the 2022 Physics Congress. We are located right in the heart of Washington, DC, and are excited to welcome so many physics students to our city. We are planning lots of fun activities for you.

On the first day of PhysCon, there's a walking tour through DC that includes national monuments and other amazing spots in the city. The first stop will be GW's historic Corcoran Hall. This building is home not only to our physics department, but to lots of physics history as well. It's where the famous Alpher-Bethe-Gamow cosmology paper was written,[1] Niels Bohr announced the splitting of the uranium atom, and the bazooka was developed.

The GW physics department has illustrious alumni, including George Gamow and Edward Teller, who were both inducted into Sigma Pi Sigma at GW in 1936. There are several tributes to their work in physics in and around Corcoran Hall. Be sure to check them out during the walking tour!

On the Friday night of PhysCon, we are hosting an evening full of games and physics inside Corcoran Hall and in the nearby quadlike area called University Yard. There will be all the board games you can imagine, trivia, physics demos, SPS outreach, and more! Telescopes will be set up for stargazing, and there will be hot chocolate, cookies, and other treats. It will be a great opportunity to make new physics friends, relax, and hang out with like-minded people.

Then, on Saturday night, we'll contribute to the Centennial Festival! There will be music, demos, and activities, as well as a bunch of booths and exhibits to explore from other groups.

We look forward to meeting everyone at the 2022 Physics Congress and being the local hosts for this centennial celebration, which is bound to be an incredible conference filled with learning and fun! //

Notes:

1. Alpher, Ralph A., Hans Bethe, and George Gamow, "The Origin of Chemical Elements," *Phys. Rev. 73*, (April 1948): 803. doi.org/10.1103/PhysRev.73.803.

   For the entertaining story of how Bethe became an author see "April 1, 1948: The Origin of Chemical Elements," *APS News*, 17 no. 4 (April 2008). aps.org/publications/apsnews/200804/physicshistory.cfm.

ABOVE LEFT: GW SPS board members Gabe Grauvogel, Marisa Lazarus, Addy Irankunda, and Davie Loria having fun with atoms.

ABOVE RIGHT: GW SPS board members Gabe Grauvogel, Marisa Lazarus, and Danny Allen making liquid nitrogen ice cream. Photos courtesy of the SPS chapter.

ABOUT US

Our chapter has won SPS Outstanding Chapter Awards for the last several years. Our regular activities include outreach at local after-school programs to expose young students to science, in particular students from underrepresented groups in physics, and to get them excited about learning. We also host weekly homework clubs where any GW student can get physics homework help from SPS members, as well as ask questions, review concepts, or simply hang out and learn about physics. We organize fun social events for students and faculty, including the physics department's Halloween and holiday parties, which helps to foster a sense of community and belonging among those interested in physics at GW. This past year we also received an SPS Chapter Research Award to support building and launching a high-altitude muon detector balloon to measure high-energy particles in the Earth's atmosphere.

SPECIAL FEATURE

James Webb Space Telescope: Looking to the Past for the Future

by Mikayla Cleaver, SPS Programs Coordinator

How can looking to the past improve our future? The James Webb Space Telescope (JWST) is officially on the mission! JWST is a space-based infrared telescope on the lookout for some of the oldest and faintest objects in the universe—early galaxies, stellar nurseries, and more. After 30 years of development, JWST was launched December 25, 2021. The primary mirror fully deployed on January 8, 2022, and the telescope went into orbit around the sun on January 24, 2022. The telescope should be ready for science research around June 2022, six months after deployment.

The JWST will begin looking into the past by observing galaxies, star formation, and exoplanets as early as 100 million years after the big bang. Studying these early structures in the universe will give scientists insight into how life-sustaining elements, such as carbon and silicon, were formed. The telescope operates within the infrared light range to gather information—a difference from Hubble, which operated within the visible range. An advantage of this will be that the JWST can look through the interstellar medium to peer into stellar nurseries, better improving our understanding of the life cycle of stars.

The telescope is also searching for the first luminous objects after the big bang, studying galaxy evolution, and investigating the potential for life in other solar systems. The JWST is not exclusively for NASA use—any scientist can apply to perform research using the new telescope. For the first three cycles of observation, 16 percent of the observation time will be allotted to scientists outside of NASA. From the first round of proposals, 266 applicants were selected to use the new telescope to study things ranging from asteroids within our solar system to galaxy formation. The James Webb Space Telescope will open many doors in astronomy, exponentially expanding our understanding about galaxy formation, the life cycles of stars, and the other mysteries of the universe. //

ABOVE: The first image that JWST captured. The image will be used to align the telescope's mirrors and get it ready for further research. Photo courtesy of NASA.

I'm thrilled that our golden eye in space has survived all challenges so far, including the vibrations and noise of a rocket launch, and now the vacuum of outer space. I'm completely in awe of our project team—10,000 people who made this happen, and made it look easy when it isn't.

We're well along with commissioning the observatory. We've taken our first images of a bright star, and we're beginning to focus the 18 hexagons to function as one giant hexagon. We have every reason to think that we'll be able to see everything that happened, from the birth of the first galaxies and black holes to grow after the big bang, to the first exploding stars, to stars and planets being born near us in glowing clouds of gas and dust, to exoplanets transiting in front of their host stars, to all the planets, satellites, asteroids, and comets from Mars on out.

Look for new science around the summer solstice!

- John Mather, Physics Nobel Laureate, Senior Astrophysicist at NASA Goddard Space Flight Center, and friend of SPS

FOR MORE INFORMATION, CHECK OUT THESE SOURCES:

"In Depth: James Webb Space Telescope," Solar System Exploration, NASA Science, January 24, 2022, solarsystem.nasa.gov/missions/james-webb-space-telescope/in-depth/.

"Early Universe," Webb Space Telescope, webbtelescope.org/webb-science/early-universe.

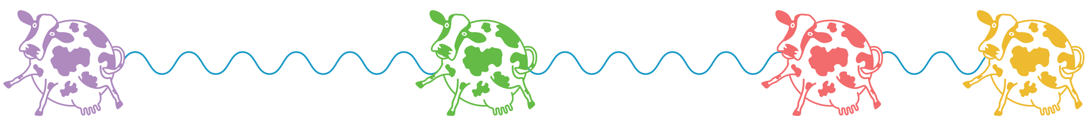
Martin Barstow, "James Webb Telescope: How It Could Uncover Some of the Universe's Best-Kept Secrets," January 2, 2022, space.com/jwst-universe-best-kept-secrets.

SOCIETY OF PHYSICS STUDENTS

An organization of the American Institute of Physics

QUARKS / LEPTONS	I	II	III	interactions / force carriers (bosons)	
	three generations of matter (fermions)				
QUARKS	u Geo	c Bio	t Chemical	g Teaching	H Hidden
QUARKS	d Quantum	s Atmospheric	b Optical	γ History	
LEPTONS	e Materials	μ Astro	τ Medical	Z Pure	
LEPTONS	ν_e Solid State	ν_μ Nuclear	ν_τ Engineering	W Applied	
				GAUGE BOSONS	SCALAR BOSONS

PHYSICISTS AND ASTRONOMERS COME IN EVERY FLAVOR:



New Ones Discovered All the Time

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Find us @SPSNational:

... and Astronomy

by the SPS and Sigma Pi Sigma Governance Committee: Julia Bauer, Shannon Clardy, Brad Conrad, Van Haslett, Larry Isenhower, Taylor Knapp, and Emma Rasmussen

SPS isn't just for physicists! From the very beginning, the society was created to support all those interested in physics and astronomy. Now, we are very excited to be making that official.

Last September the SPS National Council convened in Washington, DC. As part of that meeting, we discussed the importance of making our astronomy and astrophysics members feel welcome and supported in the SPS community. That has always been the intention, but at times astronomy has unintentionally been left in the shadow of physics.

After discussions with students and the SPS and Sigma Pi Sigma Executive Committee, the National Council proposed changing SPS's bylaws to reflect our mission of supporting physicists, *astronomers,* and *those in related fields*. Additionally, we proposed modifying the constitution to declare Sigma Pi Sigma as the honor society of physics *and* astronomy.

The SPS Council's Governance Committee then sent the following explanation to SPS chapters with the proposed changes.

> *While Sigma Pi Sigma has strived for almost 100 years to support those who study physics and astronomy, the society should be explicit in its support of the students within Physics and Astronomy so that everyone knows they belong within SPS and Sigma Pi Sigma. It has come to the attention of the Society of Physics Students that those with an interest or focus in Astronomy may not feel included within our society. Going back to our founding documents, the intention has always been to support students who study within physics and astronomy departments.*

A change to the constitution requires approval of the SPS National Council and a majority of its chapters. So, after the SPS National Council approved the change, it was put to a chapter vote. The measure passed with 93% approval! This high level of support suggests that most SPS members are as excited as we are to finally give equal footing to astronomers and astrophysicists in the SPS and Sigma Pi Sigma community.

Kevin Marvel, Executive Officer of the American Astronomical Society and longtime friend of physics and astronomy students, enthusiastically supported this change. "It is truly an honor to have astronomy now intentionally included in SPS and Sigma Pi Sigma through the historic constitutional change just approved by the membership of these important organizations," he says. "Although astronomy has always been present in the interests and focus of both organizations, having astronomy specifically called out in their foundational documents will welcome those identifying more closely with astronomy and let them know they can join and support SPS and Sigma Pi Sigma."

While SPS and Sigma Pi Sigma will retain their names, Sigma Pi Sigma will officially become the "physics *and astronomy* honor society." The SPS mission will now be "to encourage and assist students interested in physics *and astronomy*." Our documentation, websites, and publications will be revised to reflect this inclusivity. Furthermore, chapter resources will explicitly cater to students with interest in physics, astronomy, and closely related fields. We're looking forward to collaborating with the American Astronomical Society as we make this transition to a more welcoming and accessible community for astronomy students.We also look forward to collaborating with standalone astronomy programs on their potentially new chapters of SPS!

While we make these changes on an institutional level, we ask that you and your chapter extend the full range of SPS opportunities to your local astronomy community, if you haven't already. We also encourage you to welcome their ideas for new chapter activities. Please reach out to your zone counselor or the SPS National Office if you have any questions.

The stars are within our grasp (and understanding), thanks to the many wonderful astronomers and physicists who have supported research, learning, and physics curiosity over the years. We look forward to illuminating, celebrating, and supporting astronomy and astrophysics, through these changes and beyond. //

BELOW: The 2021–22 SPS National Council. Photo by Hyun Joo Kim/AIP.

100 YEARS OF MOMENTUM

physcon
2022 Physics Congress

Join us for ΣΠΣ's Centannial, the 2022 Physics Congress.

100 Years of Momentum. An interactive meeting designed for undergraduate physics and astronomy majors.

Early-Bird Registration open until September 6th, 2022!

OCTOBER 6-8, 2022 | WASHINGTON, D.C.

Special Centennial Speakers

Dr. Eric Cornell
Nobel Laureate, Professor of Physics, University of Colorado, Boulder

Dr. Jim Gates
President of APS, Brown Theoretical Physics Center Director, Brown University

Dame Susan Jocelyn Bell Burnell
PhysCon Honorary Chair, Professor of Astrophysics, University of Oxford

Dr. John C. Mather
Nobel Laureate, Senior Astrophysicist at NASA Goddard Space Flight Center

Plenary Speakers

Julianne Pollard-Larkin | K. Renee Horton | Rush Holt Jr. | Sarah Hörst

Registration Includes

- Sigma Pi Sigma Centennial Dinner, Centennial Festival, and Dance Party (sponsored by APS)
- Present Your Research and art at the Poster Session & Physics Phine Art Exhibit and Competition
- Tours of the Green Bank Observatory, National Labs, GWU, UMD, Smithsonian, and more (additional fee)
- Lunch with a Scientist
- High Energy Hot Chocolate, Game Night, & Astronomy Night at GWU
- Access to Plenaries, Workshops, and Interactive Chapter Events

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sigmapisigma.org/congress/2022

Join the conversation on Discord: https://discord.gg/eKJSbnE

SPS

ΣΠΣ ΣΟΦΙΑ

Meet Yanique Brandford: Physics Convert and Canada's Hero

by Andrew M. Zeidell, Assistant Director of Sigma Pi Sigma

As a young girl in Jamaica, Yanique Brandford didn't see college as an option—growing up in a low-income household and community, finishing high school was already a big milestone. She had never considered going to postsecondary school since the high costs made it difficult to access in Jamaica. It wasn't until her family moved to Canada and school became more accessible that she was faced with the question of what to study.

Now a master's student in biomedical physics at Ryerson University, Brandford initially avoided physics altogether. While many people in her family had careers in nursing, she decided to go another route. She researched many different pathways but was discouraged to find that they all required difficult math and physics courses. But when she came across the field of nuclear medicine, she quickly fell in love and decided to follow her interests, despite the heavy physics load to come.

Along her journey, Brandford also faced challenges related to growing up in a low-income household. A common challenge among women in her community, and across the world, is inconsistent access to feminine hygiene products. While still in high school, Brandford tackled this obstacle head-on by starting the Help a Girl Out project, which delivers feminine hygiene products to women in Canada and developing countries. These supplies are out of reach for many women, which can interrupt learning and life, and even cause women to miss class. It was this project, which she registered as a nonprofit in 2018, that won Brandford the Global Citizen Prize in 2020 and made her the first-ever recipient of Canada's Hero Award.

Brandford has continued to work on Help a Girl Out throughout her time as a university student. While she considers this work to be separate from her interest in physics, it serves as a platform for Brandford to introduce young women to STEM fields. She's a strong advocate for women in STEM and interacts with both volunteers and students through her workshops and messaging, where she also shares about her work in physics. She uses these interactions to talk about her research and how it relates to patient outcomes, and tells students that they, too, can make a mark on the world.

One of Brandford's passions is to introduce more women of color to STEM fields, as they are historically underrepresented in physics and STEM in Canada and abroad. This advocacy earned her the Viola Desmond Award in 2020, for which she was nominated by the faculty of the Ryerson University physics department. These awards celebrate the past, present, and future of the Black community in Canada, and are given to Black women at Ryerson University who are positive role models and advocates of the Black and African Canadian community.

After completing her undergraduate studies in medical physics, Brandford realized that she had only scratched the surface in physics research and decided to go deeper. She is now finishing a biomedical physics master's degree at Ryerson and plans to work in the nuclear industry.

Her advice to young women in STEM is this: "There is space for you, so don't limit yourself. Regardless of your race, economic status, or disability, you can and should consider a scintillating career in science." //

LEFT: Yanique Brandford, a biomedical physics MSc student at Ryerson University, won the Viola Desmond Award and is the first-ever recipient of Canada's Hero Award. Photo courtesy of Brandford.

Opportunities in Acoustics:

The 181st Meeting of the Acoustical Society of America (ASA)

by Kourtney Libenow, 2020-2021 Associate Zone Councilor Representative to the SPS Executive Committee and SPS Member, Central Washington University

There I was in Seattle, wide-eyed despite being in a city I had visited many times, having lived in Washington all my life. When I attended the virtual 180th meeting of the Acoustical Society of America (ASA) the previous year, I discovered the immense scope of opportunities that the field of acoustics provides. The Seattle meeting program, which contained all the presentation abstracts, proved this again. It was 385 pages long using 8- or 9-point font. I was ready, professional outfits and all.

I was excited to network in person but found myself lingering at the student booth, staring at colorful stickers. ASA divides the field of acoustics into 13 areas, and each sticker represented one. There was Engineering Acoustics, Acoustical Oceanography, Animal Bioacoustics, Architectural Acoustics, Physical Acoustics, Psychological and Physiological Acoustics, Signal Processing in Acoustics, Structural Acoustics and Vibration, Biomedical Acoustics, Musical Acoustics, Noise, Speech Communication, and Underwater Acoustics.

I was unsure which sticker to take and considered taking one of each. But I settled for none. I was there to explore research and graduate schools in all of those areas, so I would be open to every possibility.

Wandering out into the crowded third floor before the sessions started, I felt aimless. I'm typically extroverted but was overwhelmed by the vast group of people. I was thankful for Aamna Arshad from SLR Consulting, who initiated a conversation. We talked, and Aamna invited me to listen to a talk regarding rail vibration and sensitive equipment, which I later attended.

LEFT: Photo by Hyun Joo Kim, AIP.

I also joined Aamna for a talk by Jerry Lilly from JGL Acoustics, a company based out of Issaquah, Washington. He gave a presentation on the basics of noise and vibration control, specifically related to analyzing and reducing the noise from HVAC ducting. I was interested in the technical details and also excited to hear about job opportunities in the acoustics field so close to home.

In addition to technical presentations and posters, the conference provided hot-topic sessions on COVID-19, multiple workshops and tutorials, technical committee meetings, and a plenary session with awards. There were also special events, including a Women in Acoustics roundtable discussion and even an acoustics jam session!

I met a passionate group of students from The Pennsylvania State University acoustics program, some of whom played a set at the jam session. They encouraged me to join in on future jam sessions, whether that be at Penn State as a graduate student or at a future ASA meeting as colleagues.

While you're an undergrad, do your best to attend at least one professional meeting within your field. Look into opportunities at your school, within the professional societies, or within SPS National for relevant meetings and funding assistance. You're likely to meet future colleagues and good friends, discover graduate schools and career possibilities, and possibly decide on your future career goals! //

GET TRAVEL SUPPORT FOR MEETINGS

SPS offers Travel Awards of $300 to members presenting their research at AIP Member Society meetings. Review the details and apply today at spsnational.org/awards/travel.

SPS members attending and reporting on professional physics meetings are eligible to receive $300 as an individual and $250 per person as a chapter in travel reimbursement for in-person meetings. Applications are accepted on a rolling basis. Apply at spsnational.org/awards/reporter.

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SPS Chapter Report

Submission Deadline: June 15

Importance of Chapter Reports

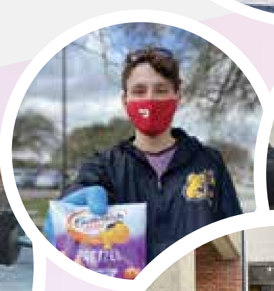
- Share your chapter's efforts and best practices with SPS chapters
- Update your chapter contact and leadership information
- Provide guidance for future SPS members in your chapter
- Determine your chapter's strengths and areas for improvement
- Receive feedback and recognition from SPS National

Qualify for National Recognition:

- SPS Outstanding Chapter Awards
- Blake Lilly Prize
- Feature in SPS publications, such as the *SPS Observer*, *JURP*, or *Radiations*.






For more information on chapter reports, visit **www.spsnational.org/chapter-reports.**
Has your leadership changed since your last chapter report? Update your contact information with the National Office anytime at **www.spsnational.org/chaptercontacts.**

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