the SPS Observer

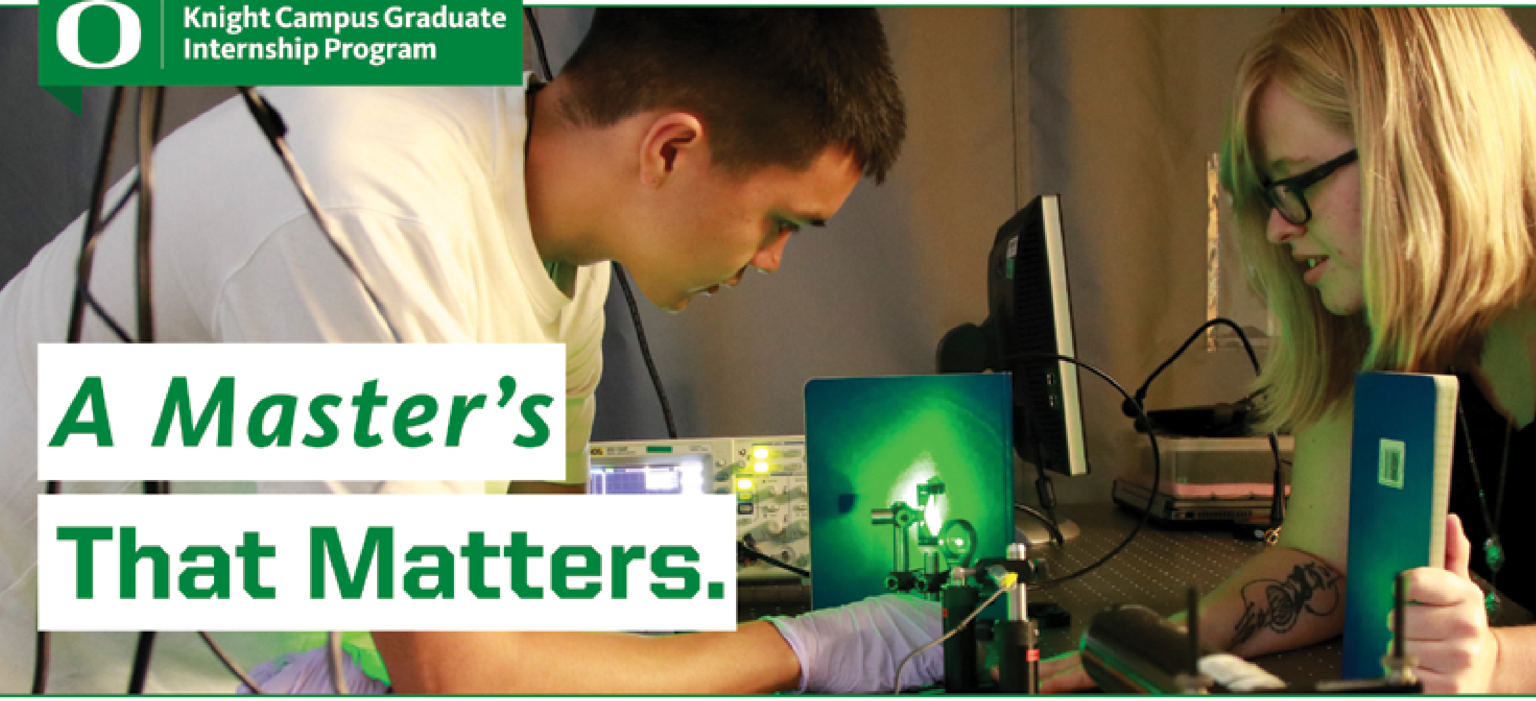
Volume LVIII, Issue 2

FALL 2024

THE GRAD SCHOOL & CAREERS ISSUE

- Getting to Work with Your Bachelor's Degree
- Nonlinear Careers of Scientists through History
- How to Conduct Informational Interviews, and Why You Should
- How to Identify Your Skill Set and Narrow Down Your Path
- How to Network Like a Pro
- Tips for Applying to Graduate School

Knight Campus Graduate Internship Program



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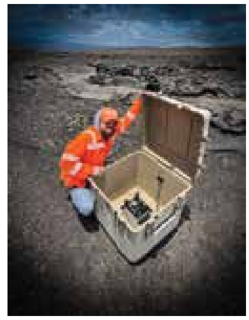
AIP

TABLE OF CONTENTS

FALL 2024 ▪ VOLUME LVIII, ISSUE 2

FEATURES

DEPARTMENTS



ON THE COVER
Ashton Flinders shows off one of the Hawaiian Volcano Observatory's continuous realtime stations for monitoring variations in gravity at the Kilauea volcano, which is in the Hawaiian Islands. Photo courtesy of Flinders.

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A Personal Reflection

by Alejandro de la Puente, Director of SPS and Sigma Pi Sigma

I grew up in a country where the opportunity to experience science as a very young student was not equitable. I don't remember learning about the beauty of mathematics, the importance of data, or of equations—ingredients critical to the scientific method, the framework which gives humanity the ability to understand and reflect on the physical world.

I grew up cultivated by my mother; she cared about my education but encouraged me to pursue a career in medicine or law. I grew up without the breadth of knowledge critical to the formation of a future scientist. I was, however, fascinated by the concept of optimization, by a feeling that there existed a set of initial conditions that when brought together could unpack the phenomena we observe and experience. I paid attention to this, even as I grew older; I knew, in the theoretical sense, that if I did things a certain way, I could achieve perfection. I learned to theorize. That drove me.

I arrived in North America at the young age of 14, mature enough to know I would dearly miss my friends and family in Peru. My first experience as a newcomer was high school, and all I remember is how different it was from what I had known all my life, how difficult it was to adjust to a new system, and how challenging it was to start from zero. I remember thinking deeply about what I wanted to become, who I wanted to be.

I found out I could theorize about my place in this new country. I learned that over the years, many others had made a similar transition and, through hard work and dedication, developed deep insights about the world. This process was not straightforward, and it was not without interruptions, barriers, and limitations. I worked arduously to unlock the full potential of my imagination.

As someone new to the United States, the taste of opportunity was always there, but the path to success was somewhat obscure. What got me through high school and up to the best times of my life was probably my imagination—again, the thought that I could optimize my way anywhere, that I could be anything I wanted to be. As I discovered the future I wanted, I prepared myself for higher education and the possibilities that attending a university presented.

Enrolling in university was not easy. I learned very early that high school does not necessarily prepare you optimally to succeed in higher education. I had to reinforce foundational coursework to propel myself into upper division classes in mathematics, physics, chemistry, and philosophy. However, as I climbed the undergraduate ladder, I fell deeper and deeper in love with science, with knowledge. I had found my path. I was happy and thriving.

My journey through higher education helped me realize that I could build my own renaissance from the ground up, that I could learn it all. It taught me that disciplines need not be constrained by their self-imposed borders. That energy is a scale, and that your experience of it can expose you to vastly different phenomena. That the Greeks had once established a society where the public was civically active

ABOVE: Alejandro de la Puente, the new director of SPS and Sigma Pi Sigma.

and used language to structure learning and experience. That 1920s advances in our understanding of the statistical nature of universal laws would revolutionize how we communicate and solve problems today. I knew then that I was in the right place. I had found a way to optimize my reality and merge my passion for knowledge with my insatiable desire to support underserved communities and youth, and to make resources and opportunities accessible and share them with as many people as I could.

I wanted my own path, and I wanted it to be colorful, just, and meaningful. I wanted to do science that could impact the world around me, both laterally and vertically. I earned a PhD and did research but decided not to make it my sole focus.

I contributed immensely to my discipline but not in the "purest" way, albeit most likely optimally. I built a career as a science communicator and worked to democratize learning in underserved communities through grassroots interventions. I immersed myself in the world of institutional theory and the process by which culture is created and meanings are shared.

I learned that there is a path to transform education, a framework that fits and optimizes everyone's learning. I worked with scientists from all backgrounds, helping them with their own transformations, navigating careers and becoming leaders in their fields, communities, and lives. I worked on the concept of readiness, or how limited resources are made available to sustain and train the workforce. And lastly, I worked to optimize this process by analyzing data and the power of transformation. I built my own renaissance.

My commitment, as the new director of SPS and Sigma Pi Sigma, is to help you, wherever you are right now, to lead your own renaissance, to amplify your voice and empower your unique journey. I want SPS to shine light on the multiplicity of routes to being a physicist or astronomer, help you on the path to realizing your own future, catalyze the conditions for institutions to meet you where you are, and nurture a welcoming and empowering physical sciences and astronomy enterprise. I want to work with you to ensure that each of you can help shape the future of the physical sciences and astronomy in higher education, the workforce, and society. //

Sharing the Love of Physics

by Levi Hancock, Past SPS Chapter President, Brigham Young University

Our SPS chapter at Brigham Young University (BYU) has noticed a glaring lack of diversity in physics, particularly among our own student body. With an urge to make a change, we applied for an SPS Future Faces of Physics Award. Support from this grant allowed our chapter to recognize and address two specific ways to promote diversity in physics: raise excitement for physics among students from underrepresented demographics in the field, and give our undergraduate physics students an opportunity to practice sharing their passion for physics with others.

We began by reaching out to local schools with considerable percentages of students from underrepresented populations in physics, particularly Latino students, offering to present a demo show about fundamental physics concepts. We put together the show with help from the BYU physics education faculty. It addressed topics such as electricity and magnetism, Bernoulli's principle, angular momentum, and conservation of energy. We tested and practiced each demo so that we knew how to best present complicated physical concepts to children, and made small demo kits to give to students that help explain some of the physical concepts. They contained objects such as a compass and magnet to demonstrate magnetism, and a battery and small light bulb from a chain of Christmas lights to demonstrate electricity.

We recently did our first presentation at Wasatch Elementary, located just a few minutes from our university. A small group of us attended the school's Family STEM Night and presented our demo show. Then we split into smaller groups to work with the kids individually and explain how to use the objects in their demo kits. Overall, the outreach activity was a tremendous success, and we hope to be able to bring similar presentations to more schools in the future.

ABOVE: Members of the Brigham Young University (BYU) SPS chapter present physics demos to local elementary school students. Photos courtesy of BYU SPS.

Through this experience we learned that one of the best ways to get excited about something is by sharing it with others. As I taught these children about physics, I discovered my own growing passion for learning how the world works and sharing that passion with others. We are incredibly grateful for the support that SPS provides as we promote physics in our local community. //

Bringing Antiracism to Physics

by Cecilia Ochoa, Past SPS Chapter President, Georgetown University

In an effort to promote a culture of active antiracism in Georgetown physics, our SPS chapter recently partnered with the physics department's Diversity, Equity, and Inclusion (DEI) Committee to host an event with A Long Talk About The Uncomfortable Truth. The organization aims to "eradicate racism and dismantle systemic oppression in America." It was founded in the wake of George Floyd's murder and the calls for racial justice in 2020.

The event brought together 20 undergraduate and graduate students, along with several faculty and staff members, for an eye-opening conversation about how systemic racism has affected the United States generally and the field of physics specifically.

Over two hours, moderators guided us through the uncomfortable but important reality of racism. The discussion had three goals: to address how the history of the US affects the present, to offer tools to help challenge racist comments and beliefs, and to provide action items for improving the community.

"I found [the event] to be very important, meaningful, and educational," says Sophie Taylor, a physics major and Georgetown SPS chapter board member. "I especially found the protocol provided by A Long Talk to be very important to learn about, since it provides a step-by-step and actionable way to combat racism in everyday life."

A Long Talk started by bringing these conversations to college-level sports teams but has since partnered with a wide range of organizations, including the American Mathematical Society. Amada Paris, current Georgetown SPS chapter president and an organizer for the event, first encountered the organization through the swim and dive team. After experiencing two of their sessions, she worked alongside SPS to bring the group to the physics department.

"Physics is not as objective as people tend to believe," Paris says. "The direction of scientific research will be affected by the culture of physics, which is why diversity in the field is so important. A Long Talk came to help us change that culture, to help us learn how to confront our biases, and ultimately to make physics an environment where everyone is safe."

The goal of A Long Talk is simple, according to founder Kyle Williams. "We want to put an antiracist at every dinner table in America," he says. "Every space that people occupy, we want to have at least one voice in the room that's not going to just allow the normalcy of—whether it's racism or sexism or just all these negative or divisive conversations going on."

If A Long Talk's goal is to put an antiracist at every dinner table, Paris says, "Our goal is to put an antiracist in every physics classroom on campus." //

ABOVE: Kyle Williams, founder and moderator of A Long Talk, and Amada Paris, SPS chapter president and a lead event organizer, pose for a photo during the event. Photo courtesy of Georgetown University's SPS chapter.

LEARN MORE

To learn more about A Long Talk and its events, visit alongtalk.com.

GET MONEY FOR INCLUSIVE CHAPTER EVENTS

This event was supported by an SPS Future Faces of Physics Award. These awards, of up to $600, are available for chapter programs or events that promote physics and astronomy across cultures. Applications are due November 15 each year. Learn more at spsnational.org/awards/future-faces.

The Value of Mirror Moments: I Made It Through Undergrad. Now What?

by Rena Beban, Graduate Student in Education, Adelphi University

Throughout my years as an undergrad, the inevitable question I was met with every time I told someone I was a physics major was, "Wow, that's really difficult. Do you want to be a teacher?" My response every single time: "No way, I'm going to work in a national laboratory and analyze data for huge projects!"

Now, I'm writing this piece shortly after finishing a paper proposal for one of my graduate education classes. Yes, I'm going to be a teacher.

I graduated with a bachelor's in physics less than a year ago. In the months leading up to graduation, I was certain I'd be working in a lab and changing the world by now. And someday maybe I will do just that, but I can't say it will be a linear path. In the meantime, I'm lucky enough to be a Noyce Scholar at Adelphi University, which means that the National Science Foundation is paying for me to earn a master's in adolescent science education. As part of the program, I'll be teaching in high-needs schools for two years, promoting interest in STEAM (science, technology, engineering, art, and math) among underrepresented student populations. So, I have a solid two-year plan, right? Right?

I'm thrilled that I'll be doing such important work with young students who may not receive the same opportunities as some of their peers—I think about girls dealing with gender norms, students with learning differences, and kids with financial barriers to out-of-class STEAM resources. It's a beautiful thing to be in a position to make a difference, and according to the Physics Teacher Education Coalition, the need for qualified physics teachers is higher than ever.

But is it what I want to do in the long run?

Frankly, I have no idea. As rewarding as teaching can be, it would be naïve to ignore the stress behind it—I find myself intimidated by the lack of funding, long hours, and not quite knowing what each day will bring. Not to mention, I still want to work in a lab!

I might want to pursue a doctorate. Law school, even?

I've created a mental pendulum for myself, constantly flowing between feeling certain of my future and feeling scared, confused, and unsure beyond comprehension. In these moments or phases I look in the mirror and tell myself one thing: "You're 22 years old. It's okay not to have it all figured out."

We constantly see inflated portrayals of individuals who seem to have their entire lives set by age 20 (think about the influencers you view on social media), and it normalizes the abnormal—it's *not* normal to be a millionaire with a mansion before you can legally have a drink. Looking at ourselves in the mirror forces us to consider where we are *at that very instant*, be it as a student, working professionally, both, or neither. Mirror moments are reminders that we are where we're meant to be, even if it's not necessarily where you *want* to be. Each day that we work toward our goals and make the most of our current position opens doors to unexpected, new opportunities, showing that there is potential in the unknown.

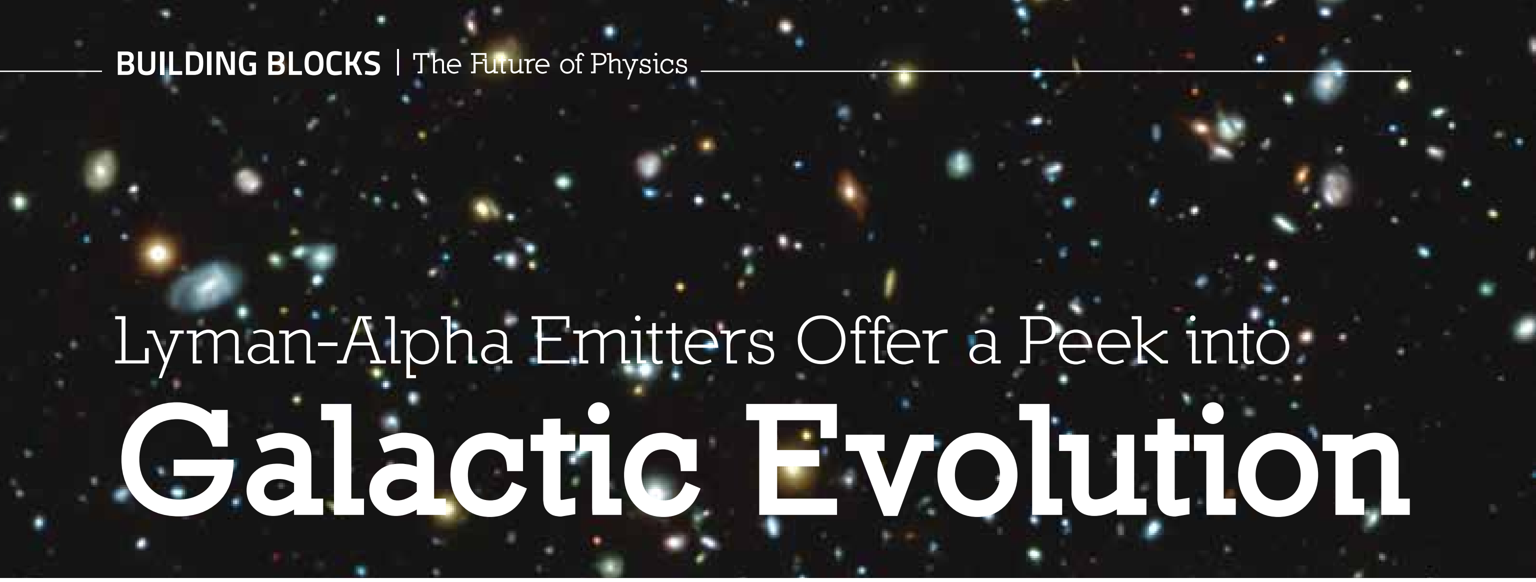
ABOVE: Rena Beban.

But how do we address those feelings of uncertainty?

The best way I've found to keep my head straight and not spiral is to give my all to whatever I'm doing, be it my studies, my work, the tiring retail job I have on the side, or my own hobbies. I've learned that remaining present and putting my genuine best effort into my current project keeps me confident in my path and helps me feel fulfilled, even in this confusing phase of my life.

Still, though, the pendulum is swinging in my head. Really, I don't know if it will ever stop (we're ignoring air resistance so it will definitely *not* stop!). What I do know is that *it's okay to be confused*. Yes, I have an end goal. I might even have 50 conflicting end goals. Maybe you do too! And if you're feeling like me—unsure about where you'll be in the future—I encourage you to have a mirror moment of your own and take your path day by day. //

For information on the Robert Noyce Teacher Scholarship Program, visit nsfnoyce.org.



Lyman-Alpha Emitters Offer a Peek into Galactic Evolution

by Tiffany Liou, 2023 SPS Summer Intern, Space Telescope Science Institute, and Past SPS Chapter President, University of California, San Diego

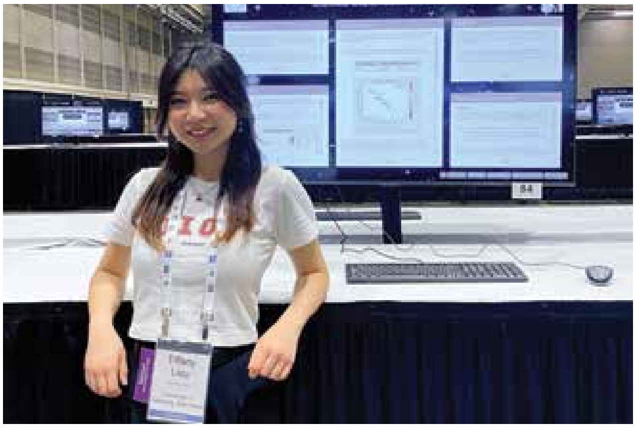
“How did this happen?” You might ask that question when your clothes shrink in the dryer or when you contemplate the fate of the universe. One of the main goals of physics and astronomy is to understand how things change over time, whether it be during the dryer cycle or on the nano to cosmological timescale. The study of galactic evolution aims to address this big question.

Our universe was built on a series of violent dynamical processes such as fusion and mergers. Such processes lead to the formation of galaxies, and their evolution is governed and regulated by the chemical abundances, gas dynamics, and star formation in their environments. Learning how galaxies form and evolve is therefore essential to understanding how the universe changes over time.

In the summer of 2023, I immersed myself in astronomical research through an SPS summer internship based in Washington, DC. I worked at the Space Telescope Science Institute (STScI), a research institute that specializes in various subfields of physics and astronomy, alongside astronomer Nimisha Kumari to explore the field of galactic evolution.

At STScI I studied the rest-ultraviolet properties of Lyman-alpha emitters (LAEs) to learn about galactic evolution. LAEs are galaxies characterized by strong Lyman-alpha (Lyα) emission lines, which occur when a hydrogen atom transitions from the second energy level to the ground-state energy level. They have high star-formation rates and low metallicities for their compact size. We studied high-redshift LAEs, which means they are among the earliest galaxies that formed in the universe.

If the intergalactic medium (IGM) of the early universe was mostly neutral hydrogen, then it would have scattered the Lyα photons emitted by these galaxies, making them undetectable by telescopes today. However, we can see them. The Lyα photons are able to escape the neutral IGM and reach our telescopes because of their highly ionized nature. This interesting feature makes LAEs popular candidates for probing the early conditions of the IGM and the environment surrounding galaxies.



TOP: This color image shows the Hubble Ultra Deep Field region as observed with the MUSE instrument on the European Southern Observatory’s Very Large Telescope. This picture only gives a very partial view of the MUSE data, which also includes a spectrum for each pixel in the picture. This data set has allowed astronomers to measure distances for far more of these galaxies than before and to learn much more about them. Image by the ESO/MUSE HUDF collaboration.

ABOVE: Tiffany Liou displays her virtual iPoster at the AAS Winter Meeting in 2024. Photo courtesy of Liou.

PUBLISH YOUR RESEARCH

The *Journal of Undergraduate Research in Physics and Astronomy* (JURPA) is a peer-reviewed publication of the Society of Physics Students that consists of papers by undergraduate researchers. Manuscripts are accepted on a rolling basis but must be submitted by March 15 each year for print consideration. Learn more at spsnational.org/jurpa.

SPS AWARD FOR OUTSTANDING UNDERGRADUATE RESEARCH

These awards recognize individuals for exceptional physics or astronomy research conducted as an undergraduate. Winners receive $2,000 in travel funding to present their research, $500 for themselves, and $500 for their SPS chapter. Applications are due March 15 each year. Learn more at spsnational.org/awards/outstanding-undergraduate-research.

LEFT: Tiffany Liou (fifth from right) poses with the rest of the 2023 SPS summer intern cohort. Photo by SPS.

To explore the properties of the LAEs, I used observational data from the MUSE Hubble Ultra Deep Field (MUSE HUDF DR2). MUSE is a ground-based spectrometer located on the Very Large Telescope in Chile. The data includes spectra from redshifts between 0 and 6.7. I focused on 98 LAEs between redshifts 2.8 and 4 whose spectra contained the lines I was interested in (Lyα, CIV λ1549,50, HeII λ1640, and CIII] λ1907,9) within the wavelength window I was studying.

After sifting through the galaxies that fit my wavelength criteria, I studied the scaling relations between the physical properties of my galaxy sample: mass, UV luminosity, star-formation rate, gas-phase metallicity, and redshift. For example, I found an inverse relationship between mass and luminosity, meaning that as the galaxies get more massive, they get brighter in the UV.

One of my most interesting findings relates to star-formation rates. I compared my LAEs to two types of local galaxies, typical "main sequence" galaxies (a group that includes our Milky Way) and local analogs, which may have similar properties to high-redshift galaxies (from the COS Legacy Archive Spectroscopy Survey, CLASSY). My sample had higher star-formation rates than local main sequence galaxies, as expected, but lower star-formation rates than the local analogs. This could mean that the local analogs are not representative of LAEs within our redshift range, or that the star-formation rate peaks around a redshift of 3 and my sample falls on the opposite side of the peak. It is also interesting that the relations for mass, star formation, and luminosity have little correlation to redshift.

Through this project the main lessons I learned are that the research process is nonlinear and that I can do it! When I first started, I felt a little bit timid—I didn't think observational astronomy was my strongest field. However, by investing time and asking lots of questions, I witnessed myself grow, not only in terms of the project but also as a scientist. My mentor, Dr. Kumari, provided a lot of support, helping me gain a conceptual understanding of the field and learn research methods and the main functionalities of observational instruments like MUSE.

I also learned that research doesn't always go as planned. One of my goals was to estimate the gas-phase metallicity of my LAE sample using specific emission lines. In my samples, however, those lines did not show up strong and resolved, so I was unable to draw solid conclusions. This was disappointing at first, but I realized that no information is still information. In addition, this knowledge can guide future research. The gap in my findings encourages me to stay curious and investigate more!

I presented a poster on my findings at the 243rd American Astronomical Society (AAS) Meeting in New Orleans, Louisiana, over the winter. It was such a fruitful experience to share my research with astronomers from various subfields and adapt my presentation for different audiences. I also learned more about this area of research and the possible implications of my results through discussions with experts in galactic evolution. At the meeting I received the AAS Chambliss Astronomy Achievement Student Award for exemplary research. This award means a lot to me because it showcased my growth in research and science communication.

Participating in the SPS internship program was one of the most influential experiences of my undergraduate career. My project with Dr. Kumari allowed me to try out a new area of astronomy and helped me realize my passion for astronomical research. I also gained exposure to other disciplines in physics and expanded my views on how physics fits into the world through the SPS internship program. While I was at STScI, others in my SPS internship cohort were stationed at Capitol Hill, the American Institute of Physics, the American Physical Society, NIST (the National Institute of Standards and Technology), and the Niels Bohr Library & Archives. The variety of projects was eye-opening, and I learned about areas of physics that I had never considered before. If you are reading this, this is your sign to apply to summer internships and research experiences and explore new topics! //

BE AN SPS SUMMER INTERN

The SPS summer internship program offers 10-week, paid positions for undergraduate physics and astronomy students in science research, education, outreach, and policy. Interns are placed with organizations in the greater Washington, DC, area that do research, engage with the community, and promote the advancement of physics and astronomy. Applications are due January 15 each year. Learn more at spsnational.org/programs/internships.

TOP: The Roanoke College starshade team in fall 2023. The team includes Bobby Hoye, Arthur Duncan, Dr. Le, Patrick Brennan, Alan Castellon, Dylan Knick, Addy Littlefield, Bryan Moctezuma, Tony Saade, Enzo Tagum Fombeno, and Erin Trost. Photos courtesy of Roanoke College.

MIDDLE: Paper models of the team's starshade design hang in the lab.

ABOVE LEFT: A team member demonstrates how the design folds for launch.

ABOVE RIGHT: A prototype of the team's design.

Designing a Starshade for Space

by Bobby Hoye, SPS Chapter President, Roanoke College

The things we build here on Earth and send out into space share our collective story. They reveal our values, ambitions, and perspectives. In pursuit of this vision, I and a team of like-minded people at Roanoke College entered the NASA HOEE Starshade Challenge. We aspired to make a significant impact and, coupled with the grit to make our idea a reality, we came together to share our story. Here is that story.

In August of 2023, SPS and the NASA Hybrid Observatory for Earth-like Exoplanets (HOEE) Starshade Team approached me about participating in the NASA HOEE Starshade Challenge. This challenge, hosted jointly by the American Institute of Physics and NASA, solicited entries from undergraduate student teams across the country for starshades 100 meters in diameter.

Starshades are a type of spacecraft that could shade Earth-based telescopes from starlight. The idea is to use them in parallel with a new era of large Earth-based telescopes—a starshade would sit between Earth and a star, blocking light from the star so that we could see any Earth-like exoplanets in its orbit. Such exoplanets serve as good candidates for life outside of Earth; therefore, learning about them serves as a crucial next step in astrophysics and astrobiology.

Through the competition, NASA aimed to compile a set of models that could serve as starting places for further design, construction, and application in space.

With the ambition of being part of this new age of space exploration, I talked to my astrophysics professor, Truong Le, and he agreed to mentor a team. We assembled a diverse group of classmates, each bringing unique specialties and strengths to the table. What started as weekly meetings quickly became a pastime and a priority, and late nights became a regularity. As a small liberal arts school in southwest Virginia, we had a passion for proving ourselves.

Our physics program has gone through tremendous change over the past few years. Despite rotating professors, virtual learning, and few resources for special projects, we managed to build a community and a family united by a passion to spark change and leave our mark on something bigger than ourselves.

For the design, we played to our strengths—a liberal arts education with a fundamental approach to physics. Our philosophy was to keep the design as simple as possible through minimizing parts. This often took the shape of a frustratingly iterative process of comparing simple ideas to more complex ideas and then simplifying again.

Our starshade design has 24 petals extending outward in increments of 15 degrees. The petals are made of lightweight carbon fiber fabric and are shaped with rigid edges of high-carbon steel to create a solid gradient of sunlight toward the tips of the petals. The petals are held together by a central disk made of a carbon nanotube support frame and Kevlar fabric. Finally, six cables made of Dyneema, a high-performance fiber, help control tension in the memory materials during deployment. This design aims to minimize weight while remaining within the constraints given by NASA.

Our team earned second place in the competition, and we are continuing to work with NASA on our design.

Not only was this experience an opportunity to engage with a modern-day challenge, but it also gave us insight into the world of engineering and how a project becomes a reality. I am proud and grateful to have had the opportunity to colead this team. I dream that the work we started will impact future generations of students.

Starshade may help answer significant questions about our place in the galaxy. If we can see what else is out there, we may even be able to learn a little bit about what makes us special or, more interestingly, what doesn't make us special. //

GET MONEY FOR CHAPTER RESEARCH

SPS Chapter Research Awards provide up to $2,000 for physics and astronomy research projects deemed imaginative and likely to contribute to strengthening the SPS program. Applications are due November 15 each year. For details visit spsnational.org/awards/chapter-research.

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Ann Arbor, Michigan
lsa.umich.edu/appliedphysics

APPLIED PHYSICS

Application due: January 5

Apply: https://bit.ly/2NschKo

Degree(s): PhD, MS

Fields offered include: Research in all areas of physics

Questions: AppliedPhysicsProgram@umich.edu

- ***78*** graduate students total
- ***37%*** of graduate students are women
- ***180+*** faculty members

BOSTON UNIVERSITY

BOSTON UNIVERSITY, DEPARTMENT OF PHYSICS

Boston University offers a top-ranked Ph.D. in Physics with research specialties in experimental, theoretical, and computational physics. Along with interdisciplinary opportunities, our students enjoy a community of diverse and accomplished physicists from around the world. Each year, we welcome an incoming class of 10 to 20 students, who receive full-tuition scholarships and competitive stipends through a combination of teaching fellowships, research assistantships, and university fellowships. For more details, visit **https://www.bu.edu/physics/admissions/graduate-program-admissions/**.

www.bu.edu/physics

Phone: (617) 353-2600 • Email: GradAdmin@physics.bu.edu

590 Commonwealth Avenue, Boston, MA 02215

Department of Medical Physics
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

Madison, Wisconsin
www.medphysics.wisc.edu

MEDICAL PHYSICS

Application due: December 1, 2024

Apply: https://bit.ly/20t1olL

Degree(s): PhD, MS

Fields offered include:
MRI, CT, ultrasound, nuclear med, X-ray

Questions: thartung2@wisc.edu

- **21** first year students
- **90** graduate students
- **60** faculty members

INDIANA UNIVERSITY
BLOOMINGTON

Bloomington, Indiana
physics.indiana.edu

DEPARTMENT OF PHYSICS

Application due: January 1, 2025

Apply: https://bit.ly/3Kpyl8C

Degree(s): PhD, MS

Fields offered include:
All subfields, experiment and theory

Questions: gradphys@indiana.edu

- **90** total graduate students
- **100%** of graduate students are receiving assistantship support
- **Special research equipment:** Interdisciplinary centers include Indiana University Center for Spacetime Symmetries (IUCSS), Center for Exploration of Energy and Matter (CEEM), and Quantum Science and Engineering Center (QSEc)

The UNIVERSITY of OKLAHOMA

Norman, Oklahoma
ou.edu/cas/physics-astronomy

HOMER L. DODGE DEPARTMENT OF PHYSICS AND ASTRONOMY

Application due: January 15, 2025

Apply: https://bit.ly/3OeWGzi

Degree(s): PhD, MS

Highlighted subfields offered:
AMO, ASTRO, Con Mat Phys, HEP, Eng Phys

Questions: pa-grad@ou.edu

- Number of faculty: **28**
- Grad students receiving assistantship support: **100%**
- Institutional Access to APO 3.5m telescope, HEP group is heavily involved in the ATLAS experiment at CERN, and our AMO/CMP labs are housed in our new 18,000 sq ft NIST-A Center for Quantum Research and Technology (CQRT).

That's Some Gourd Acceleration!

by Brad R. Conrad, Education and Workforce Development Manager, Office of Advanced Manufacturing at NIST

For many of us in the Northern Hemisphere, September through December is a season of dipping temperatures, falling leaves, dwindling pumpkin spice latte supplies, and annual pumpkin drops! It may sound a little out there, but many SPS clubs have a long history of splattering pumpkins around Halloween to raise money, build awareness of their SPS and Sigma Pi Sigma chapters and department, or even—as former members of SPS have put it—to demonstrate a love of physics.

The SPS chapter at California State University (CSU), Chico, has a long history of such events, as is evident in their project proposal for a 2016 Marsh White Outreach Award:

> *The Pumpkin Drop reenacts Galileo Galilee's Tower of Pisa experiment. On Halloween, SPS members dress as Einstein, Aristotle, Newton, and Galileo to explain the evolution of the rule of falling bodies as other SPS members demonstrate the rule by dropping pumpkins from the fifth floor of CSU Chico's Butte Hall… At the top are two dozen hollowed-out pumpkins, either empty, filled with water, feathers, or fire, ready to be dropped by SPS members….*
>
> *The Pumpkin Drop was originally thought of by physics students, based off the dropping of fruit from a five-story tower as featured in the Late Night with David Letterman show [a late-night talk show]. In 1988, SPS members Ben Catching and David Snyder wanted to demonstrate a love for physics for the entire campus and community….*
>
> *In the early 1990s, Scot Carter added the finale of coordinating smashing pumpkins with the cannon blasts of the "1812 Overture."*

When I explain that it is very common for physics and astronomy departments to drop pumpkins off a building to nonscience types, I get a lot of worried looks. **And. It. Is. Amazing!** I think pumpkin drops get to the heart (or in this case, the pulp) of why we study the world around us: a love of physics and astronomy.

If I wanted to host a pumpkin drop at my workplace, let's say off the tallest building at the National Institute of Standards and Technology (NIST) Gaithersburg Campus, which is about 12 stories, how big of a plastic sheet would I need to place on the ground to catch all of the splatter? (And if I did a pumpkin drop at NIST, would it be the "standard" pumpkin drop? NIST keeps the SI standards for the country, so why not pumpkin drops?)

TOP: A crowd eagerly awaits impact at the 2023 USC Chico Pumpkin Drop. Photo by Jason Halley/Chico State.

MIDDLE: The aftermath of the Florida Atlantic University (FAU) 2023 Pumpkin Drop, which the physics department hosted in conjunction with its Physics Carnival. Photo by Zach Greathouse, Director of Communications, Marketing, and External Relations, Charles E. Schmidt College of Science, FAU.

ABOVE: A pumpkin drops to its fate at Washington State University (WSU). Photo courtesy of the WSU SPS chapter.

HERE'S THIS ISSUE'S PUZZLER: If we drop a standard pumpkin off a 12-story building, how far could the splatter travel?

For experimental insight, we can look at some amazing examples from physics, astronomy, and engineering clubs across the country:

- In 2022, CSU Chico's chapter held its 33rd Annual Pumpkin Drop. To see a video, visit bit.ly/46zczsY.
- In 2023, the physics department at Florida Atlantic University (FAU) held its Annual Pumpkin Drop. To see a video, visit bit.ly/4ce4xqD.

Kourtney Adkisson Libenow, who helped with pumpkin drops at Central Washington University when she was an undergraduate, says that pieces regularly spread within a 20-ft diameter around the point of impact after a six-story drop.

There are several ways to approach this question using the first-semester physics tools of kinematics and conservation of energy. However, first we need to think through the problem and some assumptions.

We know that when things fly through the air, there is definitely air resistance. The force of air resistance goes as velocity squared and will eventually cause a falling object to reach a terminal velocity. It does take time to reach a terminal velocity, though. For example, it takes skydivers over 10 seconds to reach their terminal velocity.

We can see from the video evidence that in a typical pumpkin drop, the pumpkins don't fall for anything close to 10 seconds. It's about 3 seconds. Thus, let us assume we can use conservation of energy to calculate how fast a standard 10-lb pumpkin is falling right before it hits the ground.

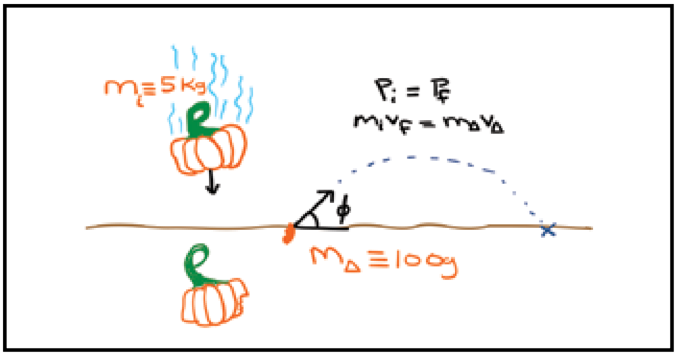


Figure 1. A pumpkin reaches terminal velocity, and the calculation for a "standard" pumpkin. Image by Brad R. Conrad.

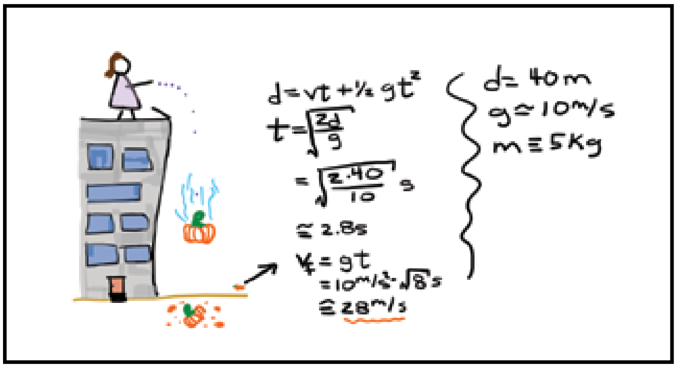


Figure 2. An illustration of conservation of momentum for a pumpkin hitting the ground and a 100-g piece flying off with all the momentum. Image by Brad R. Conrad.

Part 1: Using information in Fig. 1, how fast is the pumpkin traveling just before it hits the ground?

Now, when the pumpkin hits the ground—no matter if it's filled with feathers, fire, or liquid nitrogen—it will not remain intact. The pumpkin will break apart and many pieces will fly up, as we can see in the FAU and CSU Chico videos.

This collision is inelastic—we lose energy EVERYWHERE! The landing makes a sound. It takes energy to break the pumpkin into pieces. Some molecular bonds break. The pumpkin warms up. There's lots of friction with pieces moving around. But, for the sake of science, let's assume that all the momentum of the pumpkin goes into a single piece of pumpkin. Let's also assume that the piece is a small hunk only 100 g in mass (some seeds and a bit of the pumpkin flesh). How far could that single piece of pumpkin fly?

Part 2: Using what you've found so far and Fig. 2, what would the chunk's initial velocity be when it leaves the pumpkin? How far could that piece of pumpkin go?

If you remember the angle that results in the farthest trajectory for a launch, you should get something significantly larger than 20 feet. To make sure that everyone in a crowd stays pumpkin-free during my drop, how large of a blocked-off area would we need if there was NO air resistance?

Does your answer make sense?

Hypothetically, if a typical piece flies a maximum of 50 feet for a drop of 12 stories, how much energy is lost to air resistance as compared to your air-resistance-free situation? Is air resistance going to be significant at the initial velocity you calculated in part 1? //

READ MORE

Check out the Winter 2020 *SPS Observer* article, "Why You Should Host a Pumpkin Drop—And How to Make It Happen #SPSplat," by Deanna Marshall at spsnational.org/the-sps-observer/issues/winter-2020.

Here's Why YOU Should Join SPS

by Rianna Ehrenreich, SPS Office Intern and SPS Member, University of Rochester, and Mikayla Cleaver, SPS Programs Coordinator

LEFT: SPS members enjoy the 2022 Physics Congress. Photo by SPS.

TOP RIGHT: Rianna Ehrenreich.

BOTTOM RIGHT: Mikayla Cleaver.

As two people who were active in SPS, first as undergraduates and now in helping the society run smoothly, we know there are many benefits to getting involved in the Society of Physics Students (SPS)!

SPS is a professional association for all undergraduate students interested in physics or astronomy. It's a chapter-based society that works at the campus, regional, national, and sometimes international level to help students build community and essential skills such as research, networking, and presenting. SPS also helps connect undergraduates with advisors, fellow physics and astronomy students around the world, and their local community.

Want to get involved? First, check whether your school has an SPS chapter. If you can't find any information by talking to your department, reach out to the SPS office at sps@aip.org and ask. If it does, we'll be happy to connect you to the advisor. If not, we'll be able to help you start or reactivate a chapter! (You don't need to have a chapter to join SPS officially, but that's the way to get the most out of the experience.)

So what exactly do you gain from becoming a member?

A SUPPORTIVE AND DIVERSE COMMUNITY

The main goal of SPS is to support physics and astronomy students! Chapters receive a wide array of resources, from help building inclusive chapters to science outreach kits and ideas for fun and educational community-building events. Both your chapter and the SPS office will be there to help you in your journey through this incredibly difficult major.

Chapter meetings, zone meetings, and the SPS-led Physics and Astronomy Congress (which takes place once every three years) are great places to meet fellow students and share experiences. By helping form communities within your department and chapter,

JOIN SPS TODAY!

SPS membership includes:

- Subscription to *Physics Today*, the most influential and closely followed physics magazine in the world
- Subscription to the *SPS Observer*
- Print copy of the annual *Journal of Undergraduate Research in Physics and Astronomy* (JURPA)
- Eligibility for scholarships, internships, research awards, and outreach awards
- Membership in two American Institute of Physics Member Societies
- Membership in the National Society of Black Physicists or the National Society of Hispanic Physicists

An individual membership is $24 per year, and discounts are available for group and chapter memberships! Learn more and join at spsnational.org/about/membership.

In most SPS chapters, being a member only requires showing up to a meeting—you don't have to pay the $24 to do that. However, to take advantage of the full range of opportunities, like awards and magazine subscriptions, you need to be an official member.

and creating connections beyond them, SPS helps you build a support system that can last a lifetime.

PROFESSIONAL DEVELOPMENT OPPORTUNITIES

Joining SPS makes you eligible for a wide variety of professional opportunities. For example, SPS regularly publishes student-written articles about undergraduate experiences, special events, and research. This is a fantastic way to share your work, practice science communication, improve your writing skills, and get published. Students who publish a research paper in SPS's *Journal of Undergraduate Research in Physics and Astronomy* (JURPA) are introduced to the scientific publishing process and have a paper with a DOI to their name.

Additionally, membership enables you to attend regional meetings of SPS chapters (zone meetings) and receive travel support to attend national or international professional science conferences, such as meetings of the American Astronomical Society (AAS) and American Physical Society (APS). Such meetings can expand your professional network, help you connect with potential graduate schools and employers, and reveal career paths you might take. You can also present your research in poster sessions or by giving a talk—and even win awards.

These are just a few of the professional development opportunities SPS offers. You can also take on leadership roles, learn the grant-writing process through award applications, and more. Whether you want to go into academia or industry or pursue another path, professional skills like presenting, leading, and writing are extremely valuable. SPS provides resources and a safe space to practice these essential skills!

ELIGIBILITY FOR SCHOLARSHIPS, AWARDS, AND MORE!

Whether you want to conduct research as a chapter, host outreach events, participate in scientific meetings, or build community, or if you're in financial need, SPS offers support at the chapter and member levels. Check out the full list on the SPS website! //

THE 2025 PHYSICS AND ASTRONOMY CONGRESS IS COMING!

This three-day conference will feature one-of-a-kind tours of local scientific sites, amazing speakers, thought-provoking workshops, and unforgettable experiences for physics and astronomy undergraduates. For details visit students.aip.org/congress.

LEARN MORE ABOUT SPS

- General information: spsnational.org
- Awards and scholarships: spsnational.org/awards
- Internships: spsnational.org/programs/internships
- Outreach: spsnational.org/programs/outreach
- SPS Zone and Professional Meetings: spsnational.org/meetings
- *Journal of Undergraduate Research in Physics and Astronomy* (JURPA): spsnational.org/jurpa
- The *SPS Observer*: spsnational.org/the-sps-observer
- Sigma Pi Sigma, the physics and astronomy honor society: sigmapisigma.org

FACULTY MEMBERS: YOU SHOULD BE INVOLVED IN SPS TOO!

Does your school already have an SPS chapter? If so, consider lending it your support and encouraging your students to join! If not, consider starting or reactivating a chapter. Here are just a few of the benefits.

Funding for activities

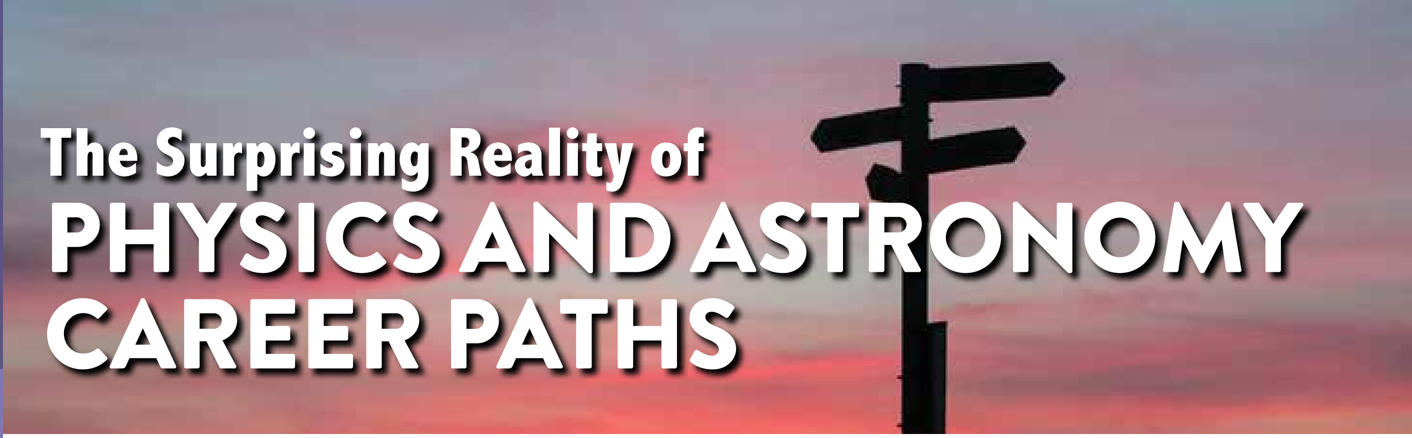
SPS chapters have various pathways to funding student and departmental activities. The SPS Chapter Research Award, for instance, grants chapters up to $2,000 for a group research project. Are you the catalyst for your department's physics and astronomy outreach events to local communities? SPS chapters can receive up to $600 to host such events. These are just a few of the many opportunities!

A supportive community

SPS aims to provide a supportive space for students interested in physics and astronomy to explore their thirst for knowledge. SPS advisors are at the forefront of that journey, mentoring students through outreach events, research projects, and conference attendance, and otherwise helping them grow into professionals. Advisors receive regular correspondence from the SPS office with opportunities, posters, and flyers. They also join a network of over 800 like-minded SPS advisors.

Recognition

Being an SPS advisor offers faculty and staff a way to get recognition for the mentoring and activities they may already be doing in their department, including through the annual SPS Outstanding Chapter Award and Outstanding Chapter Advisor Award.



The Surprising Reality of PHYSICS AND ASTRONOMY CAREER PATHS

by Kendra Redmond, Editor

As a new college student, the thought of majoring in physics never occurred to me—not even once. I declared a math major, but only because I had to choose *something*. Even the humanities weren't off the table. I took astronomy for fun, and it ended up being my gateway to physics. The enthusiastic astronomy professor (who also happened to chair the physics department) reeled me in, and I became a physics major.

Growing up, the adults I knew were teachers, nurses, therapists, and the like, not scientists. As a senior physics major, the only physicists I knew were either professors or they worked at the independent research lab where I spent a summer. I'd heard the message, "Physicists can do anything!" But that was all theory, to my mind.

Now, more than two decades later, I know that message isn't purely theoretical. I've met and interviewed many physics and astronomy majors who, by profession, are writers, analysts, engineers, leaders in community organizations, entrepreneurs, patent examiners, software developers, managers, and medical professionals. Most physics and astronomy undergraduates never become professors! As you'll see in the statistics and stories presented in this issue of the *SPS Observer*, their paths are sometimes twisty, sometimes surprising, and nearly always fulfilling.

The Alumni Careers Showcase (starting on page 22) is filled with the stories of people who've been in your shoes—physics or astronomy undergrads looking to the future. You'll learn about cool jobs and pick up excellent advice from individual contributors, but I also encourage you to consider the stories collectively. When I did this, two themes stood out to me.

Careers evolve: Many people end up in places and positions far from their initial plan—sometimes in jobs that didn't even exist when they graduated from college! Some deviate because their interests change, others for practical reasons (like where their partner is based or what field is hiring), and still others because fascinating new opportunities arise or they create such opportunities for themselves. Considering your whole self, keeping an eye out for what might be next, and being flexible is a great way to have a fascinating career!

It's about the journey: Many people work in vastly different types of jobs over their career. It strikes me that they don't talk about each stop as a rung on a ladder. Instead, they talk about each stop as doing what was right for them *at that time*. Throughout your career your goals will likely change, sometimes significantly. Changing course doesn't mean you're behind in some race to an ending—it means you have another opportunity to learn, grow, and embrace where you are in the moment.

TOP: Photo by Javier Allegue Barros on Unsplash.

ABOVE: Kendra Redmond.

As a physics major, I didn't really know what my options were or how to discover them. I liked the idea of science writing, but I didn't know how to get into that field. So I did what I thought most physics majors did; I went to physics grad school. Within a year I knew it wasn't the right place for me, which left me feeling pretty isolated and lost. I got a master's degree and, with luck and timing on my side, secured an internship in physics outreach. That led to 10 years of working in physics outreach and programs at professional societies (including SPS!). When my ambitions and life circumstances changed, the feelings returned, but I fumbled my way through, combining my love of writing and physics into a great career as a freelance science writer and editor.

If there's a third theme I hope you take away from this issue, it's that you don't have to be like me and try to figure everything out on your own. **The physics and astronomy community is here for you.** Many of us have stumbled around at times, feeling lost and uncertain of our paths. There's nothing wrong with these feelings, but you don't have to navigate them in isolation. Reach out to people doing what you love and ask about their path—odds are they'd love to talk with you.

It can be challenging and confusing to decide on a path, figure out how to get on that path, and, if necessary, change course. No matter where you are in the process, we hope you walk away from this issue of the *SPS Observer* excited about your options, equipped to explore them, and empowered to reach out to people in your fields of interest for insight and guidance. //

WANT TO GET CONNECTED?

Check out the SPS Alumni Engagement Program—a database of participants willing to be speakers, panelists, tour guides, and mentors for SPS chapters—at spsnational.org/programs/alumni-engagement.

THE UNIVERSITY *of* NORTH CAROLINA *at* CHAPEL HILL

PHYSICS AND ASTRONOMY

Application due: December 10, 2024

Apply: https://bit.ly/3pXxODR

Degree(s): PhD, MS

Questions: mejensen@email.unc.edu

- **91** total grad students
- **25%** of grad students are women
- **Special research equipment:** TUNL: Premier Nuclear Physics Lab, Biomedical Imaging Research Labs, Multiple Astronomical Instrumentation Labs

Chapel Hill, North Carolina

www.physics.unc.edu

Tufts UNIVERSITY

PHYSICS AND ASTRONOMY

Application due: December 1, 2024

Apply: https://bit.ly/4517YxV

Degree(s): PhD, MS

Fields offered include:
AST, Cosmo, HEP, PER, Condensed Matter

Questions: gradadmissions@tufts.edu

- **41%** of grad students are women
- **3:1** student to faculty ratio
- **$46,000** stipend for 2025-26 academic year

Medford, Massachusetts

as.tufts.edu/physics/academics/graduate-programs

Southern Connecticut State University
SC SU

APPLIED PHYSICS, M.S.

Degrees offered: MS

Application due: rolling admissions

Apply now: https://bit.ly/3tHNZEd

Questions: physicsgrad@southernct.edu

Subfields offered:
Nano, Materials Science, Optics, Astronomy

- **38.5%** of graduate students are women
- Student to faculty ratio of **13:7**
- **Special research equipment:** CSCU Center for Nanotechnology, Photonics Lab, Astronomical Instrumentation Lab, Computation Lab

The Applied Physics M.S. at SCSU is a Professional Science Master's program designed to prepare students to enter a wide range of high-tech industries. We offer rigorous, interdisciplinary courses with individualized attention to every student.

New Haven, Connecticut

www.southernct.edu/program/applied-physics-ms

COLLEGE OF SCIENCE PHYSICS VIRGINIA TECH

Blacksburg, Virginia
phys.vt.edu

PHYSICS

Application due: January 5, 2025

Apply: https://bit.ly/44QmzfA

Degree(s): PhD, MS

Fields offered include:
Astro, Condensed Matter, and Particle Physics

No GRE Required

Questions: gradphys@vt.edu

- ***95*** total graduate students
- ***26*** women graduate students
- ***100%*** of graduate students are receiving assistantship support

San Diego State University

MASTERS IN PHYSICS, MASTERS IN MEDICAL PHYSICS

Application due: March 1, 2025

Apply: https://bit.ly/3oviU3r

Degree(s): PhD, MS

Fields offered include: Optics, CMP, TheorNP, MedPhys, BioPhys

Questions: cjohnson@sdsu.edu

- **$15,360** average stipend per academic year; **$4164** part time in-state tuition waiver
- **10:1** student to faculty ratio
- **90%** of grad students are receiving assistantship support

San Diego, California
physics.sdsu.edu

NC STATE UNIVERSITY Physics

Raleigh, North Carolina
physics.sciences.ncsu.edu

PHYSICS

Application due: January 5, 2025

Apply: https://bit.ly/3OkN18P

Degree(s): PhD, MS

Fields offered include: Astrophysics, Biophysics, Quantum physics, Condensed Matter Physics, Experimental Nuclear Physics, Nuclear and Particle Physics

Questions: py-grad-program@ncsu.edu

- **24%** of grad students are women
- **98%** of grad students are receiving assistantship support
- **Special research equipment:** IBM QHub, Tristar reactor, NCSU NNF and AIF, Genome Sciences Laboratory, ORNL, JLab, SLS, BNL

UNIVERSITY OF DENVER

Denver, Colorado
science.du.edu/physics

PHYSICS AND ASTRONOMY

Application due: February 1, 2025

Apply: https://bit.ly/3A35qow

Degree(s): PhD

No GRE Required

Subfields offered: Condensed Matter, Biophysics, Astronomy

Questions: xin.fan@du.edu

- Average stipend of **$24,316** for 9 months
- **24:13** student to faculty ratio
- **42%** of graduate students are women

Wake Forest University
Department of Physics

PHYSICS

Application due: January 8, 2025

Apply: https://bit.ly/3093iNW

Degree(s): PhD, MS

Fields offered include:
Biophysics, condensed matter physics, gravitation

Questions: salsbufr@wfu.edu

- **18%** acceptance rate
- **2:1** student to faculty ratio
- **Special research equipment:** DEAC High-Performance Computing Cluster with GPUs for machine learning, Laboratory for Quantum Optics & laser interactions with materials, Organic Electronics facilities, Biophysical Spectroscopy and Microscopy Facility & Center for Nanotechnology

Winston-Salem, North Carolina
www.physics.wfu.edu

Texas Tech University

DEPARTMENT OF PHYSICS AND ASTRONOMY

The Department of Physics and Astronomy at Texas Tech University offers M.S. and Ph.D. degrees in the following research areas: astrophysics, biophysics, condensed matter physics, high energy physics, and physics education. We have collaborations with research centers like CERN, NASA, Fermi, Los Alamos, and Sandia National Labs, and the alumni of our programs are employed in academia and industry. The department offers several forms of financial assistance, like the teaching and research assistantships. To be nominated for additional fellowships students are encouraged to accept offers of admission prior to February 15.

depts.ttu.edu/phas
Phone: 806.742.3767 • Email: physics.academic.advising@ttu.edu
Department of Physics & Astronomy, Box 41051, Lubbock, TX 79409-1051

Vanderbilt
College of Arts and Science
Department of Physics and Astronomy

DEPARTMENT OF PHYSICS & ASTRONOMY

The Department of Physics & Astronomy at Vanderbilt University offers graduate students the opportunity to do original research working side-by-side with world-renowned faculty. We cover a wide range of research programs – from astronomy and cosmology to biological physics, materials physics, particle, nuclear, and relativistic heavy-ion physics – all while providing a friendly, welcoming environment in the heart of Nashville, TN. The department presently has 26 full-time faculty. We offer programs leading to Ph.D. degrees in Physics or Astrophysics.

- Completion rate – **99%**
- Acceptance rate – **33.3%**
- Number of first year graduate students – **16**
- Total number of graduate students – **70**
- Average stipend per academic year **$36,500**

Phone: (615) 322-2828 • Email: physastro-grad@vanderbilt.edu
6301 Stevenson Center, Nashville, TN 37240

as.vanderbilt.edu/physics

YOU HAVE OPTIONS

Career Paths for Physicists

Q: What can you do with a physics or astronomy bachelor's degree?

A: Get a PhD and become a professor, OR ...

What comes after the "or" is not widely known in many departments, even though recent data show that only about 30% of physics bachelor's degree recipients enter physics or astronomy graduate school within one year of graduating. Physics and astronomy bachelors go into a huge variety of fascinating, fulfilling, and well-paying careers! This is evidenced by decades of data collected by the American Institute of Physics (AIP).

Physics bachelor's degree recipients

There were 8,618 in the class of 2021–22.

36% had a double major, most commonly math.

13% started at two-year colleges.

Within one year of earning a physics bachelor's degree...

54% entered the workforce

Common employment sectors included:

The private sector (60%)

- The majority of these graduates took STEM positions.
- Those working in STEM fields had a median starting salary of around $70K.

Colleges or universities (11%)

- This category contained the largest proportion of part-time employees (21%).
- Many respondents worked at their alma mater.

Civilian government, including national labs (9%)

- The vast majority of these positions were in STEM.

High school teachers (6%)

Active military (4%)

- These positions spanned all branches of the armed forces and were in aviation, nuclear power, and many other areas.

16% attended graduate school NOT in physics or astronomy

48% went into engineering programs. The rest entered programs in math, medicine, education, or other fields.

- Physics majors scored among the highest of all majors on the admission tests for medical school and law school (the MCAT and LSAT); to learn more, visit aip.org and search "LSAT" or "MCAT."
- While AIP doesn't track these graduates, anecdotal evidence suggests they go on to successful careers in engineering, management, education, law, medicine, business, and a variety of other areas.

30% attended graduate school in physics or astronomy

72% started in PhD programs, the remainder in master's degree programs.

> 90% were supported by teaching or research assistantships or fellowships.

The median TA stipend for a PhD physics program was $28K.

The majority of this data comes from AIP's degree recipient follow-up surveys for the classes of 2021 and 2022 combined. The data are for bachelors receiving their degree from US physics programs and remaining in the US after graduation. Data specific to astronomy bachelors can be found at aip.org/statistics.

7% of US physics bachelor's recipients earn an "exiting" physics master's degree

- These master's degree recipients leave their department after receiving the degree, in contrast to those who earn a master's degree en route to a physics PhD in the same department.
- About 60% graduate with a specific research focus.
- A master's degree in physics takes about two years.

Of those who remain in the United States, within one year of earning a physics master's degree...

~66% enter the workforce

- About half work in the private sector, overwhelmingly in STEM fields; engineering comprises the largest proportion.
- Other common employers include colleges and universities, high schools, civilian government, and the military.

~34% continue graduate studies

- Some transfer to other institutions for a physics PhD, while others transfer to programs in other fields.
- While AIP doesn't track those who change fields, anecdotal evidence suggests these graduates go on to successful careers in engineering, management, education, law, medicine, business, and a variety of other areas.

What About Astronomy?

- About half of new astronomy bachelor's degree recipients pursue graduate studies in the year following their degree, with the largest proportion in astronomy or astrophysics.
- Among those entering the workforce, the largest proportion is employed by the private sector, followed by colleges and universities.
- In recent years, about two-thirds of new astronomy PhDs held a postdoc the winter after they graduated.
- The private sector employs the largest proportion of new astronomy PhDs that accept potentially permanent positions.
- Learn more at aip.org/statistics.

~13% of US physics bachelor's degree recipients earn a physics PhD

- Students typically take 5–7 years to earn a physics doctorate.
- 98% of physics PhD students receive financial support through teaching or research assistantships or fellowships.

Of those who remain in the United States, within one year of earning a physics PhD...

55% accept a temporary position (e.g., a postdoc)

- Doing a postdoc is typically a prerequisite for a faculty position.
- Virtually all postdocs are in the university or government sector.

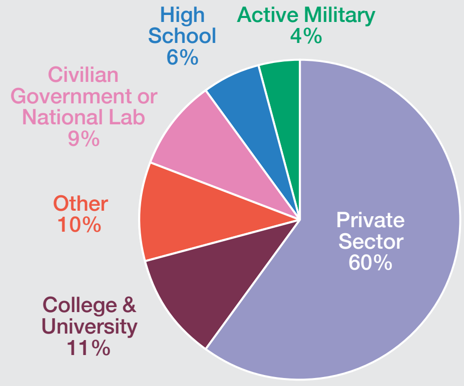
43% accept potentially permanent positions

- 73% accept private sector positions, and they have a median salary of $125K.
- 15% accept academic positions, and they have a median salary of $66K.
- To learn more about who's hiring physics PhDs, visit aip.org/statistics/whos-hiring-physics-phds.

Getting to Work with Your BACHELOR'S DEGREE

If you're like many physics and astronomy majors looking for a job after graduation, you might be unsure where to start. Here's a look at what recent bachelor's degree graduates were up to one year after graduating. To learn more, visit AIP Statistical Research at aip.org/statistics.

WHERE NEW PHYSICS BACHELORS WORK



Source: AIP Physics Bachelor's Follow-up Survey, classes of 2021 and 2022

COMMON JOB TITLES FOR NEW PHYSICS BACHELOR'S DEGREE RECIPIENTS

Education
High School Physics Teacher
High School Math Teacher
Middle School Science Teacher
Tutor

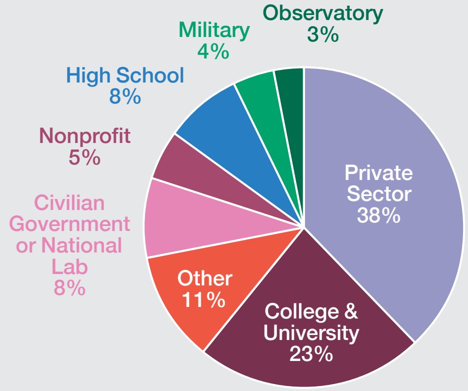
Engineering
Application Engineer
Data Engineer
Design Engineer
Engineering Technician
Electrical Engineer
Manufacturing Engineer
Mechanical Engineer
Process Engineer
Production Engineer
Project Engineer
Scientist
Systems Engineer
Test Engineer

Finance/ Business
Data Analyst
Investment Banker
Project Manager
Research Analyst

Programming/ Software
Application Developer
Consultant
Data Analyst
Data Engineer
Data Scientist
Machine Learning Engineer
Software Engineer
Software Developer

Research and Technical
Accelerator Operator
Junior Specialist
Patent Examiner
Physicist
Research Assistant
Research Technician
Researcher
Scientist

WHERE NEW ASTRONOMY BACHELORS WORK



Source: AIP Astronomy Bachelor's Follow-up Survey, classes of 2021–22

WHO'S HIRING?

These employers recently hired three or more new physics bachelor's degree recipients for technical positions, according to responses to AIP's follow-up surveys of physics bachelors in the classes of 2018–22. This list does not include high schools, colleges, universities, or enlisted US military.

Accenture
Actalent
Aerotek
Amazon
American Physical Society
Apex Systems
Apple
Applied Materials
Arete Associates
Argonne National Laboratory
ASML
ASRC Federal
AT&T
Axient
Bank of America Merrill Lynch
Baylor Scott & White Healthcare
Belcan
Benchmark Electronics
Bloomberg
Blue Origin
BNY Mellon
Boeing
Booz Allen Hamilton
Bridger Photonics
Brigham and Women's Hospital
Broad Institute of MIT and Harvard
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To search who's hiring by state, visit aip.org/statistics/whos-hiring-physics-bachelors.

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ATTORNEY

Brian Jacobsmeyer

by Brian Jacobsmeyer

I really like being a lawyer. It's not always perfect (no career or job is), but the field has been a really good fit for me. Much of what initially interested me in physics—the deep thinking, logical thinking, and working through problems—carries over into the legal profession.

Before becoming an attorney, I majored in physics and philosophy as an undergraduate at the University of Colorado Boulder. While I briefly considered a legal career during college, I instead decided to pursue a career in science writing. I started with a science writing internship for the American Water Works Association, an industry group for drinking water utilities and related professionals, followed by an internship at the American Physical Society (APS). That APS internship transitioned into a permanent position managing the society's physics outreach website. I did that for several years and really enjoyed it, but law school remained in the back of my mind.

Indeed, I thought a legal career would still include much of what I enjoyed about science writing. I loved writing and wanted to do more persuasive writing. The idea of going into patent law appealed to me—I would still be connected to writing and physics, but it would be a new path. So, after several years at APS, I quit my job, traveled with friends for a summer, then started law school. I loved law school.

Since I had a physics degree, just before my first year of law school I was able to take an exam to become a patent agent—someone who can write patent applications and apply for patents at the patent office on behalf of clients. Having a science background, and especially the patent agent credential, gave me a leg up for a paid summer associate position at a national law firm. During that first summer, I worked on both patent litigation (acting as a lawyer for clients in patent infringement lawsuits before courts) and patent prosecution (securing patents for clients at the patent office). During my second law school summer, I focused on patent litigation and more general litigation at two national law firms.

If you end up working for a big law firm after graduating from law school, odds are the offer came from a firm where you interned over the summer, as was the case for me. I took a postgraduate job at a big firm in Silicon Valley, doing a mix of patent and general business litigation.

After working in Silicon Valley for a while, my wife and I relocated to Colorado, and I became a clerk for a federal district court judge. Clerkships are a valued credential that many lawyers pursue, especially those interested in litigation. In that position, I worked closely with the judge, advising and writing opinions for him to edit and approve. I loved it. Because he was a federal judge, he addressed all kinds of cases, from criminal to civil.

Next, I went to a law firm where I focused on large patent disputes that often spanned multiple countries. I enjoyed that work, but big firms can be bureaucratic and intense, so it's common for associates at those firms to move on after several years. When the judge whom I had previously clerked for asked me to fill an unexpected absence in his chambers for a few months, I took the opportunity to return. I recently finished that temporary position and am starting at a smaller law firm that does business litigation.

ABOVE: Brian Jacobsmeyer.

Legal practice and physics research share several similarities. In both, you think logically. And in a way, both involve starting with a hypothesis or position and testing it. In law, you test it against case law and legal statutes and, eventually, before a judge or jury; in physics, you test your hypothesis against the natural world. Overall, the type of thinking involved is similar, although law involves a lot more writing.

If you like writing, thinking through logical arguments, viewing sometimes contentious issues from different perspectives, and trying to persuade someone (often through educating them—not necessarily arguing and yelling), the law could be a good fit for you. //

LAW SCHOOL Q&A

with Brian Jacobsmeyer, Attorney

Interview by Kendra Redmond, Editor

IS LAW A GOOD PATH FOR ME?

Being a lawyer involves lots of writing, so that's something to keep in mind. Some legal careers involve more "on your feet" public speaking in the courtroom, such as being a prosecutor or public defender, but all such careers involve a good deal of writing.

Also, consider whether you like thinking through logical arguments and trying to persuade people. There's an art and a science to persuasion, but it more often involves educating an audience—either a judge or a jury—about technical legal issues applied to various factual situations. As an example, talking to a jury about patent law and related technology can be really hard, but skilled trial attorneys can make it look easy.

In litigation, you're constantly arguing with smart people whose clients have very different positions than yours, so you need a thick skin to deal with that.

But perhaps one of the most overlooked traits of being a good lawyer is empathy, including being fair-minded, open to considering other positions on contentious issues, and not being dismissive. Placing yourself in the other side's shoes forces you to understand their positions and arguments and helps you refine your own arguments and positions. Some people have a natural inclination toward this, but it's also a skill you can develop.

SHOULD I GO TO LAW SCHOOL RIGHT AFTER UNDERGRAD?

My wife is a lawyer who went straight through, and it worked out great for her. She knew she was going to go down that path earlier than I did. But for me, it was really helpful to get out in the world and have a real job first, a different career even. You don't have to have it all figured out in the beginning. You can go out and try things first, see if you like them. If you're unsure about law school, there's no rush. And working first doesn't hurt; in fact, it often helps with admissions to law schools and legal hiring.

If you're on the fence about law school, didn't get the LSAT (entrance exam) score you wanted, or didn't get into a program you like—don't dive in; law school will still be there next year. It can be hard to be patient when you're starting out, but law school is a really big investment, financially and otherwise.

DO YOU HAVE ANY TIPS ON PAYING FOR LAW SCHOOL?

All but a few of the very top law schools offer merit-based scholarships. These scholarships depend heavily on your LSAT score and your undergraduate GPA. While law schools consider other things, such as work experience or community involvement, LSAT scores and GPA are by far the most important criteria for both admissions and scholarship amounts. And you can often leverage one school's scholarship offer against another's—there's a whole online ecosystem that talks about how to do this. There are also need-based scholarships at almost all schools.

WHAT OTHER ADVICE DO YOU HAVE TO SHARE?

Internships are key. If you're thinking about going into physics research, for example, get a research position and see if you like it. The same goes for other careers, like business or law. It's not a great idea to go through law school only to realize that you hate being a lawyer.

Networking is also key. Reach out to people with careers that interest you and ask to buy them coffee. You'll find that people tend to get nostalgic as they get older and love to help students.

Law isn't the most common career path for physics majors, but there are lots of physics and astronomy majors who went on to law school. Googling patent lawyers in your area may be a good start, and you'll probably find someone who majored in physics or electrical engineering who would be really happy to talk to you about their career. //

PHYSICS MAJORS AND THE LSAT

According to the Law School Admissions Council, 148 of the more than 70,000 people who applied to start law school in 2021 were undergraduate physics majors. The median high score of all applicants was 156; for the physics majors it was 163. Approximately 68% of all applicants were offered admission to law school; of the physics majors, 73% were accepted.

Learn more from the 2022 American Institute of Physics report *How Well Do Physics Bachelor's Degree Recipients Perform on the MCAT and LSAT Exams?* by going to aip.org and searching "LSAT."

FEATURE

ALUMNI CAREER SHOWCASE

OPHTHALMIC TECHNICIAN

Aman Kapoor

by Aman Kapoor

When I started college as a physics major, I expected to be an astrophysicist. But my first year of college was in 2020—the COVID year—and I started thinking about medicine because of the pandemic. I decided to become a physics premed student, and I haven't looked back since. I spent my last year of college focusing on minors in biology, chemistry, and biochemistry to further prepare myself for medical school. I graduated in December and am in the midst of a gap year to gain clinical exposure while applying to medical school.

As an ophthalmic technician, I serve as an intermediary between patients and doctors. I'm the first person to meet a patient entering our clinic. I find out what issues they're concerned about, what symptoms they have, and other information and write a full History of Present Illness (HPI) for the doctor to review. I then run tests based on the patient's HPI. I assess their visual acuity, measure intraocular pressure and corneal thickness, do refractions to find their prescription, and more. I also conduct visual field tests and take OCT (optical coherence tomography) scans of the patient's retinas.

Some of the best parts of the job are also what make it challenging: Thinking on your feet, answering tough questions, and collaborating with technicians and doctors to make the right decisions. Some patients need routine vision and pressure checks, and their requirements are fairly straightforward. But others come in for vision issues that have just started, and you have to decide what tests to do based on their symptoms. This process takes some time getting used to, and it requires knowing when to seek advice from senior technicians or doctors. Another awesome part of the job is the amount of learning involved. We spend a great deal of time training in both clinical skills and the pathophysiology behind the conditions we manage, including glaucoma, keratoconus, and cataracts. I've also learned about the biological mechanisms by which the medications we prescribe exert their effects.

ABOVE: Aman Kapoor.

In this job, it helps to enjoy interacting with people. You might meet someone who went to the same school as you growing up, as well as people with all sorts of funny stories. But there's also a responsibility that comes with knowing a patient's health is partly in your hands. While doctors check your work and ultimately make the decisions, it's important to take care when working with a patient. For instance, you must be extremely careful measuring vision or pressures, and it's essential to note a detailed patient history so that a safe and effective treatment plan can be created. We're trained to be thorough and ask questions so that we can do the best for our patients.

While physics is a less common choice for premed, it seemed pretty natural to me. A lot of diagnostic technology (MRI, CT, PET, OCT, etc.) was developed by physicists. Even much of the physiology in medicine can be broken down into physics. For example, ophthalmology involves a ton of physics applications, from the geometric optics of lenses to hydrostatic pressures of the eye in glaucoma. Cardiology relies on a solid understanding of fluid mechanics to understand blood flow, and of electricity and magnetism (E&M) to understand how the heart pumps.

Both physicians and physicists are problem solvers. While physicists think critically to solve problems in modeling the universe, physicians think critically to solve problems diagnosing and treating complex pathologies. The time I spent working on challenging physics problem sets gave me good problem-solving skills that I can build on throughout my medical journey.

I encourage premed physics undergraduates to study hard, do well in their courses, and look for the connections to physics in their premed classes—the electron transport chain that you learn about in biochemistry has a huge connection to quantum tunneling. In physiology, action potentials and the way neurons fire can be understood by E&M and circuit theory. Also, spend time outside of class working with people, whether at a senior home, tutoring center, or hospital. Even spending more time with your family and listening to their stories can be rewarding in many ways.

Don't be afraid to choose something nontraditional. Physics plays a role in everything and will prepare you for anything you do. //

DATA ANALYST

Gabrielle Feeny

by Gabrielle Feeny

When I chose to major in physics, I intended to go to graduate school for astronomy. Then when it came time to apply for grad school, I wasn't so sure what I wanted anymore. I still applied, but it was like throwing darts—I didn't apply to the same kind of program twice. Astronomy? Sure. Climate dynamics? Why not! Environmental policy? Sign me up. I ended up in a geographic information system master's program and quickly realized it wasn't a good fit. I was uninterested in the subject matter and burnt out from undergrad, so I dropped out.

It took me a year and a half to find the job I have now—I had to figure out what I wanted to do with my physics degree and how to get there. In the meantime, I moved back in with my parents and worked part time at a local park.

I'm now a senior data analyst at the company Sedgwick. It's partly a claims management company, and I am a senior data analyst in their professional liability division. I produce loss runs and stewardship reports for various clients, informing them how much they have paid due to claims made against them and helping to identify common causes for those claims. It involves a lot of using Microsoft tools such as Excel and PowerPoint, and working with our databases.

One of the best parts of my job is that I get to work from the comfort of my own home. I really love my manager and coworkers, who are kind and easy to reach out to if I need help. My manager encourages us to have a healthy work–life balance and take our paid time off.

The most challenging parts have been learning industry terminology and how to work with the databases we use—things you wouldn't necessarily be taught in college but pick up on the job. It can also be challenging to figure out how to handle some ad hoc requests, but like I said, my team makes it easy to ask for help.

Having a physics background makes you a perfect fit for data analyst roles; you just have to learn how to pitch your skills to prospective employers. If you're interested in this kind of work, take advantage of your college job board and any connections you made during your time as an undergrad. Look at job postings and see what kind of programs employers want you to have experience with, then brush up on those. My university classes did not expose me to SQL or Tableau, so I sought out ways to learn the basics so that I could include them on my resume.

If you don't know what you want to do yet, give yourself time to consider what you really want in a career. We grow a lot and learn more about ourselves throughout college, and sometimes what you thought you wanted when you started isn't what you still want by the time you graduate. There is no shame in throwing in the towel and starting anew if your original plan isn't working out. //

ABOVE: Gabrielle Feeny.

THINKING ABOUT THE WORKFORCE?

The *SPS Careers Toolbox* is an in-depth resource for learning what kind of jobs are out there for physics and astronomy majors, identifying your skills and pitching them to potential employers, successful interviewing, and more. Many of its tools can also be applied to finding internships, research positions, or even entrance into graduate programs. Explore the toolbox and download the latest version at spsnational.org/sites/all/careerstoolbox.

TEST DRIVE A CAREER AT SPS JOBS

Check out SPS Jobs for internship, research experience, and job postings in physics, astronomy, and related fields at jobs.spsnational.org.

FEATURE

ALUMNI CAREER SHOWCASE

RESEARCH GEOPHYSICIST
Ashton Flinders

by Ashton Flinders

Every day, over my morning coffee, I decide whether I'm going to spend the day at the computer or head out into the field and hike across a volcano.

I study and monitor volcanoes on the Island of Hawaii, with an emphasis on measuring and modeling variations in the gravitational field associated with changes in active volcanic storage systems. I also get to fly over the volcanoes in helicopters, which is always a blast!

My path to this career was very, very twisty! I started at the University of Wisconsin - River Falls as a biology/preveterinary major. After taking a zoology lab, I quickly realized that it wasn't for me. I latched onto the only topic I was enjoying at the time: chemistry. In my junior year, I was still insatiably curious as to "why"—Why did this reaction take place this way? Why do these electrons go there? and so on. My physical chemistry teacher recommended that I take some physics courses, and I eventually decided to double major.

By ten years later, I had followed a circuitous path that included receiving a master's degree in geology and geophysics from the University of Hawaii in 2010, a second master's in ocean engineering from the University of New Hampshire in 2014, a PhD in oceanography from the University of Rhode Island in 2016, a US Geological Survey (USGS) Mendenhall Post-Doctoral Fellowship with the California Volcano Observatory, and a Presidential Management Fellowship. During all those years of school, I also managed to spend about two years total at sea, including aboard two research cruises to north of the Arctic Circle.

In 2019, I landed a permanent research position at the Hawaiian Volcano Observatory, where I am today. I still consider myself an applied physicist, as well as an experimentalist. My experiment is the volcano—I have some power to deploy configurations of sensors in order to make observations and propose and test hypotheses. However, I am still on a volcano! This makes some of my efforts and goals logistically difficult to achieve—and sometimes impossible.

My area of expertise, gravity and gravity instrumentation, is very much focused on the cutting edge. One challenge is that it's not as easily made operational as other classic geophysical monitoring techniques, such as seismology and global navigation satellite systems monitoring. Just last year, we purchased a $650,000 absolute quantum gravimeter, the first in the US government!

TOP: Ashton Flinders spends the evening with colleagues at the edge of Kilauea caldera, monitoring the first day of the January 2019 Kilauea eruption. Photos courtesy of Flinders.

ABOVE: Ashton Flinders inside Kīlauea caldera, on the edge of a subsided crater formed during the 2018 eruption of the volcano Kīlauea in the Hawaiian Islands. The crater was subsequently filled with lava from a series of ongoing eruptions. The orange pants are part of a fire-retardant helicopter flight suit; you have to take a helicopter flight to get down there!

My advice to current undergraduates is to be curious! Be adventurous! Don't settle on a linear path from A to B. Take classes in everything, even if they seem completely unrelated to what you want to study or do. The best asset we have is our imagination, and our ability to imagine and play is fueled by our exposure to new ideas. Some of the most impactful research advances I have seen in my field were instigated by someone stepping out and adopting methods, techniques, and theories from seemingly unrelated fields of science.

Also, don't be discouraged if you don't get where you want to go—just keep swimming! Eighty percent of everything is being in the right place at the right time. //

PHYSICISTS CAN DO WHAT?

Ever wondered what you can do with a physics or astronomy degree? Check out the Hidden Physicist stories published in *Radiations*, the magazine of Sigma Pi Sigma. Real people with backgrounds in physics and astronomy who didn't become professors write about their careers in baking, science journalism, data privacy, and many more areas, and share advice with undergraduates. Go to sigmapisigma.org/sigmapisigma/radiations/hidden-physicists.

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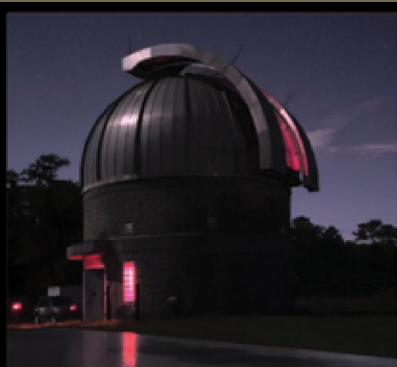

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FEATURE

ALUMNI CAREER SHOWCASE

Major US Semiconductor Investment MEANS JOBS FOR PHYSICISTS

by Kendra Redmond, Editor

The United States is currently spending billions to elevate its semiconductor industry. The effort kicked off in 2022 when President Biden signed the CHIPS and Science Act into law. Today's STEM students will be critical to its success and are well positioned for the job opportunities it will create.

A key section of the bill—CHIPS for America—provides tax incentives and $52 billion for US semiconductor research, development, and manufacturing. That includes building new facilities, partnerships, and programs in the United States, and investing in the workers who can make those efforts successful. Significant private sector investments have followed.

What does that mean for physics and astronomy students? "There are going to be lots of great manufacturing jobs," says Eric Forsythe, director of the CHIPS Manufacturing USA Program at CHIPS for America.

Physics students may not typically consider a manufacturing career, but Forsythe says that electronics manufacturing is a deeply sophisticated process. "When you're looking at what it takes to make an NVIDIA processor or an Intel processor, it is mindboggling that it works at all," he says. "And the level of engineering and process knowledge it takes is just unprecedented in any other field."

Additionally, the explosion of artificial intelligence is opening up a variety of new electronics applications, Forsythe says. Is a passion for medicine, finance, national security, or another area driving your career plans? You can impact so many areas through electronics innovations and quality manufacturing, he says. "Electronics touches everything."

People with a physics degree at any level can always find a place in manufacturing—there will always be more to learn, and it will always be challenging, Forsythe says. "Problem-solving is really what manufacturing in today's environment is all about." //

ABOVE: Researchers at NIST, the National Institute of Standards and Technology, test a new chip that converts light into microwave signals. This chip (the fluorescent panel that looks like two tiny vinyl records) could improve technologies that depend on high-precision timing and communication, such as GPS and internet connections. The gold box to its left is a semiconductor laser that emits light to the chip. Photo credit K. Palubicki/NIST.

LEARN MORE

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CHIPS: **Creating Helpful Incentives to Produce Semiconductors**

TECHNICAL DIRECTOR

Eric Forsythe

by Eric Forsythe

I work at CHIPS for America as the director of the CHIPS Manufacturing USA program. The program resides within the CHIPS Research and Development (R&D) Office, which is housed by the US Department of Commerce's National Institute of Standards and Technology (NIST).

At the end of January 2024, we announced plans for a CHIPS Manufacturing USA Institute that will develop a "digital twin" for semiconductor manufacturing. That means we'll work at the intersection of simulating semiconductor manufacturing process flows and the physical world. We aim to accelerate time to market, innovate new spaces, and create new processes and tools that expedite the manufacturing process. The US federal initiative CHIPS for America expects to award at least $200 million over five years to fund this new institute.

I am currently developing the institute's technical program goals, which involves meeting with people from the semiconductor industry, academia, federal agencies, and others in the community. I'm building out how the institute will meet the government's economic and national security objectives, integrate across government programs, and meet the needs and requirements of industry and academia to drive innovation. This is the third public–private manufacturing partnership I've developed during my career.

I've always been interested in science. I remember, during middle school, being fascinated by a spring and the fact that you could write an equation describing its motion. That's when I realized I could take math—which I really enjoyed—and apply it to the physical world to see how things operate. So I decided to be an engineering physicist.

I stuck with that plan and went to the University of Maine in Orono, seven miles from home. I studied physics with a concentration in electrical engineering to increase my job prospects within Maine, but I still ended up leaving when I graduated. I got a job at Kearfott Guidance and Navigation Corporation in New Jersey, working on stellar inertial guidance systems for the Trident missile. At night I took physics classes toward a master's degree at Stevens Institute of Technology.

After a few years, a Stevens professor suggested I consider pursuing a physics PhD and joining his lab. Hailing from the backwaters of Maine, my background emphasized practical work over higher education. Intrigued by the prospect of pursuing physics research, I accepted the offer, albeit without fully grasping its implications at the time. My doctoral journey centered on porous silicon light-emitting diodes, leading to collaborations with a small business federally funded by Small Business Innovation Research (SBIR) programs and eventually extending to a partnership with the Army Research Lab (ARL).

ABOVE: Eric Forsythe.

When I completed my PhD, my wife was in the midst of her PhD at the University of Rochester in New York. In a calculated move to support her academic journey, I accepted a postdoctoral position studying organic light-emitting diodes at the same institution. After she graduated and I concluded my postdoc, I had several job offers on the table. Contemplating between a staff position at ARL and opportunities with the display industry, I ultimately opted for ARL. The allure of broader physics research avenues and the chance to contribute to Department of Defense initiatives resonated deeply with me.

Soon after joining ARL, the Army worked with a group of companies to establish a flexible display program to develop and deliver flexible display manufacturing solutions through a public–private partnership. As the technology advanced, my role evolved to that of ensuring our flexible display technology was relevant to the needs of our warfighters. This often involved engaging directly with young soldiers to understand their requirements firsthand. These interactions solidified my commitment to public service intertwined with program management. Since then, I have maintained a steadfast focus on the intersections of electronics, physics, and manufacturing, consistently leveraging the power of public–private partnerships to drive innovation and impact.

I think it's really important to know why you're doing what you're doing. I'm motivated by strengthening national security and supporting the nation's goals. I spent most of my career with the Department of Defense, where nothing is more motivating for me than being at a base with 18-year-old soldiers who just came back from the tip of the spear and hearing, "If I had this technology, I could have…" or "My friend wouldn't have..." Today, I am privileged to work for the National Institute of Standards and Technology on the CHIPS Act and to continue my support of our economic and national security.

I encourage you always to give your best to your current job but be mindful of what's next. When building a program, I'm already looking ahead and always learning. What can I do with this? What problems are peripheral to this space? How could I solve them? We always have to be looking to the future. //

FEATURE

ALUMNI CAREER SHOWCASE

SCIENCE WRITER AND NASCAR EXPERT

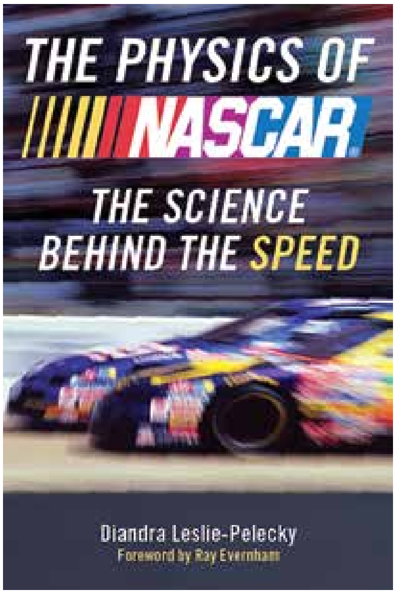
Diandra Leslie-Pelecky

by Molly McDonough, Graduate Student, Penn State

What does a physicist do when they don't know how something works? They start asking the experts. That is exactly what Diandra Leslie-Pelecky—a physics professor at the time—did after a NASCAR race caught her attention while she was flipping through TV channels one Saturday afternoon. Leslie-Pelecky happened to tune in just as a car crashed, despite not having come into contact with another car or suffering a critical component failure. She needed to know why, and that question changed the course of her career.

"The most important skill a scientist must have is being a pit bull," she explains. "When you get your teeth around a problem, you just can't let go of it until you have an answer."

Like many physicists, Leslie-Pelecky's interest in physics started in high school.



"It was the one class in high school I really enjoyed," she says. "It was the one class that challenged me." After leaving high school, she became a physics and philosophy double major at the University of North Texas. She found a home in the small physics department. "Having [the department] as a family was really important," Leslie-Pelecky says. "I dropped out of high school and went to college when I was 16, so having a bunch of surrogate parents was even more important for me."

Leslie-Pelecky knew she wanted to be a professor, so she applied to graduate school in both physics and philosophy. On choosing physics over philosophy, she explains, "You could sort of study philosophy on your own. It's pretty hard to study experimental physics on your own." She decided to pursue a PhD in physics at Michigan State University (MSU), studying condensed matter physics.

After graduating, Leslie-Pelecky took a postdoctoral position at MSU while she waited for her husband to graduate from the same physics program. Then she took a tenure track physics faculty position at the University of Nebraska. Six years later, she moved to the University of Texas at Dallas and, later, to West Virginia University.

Leslie-Pelecky had a passion for writing, but it was difficult to pursue on top of being a professor. "The problem is, you can be really good at one thing at a time. And if you're trying to run a lab and mentor graduate students, you can't have other distractions; it's just too competitive," she says.

Then the NASCAR crash piqued her curisoity. She got hooked on wanting to know why racing cars fail and the physics behind the failures. "At that time, NASCAR had maybe five or six people with PhDs working among the various teams. So I started with those folks because we all spoke the same language," she says.

ABOVE: Diandra Leslie-Pelecky.

As she dug deeper into the physics of racing, Leslie-Pelecky realized she could teach the entire first semester of physics in the context of NASCAR, which she says "is so much more interesting than a ball rolling down an inclined plane." This inspired her to write a popular science book, *The Physics of NASCAR: The Science Behind the Speed*, which kicked off her writing career.

Today, Leslie-Pelecky is a full-time writer, public speaker, and go-to NASCAR expert. She attends dozens of races each year and has written articles on NASCAR and other topics for publications including NBC Sports, *Time* magazine, and the *New York Times*. She blogs regularly at *Building Speed: The Science of Fast* at buildingspeed.org. //

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METEOROLOGIST AND CEO

Jan Dutton

by Molly McDonough, Graduate Student, Penn State

ABOVE: Jan Dutton.

BELOW LEFT: World Climate Service informs commodity trading, climate insight, and risk management decisions. Image courtesy of Dutton.

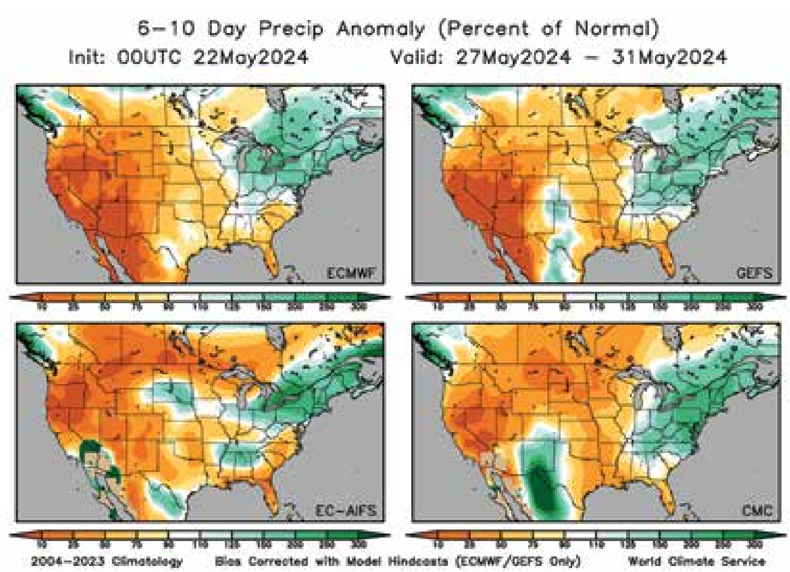
"When I headed off to college, the last thing in the world I thought I was going to be was a meteorologist," says Jan Dutton in the podcast *Clear Skies Ahead*. He's now the CEO of Prescient Weather Ltd., a private company that develops weather forecasting services for decision-makers in the energy and agriculture sectors.

Perhaps that's because his father, John Dutton, was a meteorologist—first a professor at Penn State and then dean of the College of Earth and Mineral Sciences.

Although he grew up surrounded by meteorology talk, when Dutton arrived at Colby College, he became a science, technology, and society (STS) major. The STS major is less about hardcore science and more "about understanding the interactions of science and society," says Dutton.

During his sophomore year at Colby, Dutton participated in a program called Jan Plan. Lasting the month of January, the program allowed students to stay on campus for a course or participate in an offsite internship. Dutton interned at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. There, he helped one of the scientists prepare for a research mission. "I was there for basically three weeks, but it completely turned me around in terms of how awesome science is," Dutton says.

Upon returning to Colby after his internship, Dutton declared a double major in STS and physics. He decided to pursue a physics major because Colby College didn't have an atmospheric science or meteorology major, and he knew he needed a physical science degree to be admitted to graduate school. "Physics was the gateway drug to meteorology," he said.



Dutton completed his senior thesis in paleoclimatology, the study of the climates during the Earth's geologic ages, after doing some paleoclimatology research at Penn State. In his final year of undergrad, he applied to jobs and graduate school. When he didn't get any job offers, he decided to pursue a master's degree in meteorology at Penn State.

After earning a master's degree in meteorology, Dutton was at a crossroads. "I realized that I didn't necessarily want to continue [in academia] and be, say, a professor at a university or work in government," he says. He struggled with whether to pursue an MBA, continue to a PhD program, or get a job after his master's degree. In the end, he pursued a joint PhD/MBA program at Penn State, since he felt the MBA would set him apart from other job applicants.

Upon graduating, Dutton started his own company, Weather Ventures. The company focused on weather derivatives, financial instruments corporations once used to hedge against the risk of weather-related financial losses. Weather Ventures created a toolset to help the weather derivatives market understand how the climate forecast would likely influence the value of weather derivatives. But after the Enron crash in the early 2000s, the weather derivatives market disappeared. Dutton needed to pivot.

He joined DTN, a company that sells weather information products to airports worldwide. Dutton stayed for four years, until a private equity company acquired DTN. In the meantime, his father and a colleague had started Prescient Weather, a company focused on weather forecasting services for decision-makers in energy and agriculture. In May 2018, Dutton joined as CEO.

As CEO, Dutton spends most of his time marketing two products: Prescient Weather's CropProphet (***cropprophet.com***) and the World Climate Service (***worldclimateservice.com***). Grain traders use CropProphet to forecast the impact of weather on yields of corn, soybeans, and wheat. Energy and natural gas companies use the World Climate Service to help manage and mitigate weather and climate risk.

Dutton says there are endless opportunities for graduates in meteorology and calls the field "the original big data science." He encourages students to explore their interests and take classes outside of their majors. "Science is very, very important, but to be marketable, you need to try to broaden your horizons a little bit as well," he says. "Demonstrate that you're capable of doing crisp, analytical work and then communicating about it."

This piece is based on the August 10, 2021, episode of the podcast Clear Skies Ahead: Conversations about Careers in Meteorology and Beyond, *released by the American Meteorological Society. To listen to the episode, go to* ***bit.ly/3Wyedq7***. **//**

Pathways to a Career in METEOROLOGY

by Molly McDonough, Graduate Student, Penn State, with Kendra Redmond, Editor, and the American Meteorological Society

Meteorology is the study of the atmosphere. The word is derived from the Greek word *meteoron*: something that happens high in the sky. Ancient Greeks observed the stars, sky, clouds, winds, and rain and attempted to understand where they come from and how they work together. This grew into our modern understanding of meteorology, which includes weather forecasting and now, studying climate change and its implications. The field impacts all parts of daily life, from your morning commute to the stability of the food supply.

You might think of a meteorologist as someone who talks about the weather during a news broadcast. You'd be correct, but the field is much broader than that! It includes all professionals who use science to observe, understand, forecast, and explain the Earth's atmospheric phenomena and their impact, according to the American Meteorological Society (AMS). Meteorology includes aspects of atmospheric, oceanic, and hydrological sciences.

You can find meteorologists on TV, but you can also find them helping farmers optimize plant growth, designing weather-related instruments for air traffic control, writing forecasting programs, studying hailstones, participating in urban planning, and doing much more! They work for government agencies and the military, universities, and private companies.

Although some schools offer bachelor's degrees in meteorology or atmospheric science, a degree in physics or astronomy can also be good preparation, especially if you've done research in a related area. And it's not uncommon to get a physics bachelor's degree and then an advanced degree in meteorology or atmospheric science.

Wondering if meteorology would be a good career for you? AMS suggests considering these questions:

- Am I curious about the world around me and why it is the way it is?
- Would I like to work in a field that has many important applications in human affairs, such as warning others of hazardous weather or investigating the atmospheric forces that shape our weather and climate?
- Am I challenged by the idea of applying basic scientific principles to understand the behavior of the atmosphere?
- Am I intrigued by the concept of using math as a language to describe things that happen in the world around me?
- Would I like to work with supercomputers, satellites, and other sophisticated research tools?

If your interested is piqued, check out AMS's resources for students, including many career profiles, at **ametsoc.org**. **//**

The American Meteorological Society (AMS) is a global community of scientists, professionals, and enthusiasts who advance weather, water, and climate science and service. Learn about the AMS, its science, community, and opportunities at ametsoc.org/index.cfm/ams/education-careers.

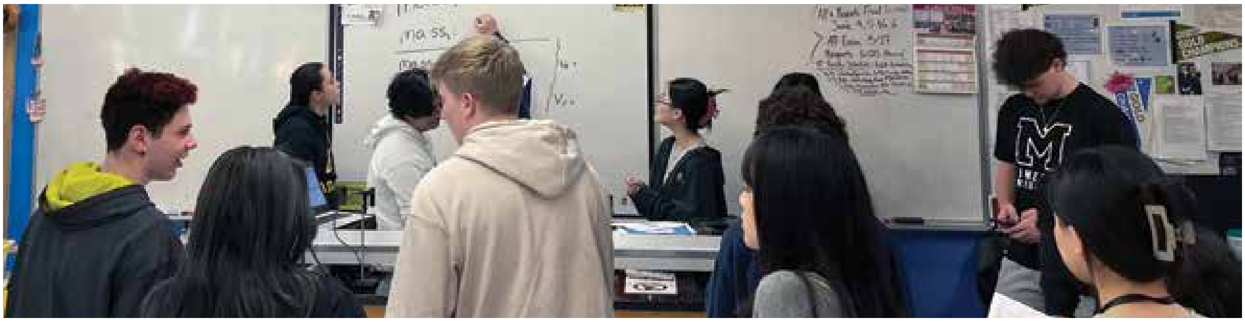
SPS members are eligible for a free year in AMS when they register or renew. For details, visit spsnational.org/about/membership/free-ms-membership.

FEATURE

ALUMNI CAREER SHOWCASE

Pathways to a Career in SECONDARY EDUCATION (IT'S NOT TOO LATE)

by Justine Harren, Interim K12 Program Manager, American Association of Physics Teachers



When I sat down in the blue armchair of my academic advisor's small windowless basement office in my first semester of college, I knew that I would be leaving in a few years with a degree in education. I just couldn't decide between pursuing my love of elementary school children and my love for physics—teaching physics would inevitably mean teaching high school. But either way, I was going to teach.

Fortunately, I was gifted with an advisor that didn't see a reason why I couldn't do both. She saw my ambition and helped me declare and complete majors in K–6 elementary education and 5–12 physics secondary education in only four years. Upon graduating with two bachelor's degrees, I found myself in a high school classroom with 150 of my own students in an urban area outside of Minneapolis, Minnesota.

My path into education was fairly direct, because I knew from the start, with little doubt, that I wanted to teach. However, stories like mine are less common than you might think. The more high school physics teachers I get to know, the more unique stories I hear of entering the profession. I recently conducted a poll in physics teacher groups on social media, asking, "What was the path you took into teaching?" The comments were filled with different meandering stories. Some were similar to mine, but most were indirect routes—a series of unpredicted experiences and decisions that landed these teachers in the classrooms they lead today.

A notable group of paths the social media responses highlighted was alternative pathways to licensure. In some cases, you can begin a teaching career *before* earning an education degree or teaching certificate. One colleague shared her story with the nonprofit Teach For America (TFA). As a college junior majoring in physics, she realized that she no longer wanted to follow her original plan to pursue a PhD. She applied to Teach For America and was placed in a high school physics classroom in Detroit, Michigan. TFA helped her earn a master's degree in education while working, and she is now a 10-year veteran of teaching! TFA is not the only option; different states have different teacher licensing programs, and many have alternative certification programs for those who didn't pursue education as an undergraduate.

TOP: Students from a high school physics class in New Jersey work on an activity. Photo by M. J. Wright.

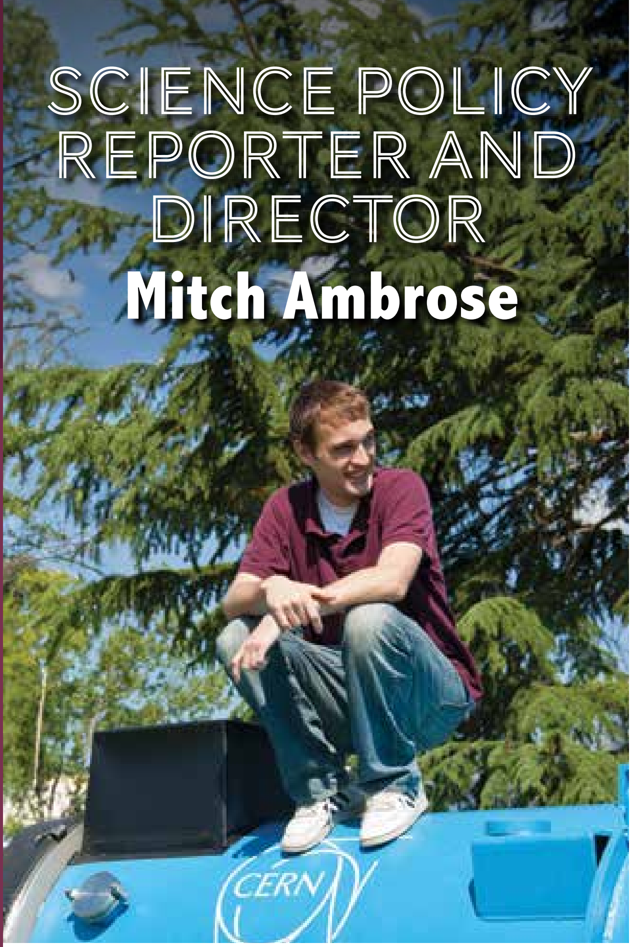
ABOVE: Justine Harren.

Another option for undergraduates who want to teach at the high school level or below is graduate school. It is not uncommon for people to earn a bachelor's of science in physics and then go to graduate school in education and get licensed to teach. I have a former intern who is currently completing this process. He entered his undergraduate studies interested in physics but unsure of teaching. He eventually realized he wanted to be in a classroom and is now finishing a master's in education and seeking a classroom position for this fall. Although it takes a little longer, this pathway produces teachers with solid content knowledge from their undergraduate studies who received high-quality education training as graduate students. It's also worth noting that teacher salaries are often based on experience *and* level of education. A first-year teacher with a master's degree will start higher on the pay scale than one without. In a field such as physics, where qualified candidates are limited, this can be a good benefit.

Recently, I was chatting with a preservice teacher in a science methods course I teach when she began telling me about her path into education. After high school, she initiated a career in culinary arts. She spent two years in the field before realizing she was more interested in working with people. She then earned a two-year degree in law enforcement and became a police officer. After a few years, she started looking for yet another option. Following an interim job as a paraprofessional in a school, she decided she was going back to school—for teaching this time. She is a bit older than many of her classmates and has the added challenge of balancing a family with coursework, but she will graduate in a few short months and will move into her own classroom. I look forward to checking back in a few years to see if education is her final landing place!

These stories from friends, colleagues, and students remind me of a conversation I had a few months ago. I was sitting with a professor from my alma mater, where I now adjunct, discussing possible joint interests. She shared a thought that continues to roll around in my mind, especially after my undergraduate experience. She explained that time and time again students tell her they are interested in teaching but think it is too late because they are two, three, or four years into their content program. This is simply not true! Students interested in teaching have many pathways into education, even after their undergraduate education. You don't have to decide whether you want to be a teacher at age 18, and your college path does not pigeonhole you into or out of a career that you want. I hope to see this attitude change and renewed encouragement and support for people exploring their options at any point in their education or career. //

SCIENCE POLICY REPORTER AND DIRECTOR
Mitch Ambrose



LEFT: Mitch Ambrose during his undergraduate stay at CERN. Photo courtesy of Ambrose.

by Kendra Redmond, Editor

As a physics major at the University of Minnesota, Mitch Ambrose did research with a particle physics group on campus. When offered the chance to work at CERN for a summer, he enthusiastically agreed. Although he didn't know it then, this would be an exceptional summer at the LHC: Physicists would announce the discovery of the Higgs boson.

"I was working on some very, very small piece of the machine that had nothing to do with the discovery, but it was still really awesome to be there for that," Ambrose says. A highlight was seeing Peter Higgs, the particle's namesake, whisked into the press conference by a security guard.

As the physics community celebrated, Ambrose realized something about himself. He wasn't that excited about what discovering the Higgs meant for science. But he was fascinated that so many countries had come together to build such a complex machine for so esoteric a purpose.

Mealtimes also got him thinking. "The CERN cafeteria is a really special place where you have all sorts of people from different cultures hanging out together, getting to know each other as people through this scientific endeavor," he recalls. He started thinking about the management of science, international collaborations, and science diplomacy.

Not long after returning to Minnesota, Ambrose swapped a dreaded quantum class for a science policy class and interned with the Minnesota State Legislature. Those experiences convinced him that public policy was a better fit for him than research or teaching.

Wanting to jump straight into science policy after college, he found a two-year fellowship for recent graduates with the Science and Technology Policy Institute (STPI). STPI conducts studies for the National Science Foundation, the White House Office of Science and Technology Policy, and other federal agencies. Ambrose says the fellowship gave him a 30,000-foot view of the US federal science landscape. "It's very decentralized—there are lots of different agencies that fund science."

When that fellowship ended, he hit a fork in the road: go to grad school for policy or get another job? He decided to stay in DC a little longer and found a four-month internship with the Senate Committee on Commerce, Science, and Transportation. "I really got a peek behind the curtain at the role of Congress in science policy; it's totally different than the work I was doing at STPI," he says. In contrast to working on large reports, the committee internship involved tasks like meeting with organizations to hear their requests, considering whom to invite to hearings, writing questions for hearings, and getting a sense of how Congress oversees science.

The internship ended before graduate school application season, so Ambrose took a job as a reporter for FYI, the science policy news service of the American Institute of Physics. Nine years later, he's still there—now as director. He never did go to graduate school.

FYI is designed to help scientists understand and navigate Washington, although it also helps Washington understand science, Ambrose says. Readers are primarily scientists; people working in science policy; people at national labs, universities, and embassies; and students interested in science policy.

Every Monday, FYI publishes an issue that highlights what's on deck for the week ahead and recaps big news from the prior week. The publication covers congressional hearings, advisory committee meetings for science agencies, and science-related legislation, reports, and funding.

Ambrose spends lots of time following the formal ways by which the government makes decisions and sets priorities for science. That includes going elbows-deep into enormous PDF documents to make sense of the federal budget and share it with readers in a meaningful way.

His team—which includes a few reporters and an intern—doesn't do advocacy work but instead aims to help scientists interpret policy developments and the mechanics behind Washington, Ambrose says. "We want to help people understand how you can have an impact." //

Check out FYI and sign up for its email newsletters at aip.org/fyi.

Pathways to a Career in SCIENCE POLICY

by Kendra Redmond, Editor

If you're passionate about science but more drawn to its big-picture societal implications than research and you lean into politics or advocacy work, you might want to explore career options in science policy.

"The traditional way to think about science policy is science for policy or policy for science," says Anna Quider, a science policy consultant with a PhD in astrophysics. The field encompasses both types of interactions, she says.

Doing science for policy means providing scientific expertise to policymakers. This includes activities like collaborating on reports, panels, or advisory committees to provide science-based advice on policy issues related to energy, public health, national security, international relations, and many other areas. It can also mean analyzing the impact of policy on a science-related area.

Doing policy for science often entails analyzing or communicating how governmental decisions will impact what science gets done, under what conditions, and by whom, explains Quider. This includes wide-ranging policy topics from immigration to intellectual property and science funding. "When the government is considering policy for science, the community has to weigh in about good policy and unintended consequences," says Quider.

Scientists often participate in science policy as an ad hoc activity, but many people with science backgrounds have fulfilling careers in the field. Science policy jobs aren't usually limited to people with a science degree, though, so it may take a little extra work to identify them. In addition, many of the common job titles—public policy specialist, policy advisor, or legislative analyst—don't mention science.

ABOVE: The 2019 SPS interns pose in front of the US Capitol. Photo by SPS.

An advanced degree in science policy may open some doors, but many people get into the field by jumping right in after undergrad, often as interns or fellows. There are also fellowships for PhD scientists, which is the pathway Quider utilized.

Science policy jobs exist in a wide range of settings: professional societies, universities, congressional committees, private companies, national and private labs, governmental agencies, lobby groups, think tanks, nonprofit organizations, and more.

As a physics or astronomy major, exploring science literacy, economics, politics, and government can help you prepare for a career in science policy. Being able to distill a complex report or policy into key points—the bottom line—is a valued skill, as is being able to communicate clearly. Nothing beats hands-on experience, though. Quider suggests working, interning, or volunteering with organizations that have a policy bent, even if you can't find one specifically in science policy. //

OPPORTUNITIES IN SCIENCE POLICY

The path into science policy is less defined than for some other careers, but getting a foot in the door is key. Don't know where to start? Here's a nonexhaustive list of science policy–related internships for undergraduates and recent graduates:

- **Society of Physics Students summer internships in policy, including the AIP Mather Policy Internship,** spsnational.org/programs/internships
- **Congressional office internships: check with your school and the websites of individual members, committees, and caucuses for opportunities**
- **DOE Energy Efficiency and Renewable Energy Science, Technology and Policy Program,** energy.gov/energysaver/energy-efficiency-and-renewable-energy-science-technology-and-policy-program
- **Federal Internship Finder,** gogovernment.org/federal-internship-finder
- **IDA Science and Technology Policy Institute fellowships,** ida.org/careers/students-and-recent-graduates/internships-and-fellowships/science-policy-fellowship
- **NIH Office of Science Policy summer internships,** osp.od.nih.gov/get-involved/osp-summer-internship-program
- **Sea Grant Community Engaged internships,** seagrant.noaa.gov/community-engaged-internship
- **USAID Pathways,** usaid.gov/careers/student-internships
- **Virtual Student Federal Service internships (part-time, academic year),** careers.state.gov/interns-fellows/virtual-student-federal-service
- **White House Office of Science & Technology Policy internships,** whitehouse.gov/get-involved/internships/ostp-internships

SCIENCE POLICY CONSULTANT

Anna Quider

by Kendra Redmond, Editor

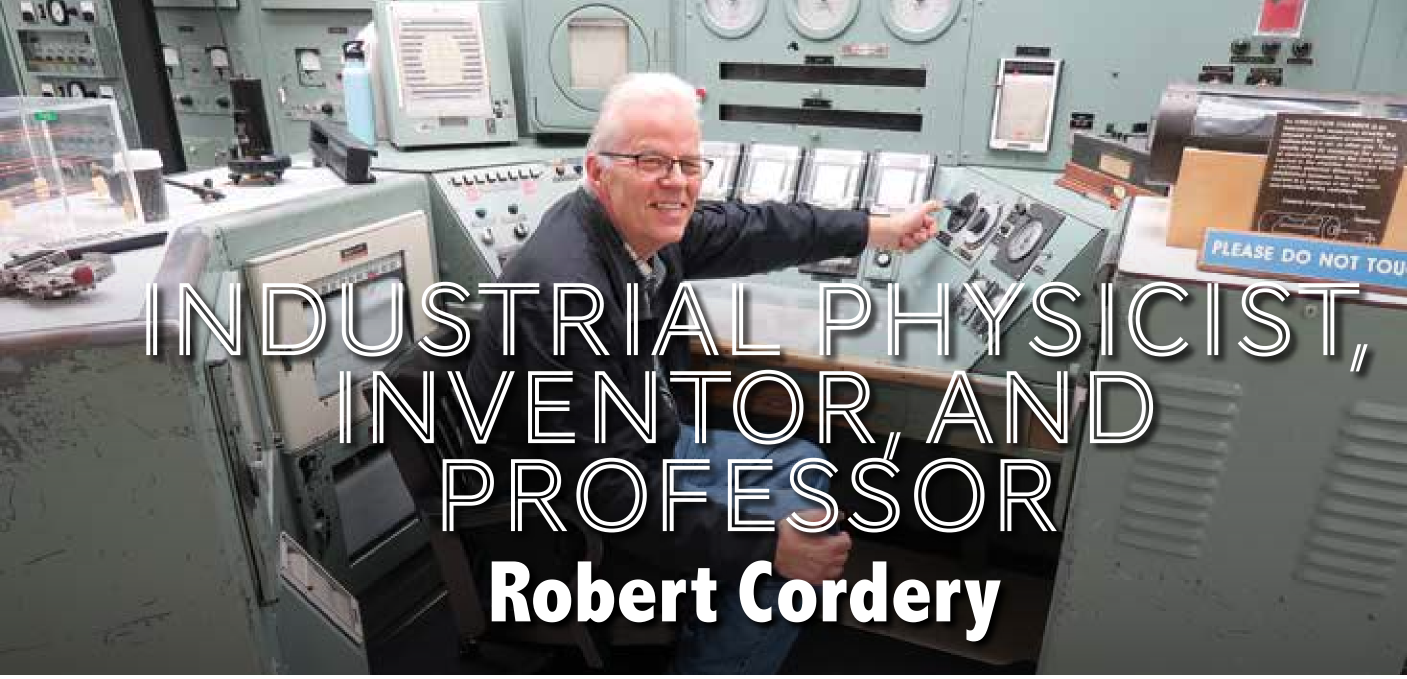
Anna Quider is a long-time friend of SPS, PhD astrophysicist, science policy professional, and CEO and founder of The Quider Group. Before starting her own consulting firm, she worked in policy-related positions for nonprofits, Congress, the federal government, and higher education.

The Quider Group's goal is to increase access to opportunities for individuals and organizations often underserved by the federal government. It works primarily with nonprofit clients in science and technology or higher education, helping them better engage with the federal government. That might include strategic planning, playing matchmaker between the nonprofit and key policymakers and programs, or maximizing an organization's chances of success on federal grant applications. Clients also enlist Quider to give keynote talks and workshops on topics from science policy to communication.

One of Quider's passion projects is promoting student success and empowerment through premier national and international scholarships, especially for diverse and underserved students and campuses. For years she has advocated for more federally funded research opportunities on campuses, and now that it's happening, she's considering how those opportunities can map to life-changing federal research fellowships for students and more prestige for the institutions.

As Quider builds her firm, she's taking a social entrepreneur approach. "The challenge is to not become just another DC firm," she says. Many places have a high budget for policy work, which means that valuable organizations operating on a shoestring budget can be left underserved by the federal government. It's about "doing well by doing good," she says. //

ABOVE: Anna Quider.



INDUSTRIAL PHYSICIST, INVENTOR, AND PROFESSOR

Robert Cordery

by Robert Cordery

ABOVE: Robert Cordery sits at the control panel of the decommissioned Hanford Nuclear Power Plant in Washington state. Photo courtesy of Cordery.

Today, I teach General Physics for Life Sciences, Physics of Light and Color, and two introductory physics labs at Fairfield University in Connecticut. I enjoy working with faculty colleagues at the university and in the physics department. In a relatively small school, I appreciate the interdisciplinary nature of the work. But I haven't always been a professor.

After earning my PhD in theoretical statistical physics from the University of Toronto, I went on to a postdoctoral position at Rutgers University. There, my two office mates and I published a few papers on applications of the renormalization group in statistical physics. Afterward, I accepted a visiting assistant professor position at Northeastern University, where colleagues and I published on the Monte Carlo renormalization group in lattice gauge field theory. I also did some work on the quantum Fermi accelerator, a system whose classical version exhibits a transition to chaotic behavior.

In both positions I totally enjoyed the research and interactions. But my wife and I had two children by the end of my second postdoc, and there were no good prospects for a tenure-track position, so I took a position in the interdisciplinary research group at Pitney Bowes Inc.

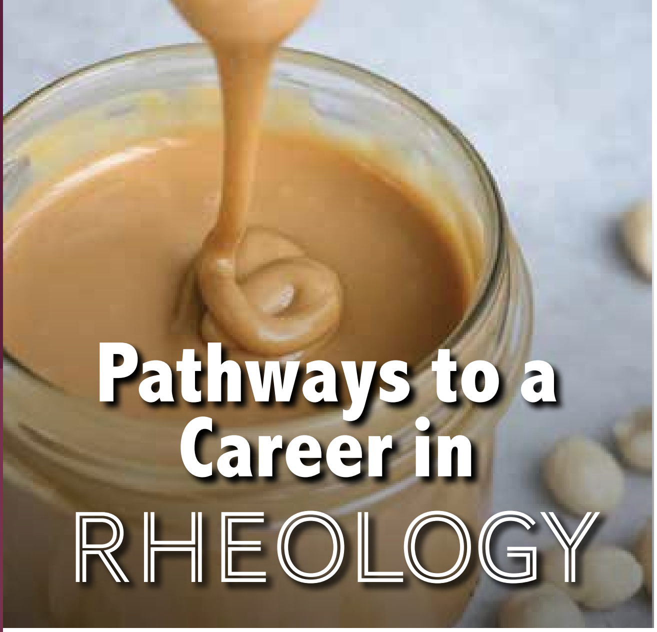
Initially, I didn't understand why the shipping and mailing company wanted a physicist. During the interview, they asked me to give a talk about my research, so I presented my work on quantum chaos! They showed me some problems they had with an experimental inkjet printhead that printed on envelopes. I diagnosed a problem with the design based on some material properties. I got the job offer—and a career that lasted 30 years.

The research and development (R&D) group at Pitney Bowes included several physicists, mathematicians, chemists, and electrical, mechanical, and software engineers. They had a number of interesting projects going, and the position came with a substantial salary increase over my academic pay. I started as an intermediate engineer, but my title was soon senior physicist. Among my first projects were an inkjet printhead design, some paper-handling theory, and a magnetic electronic article surveillance system that included signal processing, antenna design, and soft-magnetic tag design. I also looked at other problems that had a mathematical aspect. When Pitney Bowes filed patent applications on several of these projects, I became an inventor. I also studied for and became licensed as a US patent agent.

Pitney Bowes had a technical career ladder that paralleled the management ladder up to vice president. Having no interest in management, I joined the technical ladder. As a mathematically oriented person, I got involved in its secure systems group and collaborated on some projects on secure protocols, secure devices, and cryptographic key management. The last projects I collaborated on before retiring from Pitney Bowes were data mining and natural language processing applications.

After retiring, I joined Fairfield University. Overall, I value my time in industrial R&D. I don't view it as a consolation prize. I had a rewarding career, contributing to the development of several products and platforms. I worked in interdisciplinary teams on important projects with many talented people who remain good friends. As a semiretired physicist, I'm still developing new research interests. Of course, I sometimes wonder what my life would have been like if I had found that permanent academic position…

If you're interested in industrial R&D, be sure to gain a broad working knowledge of the science and math behind new technologies. I never regretted any new mathematics I learned. More math gives you flexibility. The training to apply math to real-world problems is valuable in both industry and academia. //



Pathways to a Career in RHEOLOGY

by Arif Z. Nelson, Assistant Professor, Food, Chemical and Biotechnology Cluster at the Singapore Institute of Technology, and Education Committee, Society of Rheology

Rheology is the study of the flow and deformation of complex or soft materials—materials that exist somewhere on the spectrum between fluid and solid. Though this may sound exotic, we all interact with these sorts of materials on a daily basis: toothpaste, peanut butter, and even the blood flowing through our veins are rheologically complex materials.

The scientific discipline of rheology is relevant to nearly all studies of material properties. It is a key tool and perspective for understanding a wide variety of materials applications and industries.

The big picture of rheology is about understanding the relationships between a material's complicated microstructure and its behavior on the macroscale. For example, a rheologist in the food industry might assist with designing a new food product by identifying ingredients with promising properties, helping set processing parameters to maintain a consistent product, or designing quality control measurements to ensure that the product has a consumer-approved texture.

At the same time, an engineer working in mining or construction might need to design a pumping system for slurries or pastes. In that case, understanding the rheology of these mixtures is important to ensure they reach their intended destination.

No matter the industry—food, pharmaceuticals, cosmetics and personal care products, paints and coatings, polymers, and adhesives—rheology is about linking a material's physical material properties to the way it will behave in situations across the spectrum, from initial formulation to the manufacturing plant to consumer interactions. Despite the huge variety of applications, there is often significant common ground among the underlying physical concepts which govern the microstructural interactions of polymers, gels, emulsions, particle suspensions, and other materials.

LEFT: Peanut butter is a rheologically complex material. Photo by Tetiana Bykovets on Unsplash.

ABOVE: Arif Z. Nelson.

There is no single path to a career in rheology or soft material physics. Practitioners of rheological methods have backgrounds in physics, chemical engineering, chemistry, food technology, materials science, pharmaceutical engineering, biology, and mechanical engineering, among other areas. Knowledge of rheology often complements other physical characterization or computational methods in these practitioners' toolboxes. Undergraduate courses on fluid flow, solid mechanics, and materials characterization often provide good foundational knowledge related to rheology.

At large companies handling many different materials development projects, an expert in rheology typically has a graduate degree in one of the aforementioned programs. It is not unusual for people pursuing higher education related to rheology to shift their careers and change the area in which they apply their knowledge. For example, someone who studied polymer rheology during their PhD in a chemical engineering program might pursue a career focused on food rheology. While some people who work in rheology have "rheologist" in their job title, job titles like research specialist, research scientist, product specialist, and quality engineer are more common.

To learn more about the exciting opportunities in academia, industry, and government for people who study and apply rheological theories and methods, consider attending a Society of Rheology meeting. Meeting information is available at rheology.org. //

ABOUT THE AUTHOR

Arif Z. Nelson is an assistant professor at the Singapore Institute of Technology. He studies applications of soft materials across the industries of sustainable food systems, pharmaceuticals, and other formulated products. Among other efforts to translate research into more impactful applied learning practices, Nelson also maintains a website about cooking in the context of soft materials and rheology at the Soft Matter Kitchen, arif.zone/home/kitchen. Tiramisu, anyone?

THE SOCIETY OF RHEOLOGY

The Society of Rheology (SOR) aims to expand the knowledge and practice of rheology through education, partnership, and collaboration with associated fields, industries, and organizations, as well as to share rheology and its impacts. To learn more, visit rheology.org.

SPS members are eligible for a free year in SOR when they register or renew. For details, visit spsnational.org/about/membership/free-ms-membership.

LEARNING EXPERIENCE DESIGNER

Brooke Haag

by Kendra Redmond, Editor

Considering some of her most recent job titles—instructional designer, STEM evangelist, and senior technical learning experience designer—you might not guess that Brooke Haag has a PhD in nuclear physics and spent several years as a physics professor. But a closer look reveals the thread weaving it all together: a desire to help people access more opportunities through education.

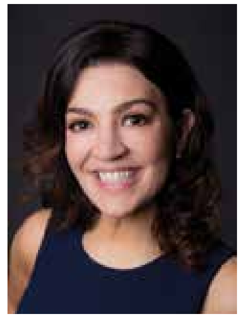
As a new community college student, a career in physics wasn't on Haag's radar. But when she needed a physical science class, she registered for physics. Her professor was so inspiring that she decided to pursue a PhD in the field. "Being in physics opened up so many things for me, personally and professionally," she says. Even as a graduate student, she knew she wanted to help open those doors for others.

After earning a PhD, Haag took her love of physics and education back to the community college where she started. She spent five years teaching physics there and two more at another two-year school, developing curricula, doing research, engaging students in extracurricular physics activities, and bringing physics education research–based practices into the classroom.

After seven years, Haag was ready for a change. She went back to school, this time earning a master's degree from Harvard's Technology, Innovation, and Education Program. There was a lot of excitement, promise, and room for innovation in online education, she says. "I wanted to be involved."

She soon became an instructional designer, working with professors to adapt their classes into edX courses for MIT. This meant grappling with how to translate what's needed for success in the classroom into an online format. "Being a learner with a background in physics and teaching suited me well for coming into the situation and having a growth mindset," she says. She started with the attitude, "I don't know what I'm doing, but I'm going to tinker around and figure it out." And she did.

Next came a job on Microsoft's education team. "That was a whole different career pivot," Haag says. She became a STEM evangelist working with Microsoft's education sales team. Many people in the education community considered STEM education as a good way to equip students with practical skills—like coding or handling data—that could help them get well-paying jobs in the future, she says. Part of her role while working in that space was thinking through Microsoft's STEM initiatives and connecting them to the education community.



ABOVE: Brook Haag.

During the COVID-19 pandemic, Haag stepped down from Microsoft but ramped up her involvement in the North America Scholastic Esports Federation. A huge volume of students play online games, she says. Esports works to harness this for educational purposes by, for example, helping students develop social and emotional learning skills through gaming or teaching them science through Minecraft building projects.

For the past three years, Haag has worked as a technical learning experience designer at Pathstream, a company that provides digital skills–based classes and certificate programs to help people advance their careers. She's helped design classes on a variety of topics and loves that she's always learning something new. She's currently the lead on a Salesforce certificate program. "Being a learner, this is a great job for me," she says. "I'm constantly having to try out new tools or figure out a new subject, or I'm spending a lot of deep, focused time doing something interesting."

As she reflects on her career, Haag says that she's enjoyed its different stages and that each made sense for the time. It's a path all her own, focused on innovation and education. "Education is really important, and so is giving people access to education and helping them use it to be successful," she says. "I was successful because of the education I received, even though I didn't have a ton of resources in my life, and I've wanted to extend the same to others." //

ATTENDING A TWO-YEAR COLLEGE? APPLY FOR AN SPS SCHOLARSHIP!

The Peggy Dixon Two-Year Scholarship supports students transitioning from a two-year college into a physics or astronomy bachelor's degree program. The $2,500 scholarship is named in memory of Peggy A. Dixon, a physics professor at Montgomery College who served as SPS and Sigma Pi Sigma historian from 1992 to 2003. To learn more and apply, visit spsnational.org/scholarships/dixon.

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FEATURE

TOOLS FOR YOUR PATH

IT'S NEVER TOO EARLY TO Start Exploring Career Options

by M. J. Wright, Physics Professor and Department Chair, Adelphi University

Some students seem to have everything worked out: what they're going to study, where they're going to work, which city they're going to live in. For others, the idea of choosing a career path is daunting—an impossible task to save for some time far in the future. Trust me, after mentoring countless students over the years, the reality is somewhere in between.

ABOVE: M. J. Wright.

The training you receive as a physics major prepares you for an unlimited number of careers. That's both kind of exciting and kind of scary. How do you decide what to do with so many different possibilities?

You have to get started early and explore. It's much like studying for a physics exam—the sooner you start trying things out and learning, the better the exam will go. Meanwhile, those who wait until the last minute may struggle and not achieve their best potential. So, too, with your career search. Dive in early. I promise it will be more fun than studying for that physics exam.

Here are some simple ideas to help you get started with exploring career options, beginning with the easiest.

- After class, talk to your professors (and not just your full-time professors) about what they do and how they made their career decisions.
- At gatherings, talk to your friends, neighbors, aunts, uncles, and other family about what they do. Trust me, your family members will be eager to give you advice.
- Watch people talk about their careers on the internet, TikTok, and YouTube.
- Participate in the wonderful local career events put on by the physics club or career center at your university.
- Attend national career events put on by SPS or the American Physical Society (APS). The next Physics and Astronomy Congress, hosted by SPS and Sigma Pi Sigma, takes place in 2025 in Denver, Colorado, and it's going to be amazing. Come see me dress up in a full-body shark costume and give my "Be a Shark" career networking workshop!

Attending workshops and talking with other people is a great way to learn about careers. But in my opinion, the best way to learn is to *do*. Here are some ideas for opportunities to learn by doing:

- Get involved in a research project at your school, or apply for National Science Foundation Research Experiences for Undergraduates, Department of Energy Science Undergraduate Laboratory Internships, or similar opportunities. Apply even if you're still early in your school journey. I like my research students to start early so they can work with me for a while.
- Explore your neighborhood for cool places! Is there a makerspace in your community? How about at your school? Visit and check it out.
- Make something! Try building something, coding up a new software company, writing a book, or starting a rock band. You may fall short of your goals, and that's okay. In the process, the skills you develop and your experiences will help move your career forward.
- Don't be afraid to do something different. One of my best summers as a college student was spent as a camp counselor at a YMCA summer camp for kids. The experience taught me how to better interact with people and exposed me to so many different ways of thinking. The loose network I developed and the conversations I had then still have meaningful impacts nearly 30 years later.

As physicists and astronomers, we find that data helps us make good decisions. The more data we have, the better our decisions will be. So get involved, start thinking about careers as early as possible, and learn all about the opportunities that are out there. //

FIND HANDS-ON EXPERIENCES

- **Department of Energy Science Undergraduate Laboratory Internships (SULIs):** science.osti.gov/wdts/suli
- **NSF Research Experiences for Undergraduates (REUs):** nsf.gov/crssprgm/reu
- **SPS Jobs, Internship Listings:** jobs.spsnational.org/jobseekers/internships
- **SPS Summer Internship Program:** spsnational.org/programs/internships

How to Identify Your Skill Set and NARROW DOWN YOUR PATH

As a physics or astronomy student you possess valuable skills, but it can be challenging to articulate them and pitch them to potential employers. To get an idea of which careers might be a good fit for you, take some time to reflect on your experiences, as well as the knowledge and skills you've learned and how those skills transfer to the job market.

A great first step is to consider the wide range of capabilities that physics and astronomy students commonly develop.

Working with laboratory instruments

As you participate in lab courses or research, you learn to use a variety of instruments (e.g., optical components, electronics, machine shop tools) and often develop skills related to their operation, maintenance, repair, quality control, and troubleshooting.

Conducting research

Research experiences engage higher level thinking skills such as research design, data collection and analysis, critical thinking, error analysis, problem solving, and the ability to find, read, analyze, and interpret relevant background information to simplify a problem.

Utilizing computer hardware and software

Research often involves writing or modifying code, using statistical analysis software, and applying modeling, image processing, or simulation techniques. You may also have used programs like LabVIEW or Python to run equipment and collect data or built specialized interfaces for this purpose.

Communicating complex ideas

You've likely had lots of experience presenting complex information or ideas to different audiences, such as writing technical lab reports and research papers, presenting research or class work via a talk or poster, and participating in an outreach event for kids or the public.

Thinking analytically and quantitatively

Through endless hours of homework and labs, you've learned to apply mathematics to a variety of practical problems. You can manage information effectively, think logically, interpret data, and intuit what information is relevant to finding a solution. You also have lots of experience identifying essential unknowns.

Working with others

Teamwork, collaboration, leadership, and decision-making come along with earning a physics or astronomy degree. Don't underestimate the importance of being part of research teams, campus organizations like SPS, and group projects.

Solving problems and thinking critically

Again and again, in labs, research, group projects, and homework, you've examined a situation, identified problems, thought creatively about solutions, and implemented them. You've also learned how to find solutions through literature and online searches, collaborating with colleagues, experiments, and reasoning.

Now spend some time brainstorming—and actually writing down—an exhaustive list of every experience you've had that could be relevant to a career. Include classes, labs, and research, but also include jobs, extracurricular activities, hobbies, side gigs, and volunteer work, even if they seem unrelated to your intended career.

Next, go through each one, revisiting the broad categories and identifying the specific skills you developed through that experience. Be specific and avoid generic terms like "worked on." Instead, use more descriptive verbs: collected, measured, assembled, repaired, calibrated, trained, analyzed, processed, designed, managed, etc.

Finally, analyze your list of skills. Which were most fulfilling, exciting, or fascinating to develop? To apply? Did you enjoy applying a skill in some environments more than others? Are there any skills you never want to use again? What common themes emerge?

Keep these skills in mind as you explore different careers through the stories in this issue, informational interviews, and beyond. People with the same degree may have vastly different experiences and levels of success in the same career. Noting how well your skills and passion align with various possibilities can be a helpful way to zero in on great options for you. //

This piece is adapted from Tool #5 in the SPS Careers Toolbox*, a workbook published by SPS and the American Institute of Physics.*

THE SPS CAREERS TOOLBOX

The SPS Careers Toolbox is an in-depth resource for physics and astronomy undergraduates planning to enter the workforce after graduation. Many of the tools can also be applied to finding internships, research positions, or even entrance into graduate programs. Explore the toolbox at spsnational.org/sites/all/careerstoolbox.

How to NETWORK LIKE A PRO

SPS ZONE MEETINGS

Zone meetings bring together students from SPS chapters within a geographic region. They're fun and effective ways to meet other students, present research, and network. To see which zone you're in and a list of upcoming meetings, visit spsnational.org/meetings/zone-meetings.

Having great credentials is important for navigating a career path, but networking—making professional contacts—is often just as important. Such contacts can provide guidance and expand your access to opportunities, particularly those that may not be widely advertised. For physics and astronomy students interested in adjacent careers like engineering, data science, or patent law, networking can get you in a door that's sometimes hard to find. Here are some tips for taking your networking skills to the next level.

Prepare an elevator speech

An elevator speech is a 30-second introduction to yourself, named for the time you'd have to introduce yourself during an elevator ride. In your introduction, briefly mention who you are, what you're passionate about, and what you want to do next.

Focus on connecting to others

One of the simplest ways to start a conversation is by asking, "So what do you do?" Conversation often progresses fluidly if you show interest in the other person and focus on connecting with them. What do you have in common? What might you help them with? Who could you introduce them to? This approach makes networking less intimidating and can help you form meaningful and lasting connections.

Network everywhere

Whether you're at a research meeting, department colloquium, birthday party, or family function, look for new people to meet. Practice your elevator speech, asking people about themselves, and identifying common interests. Keep in mind that you don't have to meet *everyone* at an event; often one or two quality conversations are more impactful than many brief handshakes.

Attend professional meetings

Regional SPS meetings, or zone meetings, are great places to meet physics and astronomy peers and faculty members with ties to your local area. Most professional societies also host regular regional, national, or international meetings. Many offer professional development opportunities and career fairs in addition to typical sessions and keynote talks, and most have opportunities for undergraduates to present their work. They are great networking venues.

Attend events in your circle

Attend professional events at your school, such as colloquia and guest lectures, but don't stop there. Look for functions in your neighborhood or interest communities. Ask questions and introduce yourself to speakers and attendees using your elevator speech.

Cultivate relationships

Follow up with new contacts and keep in touch via email or LinkedIn. Let people know how school is going or where you are in your job search, or pass along information they may find interesting. Ask them about the project or life event they mentioned the last time you spoke. You don't need to be close to every connection, but develop a strong foundation with anyone you'd like to be an advisor, mentor, colleague, or friend.

Be confident

Go into networking with a positive outlook and be confident in your ability to have a meaningful conversation. Enjoy talking to new people and finding common ground—and don't forget to follow up! //

This piece is adapted from Tool #4 in the SPS Careers Toolbox, *a workbook published by SPS and the American Institute of Physics. For details and to download the toolbox, visit spsnational.org/sites/all/careerstoolbox.*

LEFT: Students connect and collaborate at the 2022 Physics Congress. Photo by SPS.

GET FUNDING FOR CONFERENCE TRAVEL

- **SPS Travel Awards offer partial support for SPS members presenting their research at professional physics and astronomy meetings. Learn more at spsnational.org/awards/travel.**
- **SPS Reporter Awards offer partial travel support for SPS chapters or members reporting on professional physics and astronomy meetings for SPS publications. Learn more at spsnational.org/awards/chapter-awards.**

How to Conduct Informational Interviews, AND WHY YOU SHOULD

An informational interview is a professional meeting with someone who has a job that interests you. Conducting informational interviews can give you a deeper understanding of that job, pathways to getting there, and whether a similar position would be a good fit for you. You can also get helpful advice and expand your network.

Informational interviews can be great resources for physics and astronomy students. Many faculty advisors in these fields have little experience outside of academia, and career centers aren't always sure what to do with physics and astronomy students. By conducting multiple informational interviews, you can get a good sense of career paths that you might like to pursue—and those that you want to avoid—in a relatively short amount of time. Here's how to get started.

Brainstorm a few types of jobs that interest you

Need ideas? Read through the stories in this issue and look through the common job titles on page 20.

Get connected

Ask professors, career or alumni offices, friends, and family if they know anyone in those fields who might be willing to talk with you. You can also reach out to colloquium speakers or people you find on LinkedIn. Don't limit yourself to people with physics or astronomy degrees, although such people might have valuable perspectives if you can find them.

Set up the interview

When you request an informational interview, be professional and clear. Tell your contact who you are, why you are contacting them, and how you heard about them. Let them know that you're a student exploring career options and you'd like to hear about their job. Be clear that you're not asking for a job, and be specific about whether you'd like to meet by phone, video, or in person and for how long. A typical interview is 15 to 30 minutes.

Research and write your questions

Research the person, position, division, and company (or equivalent) in advance. Let your research guide your questions, but don't be too personal. For example, instead of asking how much money they make, ask about the typical starting salary in the field. Instead of asking for a job, ask for advice on getting into the field. It's best to ask broad questions that will result in lots of information. You might ask about typical duties and responsibilities, highlights and challenges of the job, necessary skills or training, opportunities for advancement, workplace culture, and advice for students seeking to enter the field. Write down your questions and take them to the interview.

Conduct the interview

Informational interviews are fun opportunities to learn and expand your network. Be professional, respectful, on time (or early!), and prepared to introduce yourself and your interests. Bring a notepad and have your list of questions on hand.

Send a thank you

Send a short, personal thank you note within a few days of the interview to convey your gratitude and demonstrate your professionalism. In the note, mention something that you found particularly useful or helpful from the interview. This can help strengthen your relationship.

Reflect on what you learned

Summarize what you learned and decide on your next steps. For example, if your contact said that most people in that field are members of a specific professional society, you might consider joining. Or if they connected you to other people or opportunities, follow up on those leads.

Informational interviews are powerful tools; you can use them at any point in your education or career to explore new interests and possibilities! //

This piece is adapted from Tool #2 in the SPS Careers Toolbox, *a workbook published by SPS and the American Institute of Physics. For details and to download the toolbox, visit spsnational.org/sites/all/careerstoolbox.*

INTERNSHIPS Can Change Your Life

by Kayla Stephens, Associate Director, SPS Student Engagement

The 2022 SPS interns and staff pose with Nobel Laureate John Mather (center). Photo by SPS.

This year marks my sixth year overseeing the SPS Summer Internship program. We bring undergraduate students from across the country and international students to the Washington, DC, area. These students work in various positions and emphases, including research at NIST, NASA, and the Space Telescope Science Institute; science policy on Capitol Hill; and education and outreach, science writing, history, careers, and diversity, equity, and inclusion for professional societies—all under the umbrella of physics and astronomy.

Each summer our interns write about their experiences through weekly blogs. They discuss their day-to-day job responsibilities, experiences with SPS programs, professional development, extracurricular activities, and the relationships they build with their peers. Through the relationships I've built with many interns and by reading their blogs, several themes have emerged that highlight the value of students participating in internships (including research experiences):

1 NETWORKING

Your internship is a prime opportunity to network. You will meet many professionals in your field of interest, whether on the job, through activities and events, or through interactions with your fellow interns. Be intentional about the relationships you build and have a plan to stay in contact (e.g., LinkedIn)—you never know how you can be a resource to each other in the future.

2 GAINING EXPERIENCE

Internships are jobs. You are part of the team, gaining real-world experience. Your internship contributes to your professional profile and gives you an advantage when applying for future positions or graduate school.

3 FINDING YOUR PLACE

Internships are an opportunity to discover your interests. You may start your program with a clear career goal but leave with different aspirations. That's okay! Even if you realize a particular path isn't for you, the experience is still valuable.

4 FINDING COMMUNITY AND SENSE OF BELONGING

This is perhaps the most common theme I've seen among the SPS interns. The relationships built among the cohort, colleagues, staff members, and mentors last a lifetime. Many interns also express a sense of belonging, which is especially important for people from communities traditionally underrepresented in physics and astronomy. You might start with imposter syndrome but leave knowing you are valued and belong in the room just as much as anyone else.

As you look to apply for an internship or if you have already been accepted to one, here are a few tips to keep in mind:

THIS IS A LEARNING EXPERIENCE

You don't have to know everything; we understand that you are students. This is the time to absorb knowledge from your mentors and colleagues. Leverage the skills you already have and be open to mastering new ones.

DON'T UNDERESTIMATE YOUR SKILLS

Your undergraduate experience has provided you with more skills than you might realize. When preparing for interviews, highlight the skills you've developed from classwork, research projects, professional meetings, presentations, group work, campus volunteering, outreach, and even extracurricular activities. It all counts.

YOU GET WHAT YOU PUT IN

Make the most of your time—the weeks pass by quickly. Take every opportunity to gain skills you may not get elsewhere. Participate in all professional development activities offered and, most importantly, have fun! Explore the city you're in.

BE YOUR BIGGEST ADVOCATE

Speak up about your goals for the summer. Many mentors will modify projects around their interns' interests, but that might not happen if you don't express them. Don't be afraid to ask—the worst they can say is no.

Internships are invaluable experiences that provide more than just practical skills—they offer a unique opportunity to explore your career interests, build a professional network, and develop a sense of community and belonging. By immersing yourself in real-world environments, you can build relationships and gain experiences that have a lasting impact, fostering personal and professional growth that extends well beyond the internship period. Ultimately, internships are crucial stepping stones that equip you with the tools, confidence, and connections necessary to succeed in your professional journey. //

BE AN SPS SUMMER INTERN

The SPS internship program offers 10-week, paid positions for undergraduate physics and astronomy students in science research, education, outreach, and policy. Interns are placed with organizations in the greater Washington, DC, area. Applications open November 1 and close January 15 each year. Learn more and read former intern blogs at spsnational.org/programs/internships.

Building and Making the Most Out of MENTORING RELATIONSHIPS

by Bri Hart, Senior Program Manager for Diversity and Careers, and Midhat Farooq, Senior Careers Program Manager, American Physical Society

When she thought about dropping her physics major, Jasmine (not her real name) sought mentorship. That mentor helped her stick with the major and find resources outside of school to thrive in physics. With her mentor's support, Jasmine prepared for graduate school, pursued internships geared toward quantum physics, and connected with other Black women in the field. Having someone she could talk with monthly about the challenges she faced and how to overcome them, sometimes in person, was essential in Jasmine's undergraduate career. Looking ahead, she says it helps to know that she has someone rooting for her who will help her navigate any challenges she might face.

According to the National Academy of Sciences, mentorship is an "alliance in which individuals work together over time to support the personal and professional growth, development, and success of the relational partners through the provision of career and psychosocial support." Whether you're tackling a research project or plotting your career path, having a mentor by your side can be a game-changer.

According to Life Design Catalyst Coach William H. Johnson Jr., at this stage in your career, good mentors can build your scientific knowledge and expertise, help you grow personally and professionally, offer career guidance that is inclusive of various career paths, and support you as a whole person.

Good mentors may be closer than you think. Consider your professors, SPS advisor, academic advisors, postdocs, or even graduate students. Do they treat students or colleagues well? Do they possess relevant expertise and are they approachable?

To initiate a mentoring relationship, you can begin by expressing genuine interest in the person's work or seeking advice on a specific topic. You can ask for an informational interview (see page 45) or offer to assist with projects. Many mentors also appreciate direct requests for mentorship if approached with a clear purpose.

TOP: Bri Hart.
ABOVE: Midhat Farooq.

Here are five tips to make the most of your mentoring relationships:

1 SET GOALS FOR THE MENTORING RELATIONSHIP

Share your aspirations with your mentor, using the SMART framework (Specific, Measurable, Achievable, Relevant, and Time-bound) to craft goals in academics, career, and personal growth. Your mentor can offer insights and suggestions based on your needs, and together you can brainstorm potential areas of focus for the mentorship.

2 COMMUNICATE EXPECTATIONS

Discuss shared expectations for communication methods, frequency, and responsiveness with your mentor. Establish a plan for missed meetings to maintain accountability and adaptability.

3 TAKE INITIATIVE

Actively pursue opportunities for growth, implement your mentor's advice, and seek feedback on your progress. Be resourceful in supplementing your mentor's guidance with additional resources, and stay committed to consistent communication and progress towards your goals.

4 SHOW APPRECIATION

If you have a great mentor, let them know! Not only is appreciation a nice gesture, but giving positive feedback will convey to the mentor that they are providing the type of guidance and support you are seeking.

5 CULTIVATE A NETWORK OF MENTORS

In most instances, no one mentor will be able to meet all of your mentoring needs. Consider what your personal and professional needs are with respect to current mentoring relationships. If there are gaps, seek additional mentors to add to your network. //

INTERESTED IN GROWING YOUR NETWORK OF MENTORS?

Check out these American Physical Society (APS) mentoring opportunities.

- **The National Mentoring Community (NMC)** focuses on the needs of marginalized and minoritized students in physics and is open to all physics students. The program offers one-on-one mentoring relationships, virtual and in-person meetups with other mentees in the program, and emergency funding! Join now at go.aps.org/nmc.
- If you are looking to connect with industry physicists, check out the **APS IMPact** program that helps connect physics students with industry physicists around the world at impact.aps.org.
- Attending an APS March, April, or the Division of Plasma Physics Meeting? You might chat with **APS Career Mentoring Fellows**, who can offer expertise on career paths in physics. You can also invite these mentors to your department or SPS chapter to give a career talk. To learn more, visit aps.org/careers/guidance/mentoring.cfm.

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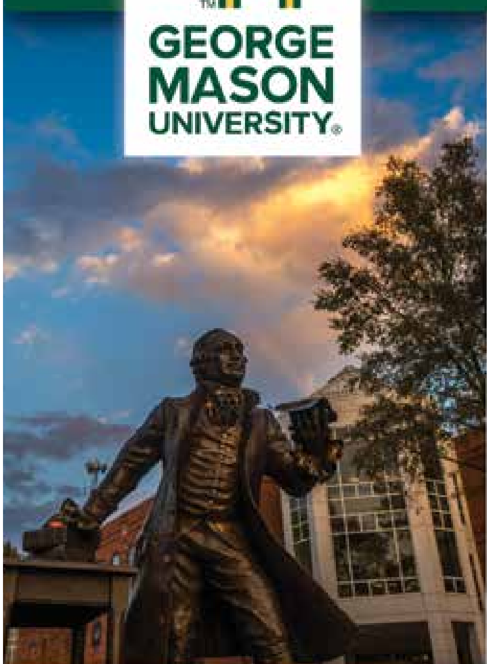
DEPARTMENT OF PHYSICS AND ASTRONOMY



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- High Energy Physics
- Materials Physics
- Space Sciences
- Astrophysics

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FEATURE

TOOLS FOR YOUR PATH

Considering Graduate School? SPS IS HERE FOR YOU

SPS has a trove of resources for people considering graduate school in physics or a related field! Here are teasers for some of our favorites. To find the full versions of these articles and many more, check out the Fall 2023 issue of the *SPS Observer* online at spsnational.org/the-sps-observer/issues/fall-2023.

SO YOU WANT TO GO TO GRADUATE SCHOOL

by M. J. Wright, Associate Physics Professor and Chair, Adelphi University

Graduate school can be one of the most rewarding and exciting opportunities in your life. It can be transformative.

The training that you receive in the process of obtaining a PhD puts you at the forefront of human knowledge and technology while simultaneously exposing you to the deeper workings of the universe. You'll develop confidence and the ability to solve nearly impossible problems...

Continue reading at spsnational.org/the-sps-observer/fall/2023/so-you-want-go-graduate-school for advice on jumping on the grad school path, finding programs for you, and crafting successful applications.

GRADUATE PROGRAMS 101

Physics and astronomy majors are qualified for many educational pathways

by Ben Perez, Contributing Writer

There is no one-size-fits-all grad program, even in a field like astronomy or physics. Most programs are classified by the highest degree they offer, master's degree or PhD, but there are variations even within those categories. And having a physics or astronomy major doesn't mean you're limited to physics and astronomy grad programs. You're qualified for many physics-adjacent grad programs and professional degree programs too...

Continue reading at spsnational.org/the-sps-observer/fall/2023/graduate-programs-101 to learn about master's, PhD, and professional degree programs often pursued by physics and astronomy undergraduates.

FINDING GREAT GRAD PROGRAMS FOR YOU

by Brad R. Conrad, Past Director of SPS and Sigma Pi Sigma

The most important thing to know about searching for a grad program is that there isn't just one "right" program for you—there are likely many places where you could thrive and excel. The key is to identify what is best for you and your goals...

What programs will fit you best? Continue reading at spsnational.org/the-sps-observer/fall/2023/finding-great-grad-programs-you for questions to consider before you start applying.

WHO PAYS FOR PHD PROGRAMS?

by Kendra Redmond, Editor

In physics and astronomy PhD programs, the department typically covers tuition and related expenses for its graduate students, or the university waives these expenses. Most students never see a bill—or if they do, it has a zero balance.

To cover the cost of living, graduate students typically earn a stipend—a fixed amount paid as a salary. The typical stipend is less than what you might earn in the workforce, but it offers some breathing room along the way to a PhD...

Continue reading at spsnational.org/the-sps-observer/fall/2023/who-pays-grad-school to learn about teaching assistantships, research assistantships, and fellowships.

MORE RESOURCES

- **GradSchoolShopper.com**
  GradSchoolShopper has a great resource section! Go to gradschoolshopper.com/grad-school-resources.html.
- ***GradSchoolShopper's Guide to Grad School in Physics, Astronomy, and Related Fields***
  Follow the links to the 2021 and 2022 issues at gradschoolshopper.com/gradschoolshopper-magazine.html.
- **Three Tips for Staying Grounded in Grad School**
  Read the stories of three people who almost left grad school, what made the difference, and their advice for you at spsnational.org/the-sps-observer/fall/2023/three-tips-staying-grounded-grad-school.
- **You're Not Limited to Physics and Astronomy**
  Check out the long list of fields physics and astronomy undergraduates pursue in grad school at spsnational.org/the-sps-observer/fall/2023/you're-not-limited-physics-and-astronomy.

SELECTING THE RIGHT PHD ADVISOR FOR YOU

by Molly McDonough, Graduate Student, Penn State University

Deciding to pursue a PhD is a big deal—you're committing to one place for the next five to seven years of your life.

Even more important than deciding where to attend is deciding who will be your thesis advisor, the principal investigator (PI). This may be the only time in your career that you get to choose your boss, and since it's a long-term commitment and your advisor will have a direct impact on when you graduate and your career path, you definitely want someone who's a good fit for you.

I've learned from personal experience that taking these steps can help you identify a good match...

Continue reading at ***spsnational.org/the-sps-observer/fall/2023/selecting-right-phd-advisor-you*** *to check out the steps!*

MAKE YOUR APPLICATIONS COUNT

by Brad R. Conrad, Past Director of SPS and Sigma Pi Sigma, and M. J. Wright, Associate Physics Professor and Chair, Adelphi University

When admissions committees review your grad school applications, they'll consider many factors: your letters of recommendation, personal statement, academic record, research experience, accomplishments, desired research area, and personal characteristics. Together they'll decide, based on that picture, whether you're likely to be a good fit and succeed in their program. We've helped many students get into research-based physics and astronomy graduate programs in the United States and Canada—here's what we've learned along the way...

Continue reading at ***spsnational.org/the-sps-observer/fall/2023/make-your-applications-count*** *to learn essential tips like why you should personalize your application for each program.*

HEAR FROM THE EXPERTS

Check out this series of Q&As to learn more about what grad programs want to see in applicants.

How to Write an Effective Personal Statement

"We're interested not just in your research title or who you worked for, but how you talk about your research. What were the big picture goals? What did the research group hope to learn about nature? What did you work on? Be very specific about your particular tasks, for example, 'I tested hundreds of readout boards,' or, 'I wrote a LabVIEW program that provided data on new samples.'"

Read the Q&A with Ritchie Patterson, a professor in the Department of Physics at Cornell University, at ***spsnational.org/the-sps-observer/fall/2023/how-write-effective-statement-purpose****. Patterson has been the director of graduate studies, chaired the Graduate Admissions Committee, and advised students at and beyond Cornell on applying to graduate school.*

How to Build a Strong CV and Résumé

"A résumé is typically short, a couple of pages at most, and highlights your experiences, accomplishments, and skills relevant to the job or program you're applying to. I think of a CV as an uber-résumé that contains every accomplishment and highlight of your career."

Read the Q&A with Michael "Bodhi" Rogers, chair of the Department of Physics at the University of Colorado Denver, at ***spsnational.org/the-sps-observer/fall/2023/how-build-strong-cv-and-résumé****. Rogers created and teaches a series of one-credit professional development seminars for physics majors.*

How to Create a Compelling Highlight Reel (aka Résumé)

"People are drawn in by a résumé (or not) in 10 to 15 seconds, so grab their attention. Instead of a template, use tools like bold text, bullet points, action verbs, and key words to keep the reader's eyes moving and direct them to key information."

Read the Q&A with Lindsay Buettner, a certified professional résumé writer who frequently teaches science students how to write résumés, at ***spsnational.org/the-sps-observer/fall/2023/how-create-compelling-highlight-reel-aka-résumé****. Buettner leads the university student programs at Argonne National Laboratory.*

How to Get Great Letters of Recommendation

"Send each recommender your CV, personal statement, and a page highlighting your relationship. For a research advisor, this might include when you did research together, the project, your contributions, the equipment you used, and related presentations or papers."

Read the Q&A with Osase Omoruyi, a graduate student in the Department of Astronomy at Harvard University, at ***spsnational.org/the-sps-observer/fall/2023/how-get-great-letters-recommendation****. Since 2020 Omoruyi has led workshops for the Women+ of Color Project on getting great letters of recommendation for grad school.*

What Grad Programs Look For

"It's a mistake not to include [in your personal statement] the areas of physics you're interested in, and it's even better to mention specific professors you would like to do research with."

–Abdelkader Kara, professor and graduate program director, Department of Physics at the University of Central Florida (UCF)

"We're interested in predicting how well an applicant will do when they get to our department, given our resources. To gauge that, we try to determine what the student achieved as an undergraduate given the resources they had."

–Puragra (Raja) GuhaThakurta, professor and past chair of the Department of Astronomy and Astrophysics at the University of California, Santa Cruz

"The main missed opportunity is in the letters of recommendation. Sometimes letters can be insightful and helpful, but sometimes not. We use the letters to judge a student's interest, experience, and nonacademic qualities, like motivation and collegiality."

–Diyar Talbayev, professor and graduate physics advisor, Department of Physics and Engineering Physics at Tulane University

Read the full Q&As at ***www.spsnational.org/the-sps-observer/fall/2023/what-grad-programs-look*** *to find out what matters most to graduate school admissions committees.* **//**

GRAD SCHOOL SHOPPER.COM

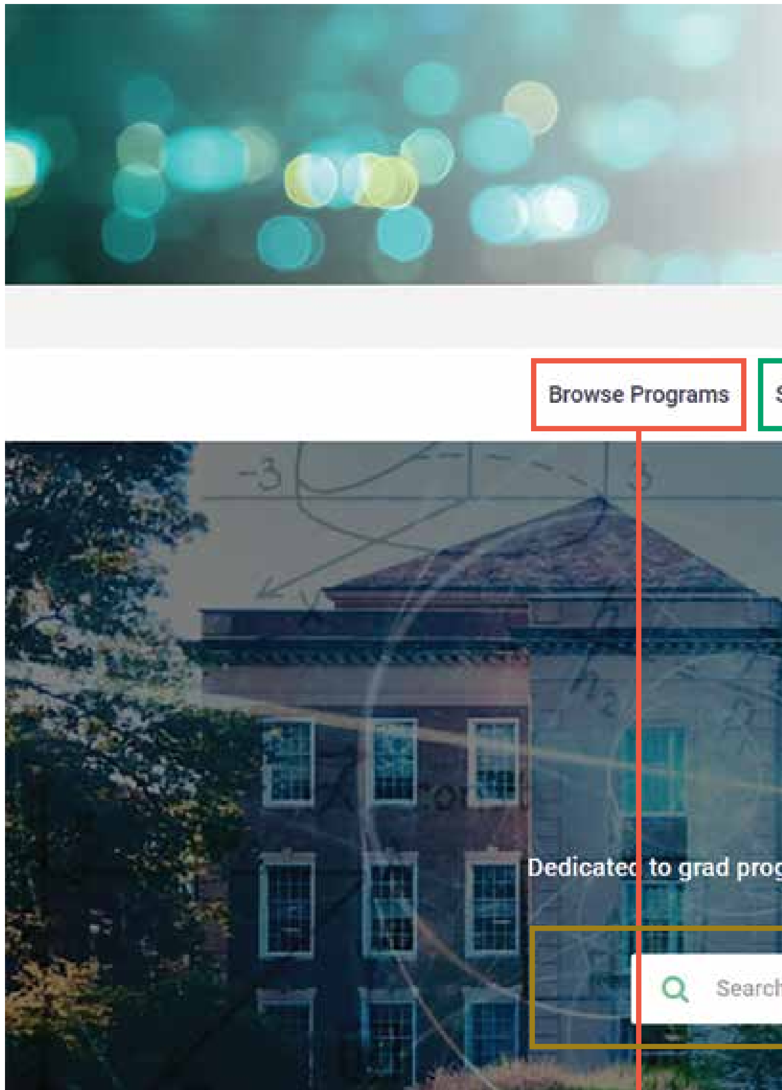
Simplifies the Grad School Search

The online resource for graduate programs in physics, astronomy, and related fields

by Kendra Redmond, Editor

Searching for the right grad program can be time consuming, but it doesn't have to consume you. In support of physics and astronomy students and the future of the physical sciences, the American Institute of Physics hosts GradSchoolShopper.com (GSS), a free online resource for browsing, sorting, and comparing hundreds of graduate programs in physics, astronomy, and related fields. GSS is an official partner of *Physics Today* and the Society of Physics Students (and this issue of the *SPS Observer*!).

The backbone of GSS is an extensive and searchable collection of graduate program profiles. Each profile includes, at minimum, a list of research specialties and contact information. Many programs have enhanced profile pages that provide an overview, application requirements, a description of the department culture, quick links to relevant web pages and social networking pages, and even videos and photos.

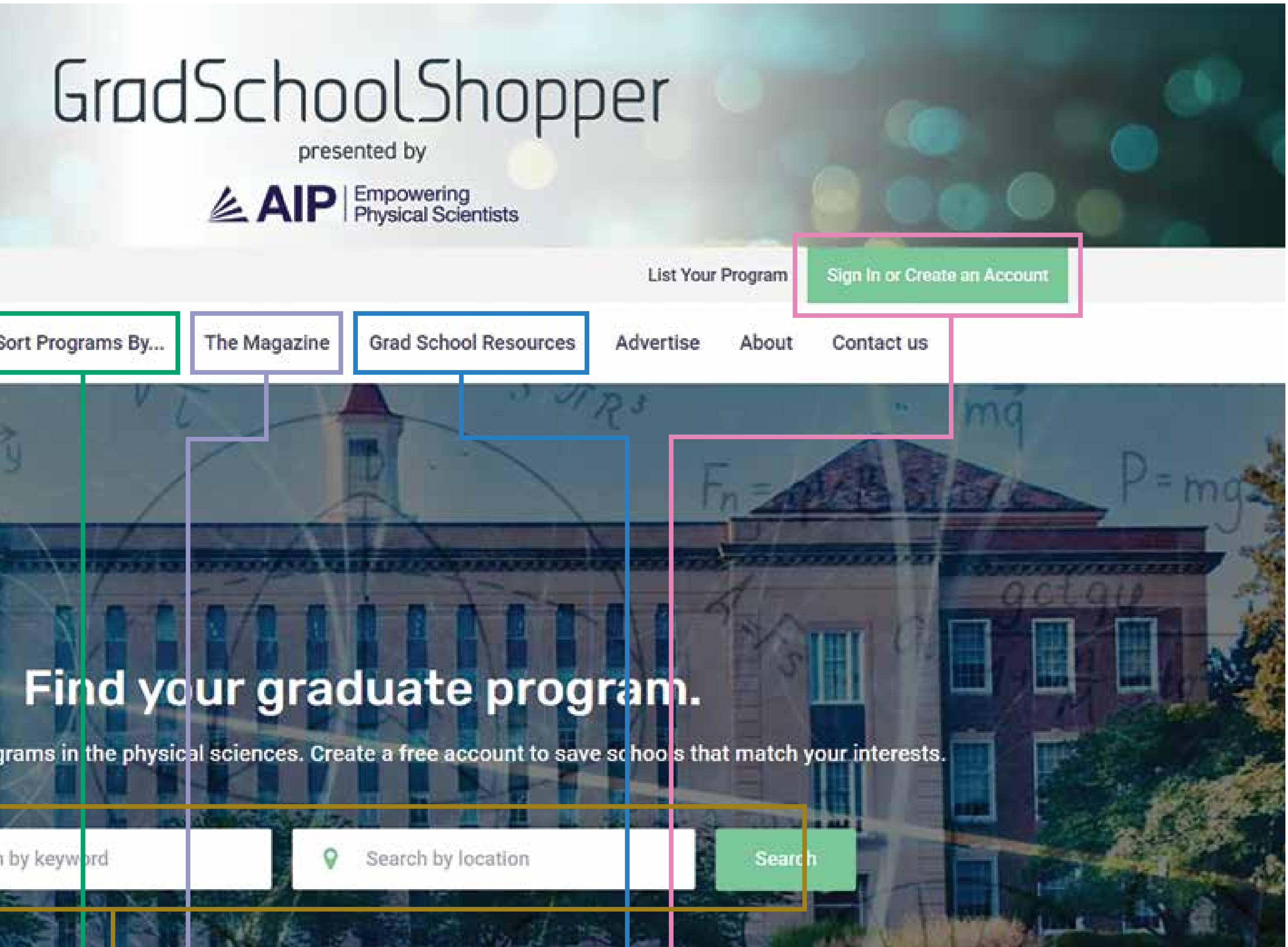


BROWSE PROGRAMS

Get excited about your future by considering the possibilities. You can browse GSS profiles by more than 50 research specialties.

SORT PROGRAMS

Once you know what's important to you in a graduate program, GSS can narrow your options. With the "sort by" function, you can filter programs by degrees offered, research specialty, campus setting (urban, suburban, or rural), acceptance rate, and application deadline. You can sort programs online and save your results, or download the data to work through later.



GSS MAGAZINE

Before GSS and SPS partnered on the Fall issues of the *SPS Observer*, GSS had its own magazine. You can check out past issues here.

SEARCH

Know what you're looking for? Search by school, specialty, or key words. And if you're looking for a mountain view, an oceanside setting, or someplace near family, the "search by location" tool is here for you—just input your desired state or country.

SIGN IN OR CREATE ACCOUNT

You don't need an account to access all the resources on GSS, but creating one is a helpful way to keep track of interesting programs. It's quick and easy to do, and once you're logged in, you can bookmark the programs you like and revisit them anytime through the "favorites" list in your profile.

GRAD SCHOOL RESOURCES

Here you'll find links to graduate school–related resources, including lists of physics bridge programs, the latest data on physics and astronomy graduate education, *Physics Today* career issues, and many related organizations and reports. //

This is an updated version of a piece by the same name published in the Fall 2022 issue of GradSchoolShopper *magazine.*

WHY GRADUATE SCHOOL?

by Frank Efe, PhD Candidate in Electrical and Computer Engineering, Morgan State University

I am currently a doctoral student in electrical and computer engineering with a focus on microelectronic fabrication at Morgan State University. I have master's degrees in physics and engineering/applied physics from Morgan State and a master's degree in materials science from Obafemi Awolowo University in Nigeria. My research is focused on the growth of 2D microelectronic materials for device fabrication. I am also a teaching assistant.

In graduate school, I have found it particularly rewarding to gain a comprehensive understanding of how microelectronics function at the atomic level. This involves examining the behavior of atoms in response to external factors such as temperature and the presence of photons. The main difficulty lies in comprehending the fundamental concepts that explain the behaviors we see in our findings.

Graduate school has played a pivotal role in shaping my research interests. Through it, I have learned the rules of growing semiconductor materials, the necessary precautions for utilizing growth techniques, and methods for analyzing and evaluating samples. Pursuing a double-major in my master's program allowed me to achieve mastery in different aspects of physics along the way to a PhD in engineering.

Students interested in this kind of path should maintain focus on their aspirations and have faith in their attainability. All professionals were once novices. I instruct my students to seek a fundamental understanding of the material so as to educate others or utilize it in the future, rather than solely to achieve a passing grade.

ABOVE: Frank Efe in a microelectronics fabrication laboratory, where researchers grow and characterize nanomaterials for device applications, at Morgan State University in Baltimore, Maryland. Photo courtesy of Efe.

Physics serves as the foundation for engineering applications. Semiconductor materials research in particular offers significant advantages to the United States due to its crucial contribution to technological advancement, the growth of the electronics industry, and the preservation of economic competitiveness and national security.

I recommend that students interested in engineering work persistently and strategically on their research and classwork, even when the subject seems abstract. Although a discovery or concept may appear intangible now, in the future it might lead to concrete scientific advancements. Thirty years ago, the idea of an Apple watch seemed unimaginable, but thanks to technological advancements, it has become a reality. //

Pursuing a UNIQUE PATH

ABOVE: Amber Elinsky.

by Amber Elinsky, Graduate Student, University of Edinburgh

FEATURE

TOOLS FOR YOUR PATH

After graduating from Lycoming College with a physics bachelor's degree in 2023, I am pursuing an advanced degree. But not in physics—in science and religion.

As an undergraduate I spent two weeks doing research at the University of Cambridge in the United Kingdom with Michael E. Heyes, an associate professor of religion at Lycoming. He was working on an upcoming book, and I assisted with collecting sources such as the journal of John Wickens, a friend and roommate of Sir Isaac Newton. The journal transcribed Newton's religious views, and it fascinated me that a pivotal figure in physics could hold such devoutly religious beliefs.

Shortly after this experience, I completed a senior thesis on the apparent conflict between physics and Christianity. Specifically, I explored how physics textbooks often omit the influence of religion on historical scientists (therefore suggesting a requirement to choose between physics and religion) and how this limits students' understanding of the field's fundamental origins. I found this interdisciplinary experience exciting because it allowed me to explore my varied interests from different perspectives. That's what led me to pursue an advanced degree in the area.

I knew I wanted to study abroad for graduate school—I love to travel—so while researching in the UK with Dr. Heyes, I took the opportunity to explore more of the region and its universities. Admittedly, I have always longed to explore Scotland, and luckily, I found a master of science degree program in science and religion at the University of Edinburgh. I met with the program director, Rev. Dr. Michael Fuller, and quickly decided to apply.

In the Science and Religion program, I explore how scientific disciplines interact with Christianity. Subjects such as the metaphysics of quantum mechanics, biblical issues with Darwinism, the aesthetics of mathematics, and the definition of human uniqueness are weekly discussion topics. I approach them through the lenses of philosophy, physics, literature, history, and others. The one-year program is heavily discussion based and culminates with a dissertation on a topic of my choice. I'm combining my interest in the physical sciences with my desire to learn more about nature religions, or neo-paganism, by exploring the social concept of nature on Earth through that lens. For its relevance to current affairs, I'm assessing whether a neo-paganistic understanding of nature is applicable to Mars, an important question with regard to the Mars colonization project.

Although a niche area, studying science and religion at the master's level has allowed me to hone a range of transferrable skills. Through this program and my physics education, I have been trained in skills such as problem solving, data analysis, literary analysis, adaptability, and communication, both within STEM (along with its jargon) and many of the social sciences. In addition, the master's content knowledge enables me to understand the religious and historical perspectives of a wide variety of people from a multitude of backgrounds and beliefs, creating the opportunity for more holistic professional relationships and networking experiences. After completing my degree, I aim to put these skills to work in a technical writing or project management career.

Attending graduate school outside of the United States has been an amazing experience. In meeting and creating friendships with people from all over the world and learning to navigate foreign countries and cultures on my own, I find myself developing both academically and personally. I continue to find that embracing a journey unique to my interests brings new, enriching opportunities each day. It inspires me to share my story with the hope that you will be encouraged to explore your unique path as well. //

FEATURE

TOOLS FOR YOUR PATH

TIPS FOR APPLYING TO GRADUATE SCHOOL

Reach Out to Potential Grad School Advisors Before You Apply

by Barkotel Zemenu, Graduate Student, Stanford University

Before I applied to graduate programs, I had helpful conversations with a lot of faculty members, postdocs, and graduate students. During my undergrad at Yale University, I was working in a large collaboration with researchers from different institutions, and I asked them which schools they'd recommend for my subfield. They pointed me to colleagues at specific institutions who were looking for new students, which experiments were likely to get funding in the short run, and which experiments were winding down. Many of them advised me to reach out to professors I was interested in working with in advance.

The summer before applications were due, I started emailing professors. I had a short list of 10 schools I was interested in and about three professors from each school. I sent a brief but tailored email to each one, asking if they would be taking incoming graduate students next year, introducing myself and my research experience, and letting them know how their work coincided with my PhD interests; I also attached my CV. I followed up (sometimes many times) with the people who didn't get back to me right away and ended up hearing from almost all of them!

There were a range of responses. Some professors didn't have funding or weren't taking students, so I ruled them out. Some professors suggested we Zoom, and on the call, they asked me to tell them about myself and then shared their research with me, which was really helpful. Some also told me that they weren't involved with the admissions committee but were happy to connect if I was admitted, while others explicitly said they'd be on the lookout for my application.

ABOVE: Barkotel Zemenu.

Reaching out required a lot of specificity—I had to look at each school and each professor and what they were doing, then tailor my email. But hearing back from them was extremely helpful in deciding where to apply and where to ultimately commit.

Don't Compare Yourself to Others

by Ben Burdick, Grad Student, Virginia Tech

ABOVE: Ben Burdick.

The best part of being a grad student is that you have a community built around physics, which makes it very easy to make friends and build connections. However, one of the biggest challenges is imposter syndrome, feeling insecure or like you don't deserve to be here. I think that's something all grad students struggle with, and it continues to be a challenge for me.

Applying to graduate schools is really difficult, and the process of hearing back is hardly ever fun. One of the most useful things to keep in mind is don't compare yourself to your peers. Learning to avoid comparing yourself to others and play your own game is a skill that will serve you long after starting grad school.

Finally, never pigeonhole yourself into a group. If you're picking between schools, the one that has more professors you're interested in working with is almost always the best choice. And talk to people before committing! //

Conversations with ASTRONOMY GRADUATE STUDENTS

by Marie Olivia Sykes, Graduate Student, University of North Carolina at Chapel Hill

When considering grad school, talking to current grad students may be one of the most important steps you can take. Conferences like the American Astronomical Society (AAS) meetings bring together grad students from across the country, so they are great opportunities to get firsthand accounts of the experience. After sending off my grad school applications and trying not to think too much about when I would hear back, I attended the 243rd AAS meeting. While there I interviewed graduate students about why they chose to attend grad school and their plans. Here are some of the insights they shared with me.

Dashon Jones, Rice University

Dashon Jones was in his first year of grad school when I talked to him. His advice to undergraduates is to get involved in research. When looking for opportunities, he recommends reaching out to professors whose work interests you. When Jones did this, he made sure to tell them he had read their papers and was interested in their specific research. "If you're afraid to send an email, if you're scared they're going to reject you—the worst they can tell you is no," he said. But they might say yes. "If you reach out to people, if you show initiative, [many are] more than willing to take you."

Maria Regina Apodaca Moreno, Massachusetts Institute of Technology

At the conference, Maria Regina Apodaca Moreno presented her work with the Rocket Lab Mission to Venus; she studies cloud particle data retrieval. She told me that her current project stemmed from the question, If you could do anything, what would you do? Apodaca Moreno realized that she wanted to increase accessibility

ABOVE: Marie Olivia Sykes.

to space as well as reevaluate scientific assumptions. "I wanted to be asking the more controversial and daring questions… Is there a possibility of life on Venus? Is there something we're overlooking?" She continued, "Just because we haven't seen [it] doesn't mean there isn't any. Especially if the way we get to that conclusion is flawed."

Kishore Petra, University of California, Berkeley

Kishore Petra is an international student who came to the United States from India. He studied exoplanets as an undergraduate but transitioned into gravitational potentials in graduate school. Petra now does spectropolarimetry of astrophysical transients such as supernovae. This was his first AAS meeting. Many conferences occur on the edge of university breaks, which he says can be difficult for international students who often travel home then. "I've always wanted to come to AAS [but] never got an opportunity," he said. He really enjoyed the conference.

Benjamin Amend, Clemson University

Benjamin Amend studies galactic chemical evolution, nucleosynthesis, and compact binary star mergers. "Maybe my reasons for going to grad school were unconventional," he told me when I asked why he went to graduate school. "I enjoyed doing research. I enjoyed looking into these unsolved problems in astronomy and astrophysics, [but the] main reason I went to grad school is because a doctorate is required for teaching." He aims to teach at a big university and sees earning a PhD as the first step in accomplishing that goal.

Lawrence Machia, University of North Carolina at Chapel Hill

Lawrence Machia is a graduate student working on the Argus Array, which is a large deep-sky survey instrument that will be built in North Carolina. Interestingly, Machia is also a Benedictine monk at St. Vincent Archabbey. He decided to attend graduate school so that he could teach physics at his home institution. He plans to work with undergraduates and involve them in his research.

Madeline Clyburn, Clemson University

Madeline Clyburn is a PhD candidate whose research predicts the "electromagnetic signatures from unequal-mass massive black hole binaries." She's doing this work in preparation for multimessenger gravitational wave detections, including by the space-based detector LISA. Clyburn originally planned to teach high school physics and double majored in physics and education. She described being pushed to apply to graduate programs by mentors who saw her potential and finding how much she enjoyed research, which she describes as "trying to solve problems within astrophysics that no one has ever tried to solve." //

To hear more about the AAS meeting from Marie Olivia Sykes, check out her piece "AAS 243: New Orleans Wrap-up" in the Spring 2024 issue of the *SPS Observer* at spsnational.org/the-sps-observer/issues/spring-2024.

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Making Time for You—It's the Simple Things

by Kayla Stephens, Associate Director, SPS Student Engagement

> "Almost everything will work again if you unplug it for a few minutes, including you." — Anne Lamott

Navigating your life can feel like a juggling act—balancing classes, work, job searches, grad school applications, family, and a social life can leave you feeling overwhelmed. Amidst the hustle, it's crucial to find ways to unplug and prioritize your mental and physical health to avoid burning out.

So why is it that self-care often takes a back seat to our other commitments? Perhaps it's because prioritizing ourselves can feel inconvenient (maybe even selfish), or because it's simply easier to focus on taking care of everything and everyone else. However, making yourself a priority can significantly enhance various aspects of your busy life, boosting your energy levels, mood, focus, relationships, and overall sense of fulfillment.

It's essential to remember that self-care doesn't have to mean training for a marathon or spending hours at the gym. It's about doing what makes you happy and relaxed, whether that's working outside on a nice day, taking a brief walk, enjoying a mani-pedi, squeezing in 10 minutes of yoga between meetings, or baking homemade scones with whatever ingredients you have on hand.

ABOVE: Kayla Stephens, MPH.

Here are some simple, inexpensive (or free), and time-efficient ways to incorporate self-care into your daily routine:

1 MOVE YOUR BODY

Take a solo walk (or grab a partner to accompany you), immerse yourself in nature on a hike, or do some yoga or stretching.

2 GET FRESH AIR

Work outside or simply step outside for a breath of fresh air. This can do wonders for your mood and energy levels.

3 FOCUS ON BREATHING AND MEDITATION

Start your day or take a break during a stressful moment to focus on your breath. This simple practice can help clear your mind and center your thoughts.

4 ENGAGE YOUR MIND

Try crossword puzzles or coloring to relax, unwind, and to stimulate your brain in a positive way.

5 GET A PLANT

This isn't just a social media trend—caring for a plant can actually be therapeutic and rewarding.

6 INDULGE IN A BUBBLE BATH OR SHOWER

Treat yourself to a relaxing soak or a refreshing shower to unwind and pamper yourself.

7 READ FOR PLEASURE

Escape into a good book, something unrelated to your studies, work, or daily responsibilities.

8 COOK OR BAKE

Experimenting in the kitchen can be both fun and rewarding, especially when you get a delicious meal or treat out of it!

9 PLAY A MUSICAL INSTRUMENT OR SING

Whether you're skilled at playing, like to burst into song, or simply enjoy listening, music can be soothing to the soul. Lose yourself in the melodies for a while.

10 DO NOTHING AT ALL

Sometimes giving yourself permission to relax and do nothing is the best self-care.

What brings you joy? Share your self-care moments with us on social media by tagging @SPSNational. Taking care of your whole self doesn't have to be complicated—know that it is a journey, and every small step counts. //

The Value of a Plan

by Kendra Redmond, Editor

ABOVE: Emily Wilson stands in front of the potatoes her students grew during a "Life on Mars" class. Photo courtesy of Wilson.

Emily Wilson's career plan was to be a professor at a small, teaching-focused college in Pennsylvania. Right out of graduate school, she got exactly that job: a tenure-track astrophysics professorship at Lycoming College.

"Paths wander," she says. "But if you have a goal, then planning towards that goal is one of the best ways to achieve it."

Inspired by her high school physics teacher, Wilson majored in astrophysics at Franklin and Marshall College, a small liberal arts college also in Pennsylvania. She double majored in German. "It was so much fun," she says. "German kept me sane." Wilson embraced the liberal arts education, studied abroad, and enjoyed being part of both STEM and non-STEM communities.

Wilson applied to graduate programs knowing she'd need a PhD to become a professor. Rochester Institute of Technology (RIT) wasn't initially on her list, but a friend went there, so she applied and visited.

"It was a technical school, but they had a lot of the same values as my liberal arts school," she recalls. They wanted their students to be well-rounded and told her she'd even be able to teach a course as the instructor of record while a graduate student. "All of these things were just laser-focusing me to where I wanted to be," she says. She accepted their offer.

Not everything went exactly as planned. Although she intended to do observational research on binary stars, Wilson ended up doing more theoretical work. But she says that the flexibility opened up a key opportunity for her. Her research advisor, Jason Nordhaus, was a professor at RIT's National Technical Institute for the Deaf. Because of her interest in language and teaching, Nordhaus invited her to work on a grant project developing sign language for physics concepts. Wilson spent the latter half of grad school doing educational development alongside her astrophysics research.

Physics terms often have nuanced and abstract meanings. For example, Wilson says the team of professors and interpreters she worked with put immense thought into how to sign the concept of speed, which traditionally shares a sign with fast, and differentiate it from velocity. That work required her to reflect on introductory topics in a new way, which has impacted her teaching. When she introduces concepts, Wilson now imagines what it's like to hear them for the first time. "It really grounds you in remembering that for everybody in the room except for you, this is brand new."

At Lycoming, Wilson balances teaching and doing research on stellar systems. She has high standards for students but sees teaching as an opportunity to do more than impart knowledge. She fell in love with physics because of her high school physics teacher's passion for making physics fun and accessible. So now, that's what she aims to do.

When considering what's next after graduation, Wilson finds that many undergrads are worried they aren't good enough to do what they really want to do. "You *are* good enough. Make a plan, put in the work, and you can at least make steps towards achieving that goal," she says. "Don't count yourself out." //

Wisdom for Your Path
from Sigma Pi Sigma Members

Compiled by Rianna Ehrenreich, SPS Office Intern and 2023 Inductee

Sigma Pi Sigma is the physics and astronomy honor society, and is closely associated with SPS (see sigmapisigma.org for details). Membership in Sigma Pi Sigma is for a lifetime. We asked members, from recent inductees to those now retired, What advice would you share with undergrad physics and astronomy majors thinking about their careers? Here are their responses.

Think big now, compromise to be realistic later. What are the big questions you would like to work on? What would be fun to do? Your answers will evolve during your undergraduate days. And realize your answers will continue to evolve throughout your life. Then grow wherever you find yourself.

–Richard O., Retired, 1966 Inductee

I still recall reading in the early pages of Griffith's electromagnetism textbook—maybe in the first few pages of the second chapter—something like, “You now know everything you need to know about the subject; the rest of the course is devoted to assembling a bag of tricks to actually solve some problems.” Look anywhere and there are problems to be solved, legal ones in my case. Physics taught me how to solve them.

–Kevin Trainer, Senior Associate, Langer Grogan & Diver P.C., 2010 Inductee

Spend time with your professors outside of the classroom and take advantage of opportunities for undergraduate research, conferences, and publishing work whenever possible. It will help you grow as a scientist and as a person far more than your required courses.

–Laura Marschke, Senior Project Administrator and Document Control, M.C. Dean, 2006 Inductee

Be involved with the applications of physics to real-world problems, plus take interest in the latest physics announcements. In this manner, you will be introduced to many new concepts, but perhaps just as important, you will discover the physics subject that you cannot stop thinking about.

–Eric Jones, Retired, 1957 Inductee

Dive deep into information about possibilities. Keep in mind that it is always possible to change jobs or even career paths.

–David Garfinkle, Retired, 1959 Inductee

People don’t tend to talk about how competitive graduate programs are (especially astronomy programs) and how many people aren't accepted to any programs the first time around. I accepted a nice fellowship offer at a top-10 university for astronomy, but I was still rejected from over 90% of the programs to which I applied. This was after taking a gap year to do research full time, publishing a paper, and having two more first-author papers submitted or in prep. You can do everything right and still not be accepted, just because your specialties don't happen to align with what the programs you applied for want right now. Have a backup plan.

–Tristan Weaverale, Graduate Student, Penn State, 2023 Inductee

Physics is a great place to start in many careers. Many of my classmates went on to law, nuclear engineering (in the Navy), engineering, etc. I spent most of my time doing software development, but I also did physics-related work at Ford, worked on financial options on Wall Street, and worked with the insurance company Aon. Be flexible and think outside the box.

–Kenneth LaToza, Retired, 1975 Inductee

There is no "right path." Some people go right to grad school, some get a job and decide later to go to grad school. Some go into academia. Others go out into industry, love it, and stay there. Do not assume you need a doctorate to be a successful physicist or astronomer.

–Carolynn Moore, Physicist, US Army, 2004 Inductee

Do an internship or a summer research project if possible; you only have three summers before graduation. At least two of those you should dedicate to your career. The opportunities are harder for nonstudents; most internships are for currently enrolled students. Additionally, if you're going into an unknown research group, ask many questions to see how the group operates, especially to see if your supervisor likes to teach others. Make sure you find an advisor who is interested in mentoring someone at your level.

–Angel-Emilio Villegas Sanchez, Graduate Student, Central Michigan University, 2024 Inductee

Speak to people who know you, your academic work, your personality, psychology, etc. Get advice about your career, but also about your personal life. Most people are willing, even eager to help if you ask. After you've gained some insight, don't be afraid to follow up. Ask people to speak freely about your shortcomings, not to sugarcoat their evaluations, and, when they do, take that as a sign that they may be pointing to truths that you shouldn't ignore.

–Craig Hunter, Retired, 1979 Inductee

Learn one computer language, keep everything you do in that language, organize it, build on it, time and date stamp it, back it up.

–Thomas M. Jordan, President, Experimental & Mathematical Physics Consultants (EMPC), 1960 Inductee

It might not happen right away, and the route you take might be a roundabout one, but if you stay persistent and you are truly passionate about your field, you will find a way to bring it into your career.

–Jessica Zarkos, Program Coordinator, Central Washington University, 2022 Inductee

Think about what you enjoy doing as well as what you enjoy learning about. Sometimes the "doing" might not be as exciting as the "learning," and you can end up overqualified in a field you love to learn about but don't want to work in. It's best to admit that to yourself sooner than later. Don't let others define how you feel about yourself or your career. What's most important is what makes you feel fulfilled.

–Jonathan Sullivan-Wood, Graduate Student, Purdue University, 2019 Inductee

Find something that you are good enough at to earn your living, finish the necessary education, and go do it. There will be lots of other opportunities later, since you are all going to live to be 100. And it is much easier to be a professional physicist or engineer and an amateur musician than the other way around.

–Virginia Trimble, Professor, University of California, Irvine, Sigma Pi Sigma Honorary Member (2019)

Find a career and job that fascinates you. Work to do what you love, the money will take care of itself. Good luck, and HAVE FUN.

–Bob Kvaas, Retired, 1971 Inductee

Physics is one of the most universally applicable degrees for any career path. It provides a framework and skill set for identifying and solving problems. Be open to career paths you may not have previously considered prior to getting your degree. You'll be amazed at how many opportunities are out there and how uniquely positioned you are to pursue those opportunities.

–Lukas Swanson, Senior QA Specialist, GSK, 2006 Inductee

Do undergrad research and internships to find what you like. Email people you're interested in working with. The worst they can say is no. And it's okay if you don't have the perfect CV.

–Cole Stewart, Graduate Student, Michigan State University, 2021 Inductee

If you see a job posting that you like but you're not sure you meet 100% of the requirements, remember this: If you're confident you can do 80% of it, they'll train you on the rest.

–Cassie Crowe, McDonald Observatory Telescope Operator, University of Texas at Austin, 2015 Inductee

Don't feel boxed in when considering your future career! Whether it be knowledge or money, you still have many more years to obtain them both. While not unique to physics, the critical thinking and mathematical framework we develop as undergrads is translatable to many professions aside from research and academia. Experiment to find what excites you, as ultimately, that will be what gets you out of bed each morning.

–Nathaniel Sparrow, Graduate Student, University of Louisville, 2017 Inductee

Be honest with yourself about what you actually enjoy and what you want to do. However, it's okay if your plans don't turn out like you expect, and it doesn't mean you've failed or done the "wrong" thing. Try to appreciate each stage and season for what it is, and grab hold of interesting opportunities (like viewing eclipses or engaging with people in your extended network) when they arise! Just as life is more than work, physics and astronomy are more than academic disciplines. They are inextricably embedded in the world around us.

–Betsy Olson, Physics Contract Author and Private Tutor, 2012 Inductee

A defense-related job may seem attractive and interesting, but it's hard to escape from once inside. Certain other careers (for example, medical devices) pretty much require you to be in at an early age to achieve advanced roles appropriate for later in your career. Figure out what your passion is early on, and follow it.

–Alex Matulich, Retired Technical Program Manager, Seagate Technology, 1980 Inductee

Take things one step at a time. Trying to plan everything out in advance is daunting and, frankly, scary. More than anything, just remember to breathe. We have good days and bad days, but we'll all wind up where we want to be eventually.

–Garath Vetters, Graduate Student, Texas Tech University, 2022 Inductee

Science in and of itself is fascinating, yet using science to help others is life-changing. Choose a mission that's meaningful to you and infuse science into that field. By aligning your expertise with your passion, you set yourself up to experience the highest degree of purpose and fulfillment in life!

–Beverly Rogers, CEO and Life Coach, Core Level Lifestyle, 2008 Inductee

Learn how you can best interact with peers and colleagues to achieve common goals.

–Jack Lloyd, Retired, 1967 Inductee

Make sure to take classes that you think might benefit you that are not part of your required classes.

–Glenn Mesa, Systems Engineer, 2009 Inductee

Share your love of physics with others your entire life.

–Richard G. Born, Associate Professor Emeritus, Northern Illinois University, 1972 Inductee

Sometimes it can feel like you're not "cut out" for physics, but if you keep working hard and always seek the wonders of the universe, you will find your fit. Keep working towards your goals and see that you have an unbelievable community around you—in SPS, Sigma Pi Sigma, and more. You stand on the shoulders of giants that came before you. Your work is what others will use to further unravel the universe's secrets in time. Keep going!

–Connor Pickett, PhD Student, University of Surrey, 2021 Inductee

Follow your passion, and remember three things: You understand the physical world better than most people. You have demonstrated that you know how to handle complexity. You love word problems—you are a problem-solver!

–Dave Wasil, Climate Advocate and Retired Director of Strategic IT Projects, Matthews International, 1982 Inductee

Explore interdisciplinary fields, gain practical experience, develop strong analytical skills, stay informed about industry trends, consider graduate studies, explore diverse career paths, and build a professional network—all of which can help you navigate your career path effectively.

–Frank Efe, Graduate Student, Morgan State University, 2023 Inductee

Remember the study skills you learned here. Learning new things is easier in a group. Form study groups with peers that you get along with, and not only will you excel at work but you'll enjoy it more too.

–Jess Kenny, Supervisory Scientist, US Navy, 2016 Inductee

Your future career may be in a specialty that doesn't yet exist. So prepare by getting broad course exposure and varied work or intern experience. Not all STEM degrees lead to research, just as not all English degrees lead to successful writing careers. You will find that the math and problem-solving skills you develop will serve you well. Don't neglect the communication skills, both in writing and in speech.

–William A. Watson, Retired Program Manager, NASA, 1970 Inductee

Physics is everywhere! Don't limit yourself, and never stop wondering or asking questions to find out more.

–Glenn Spiczak, Physics Professor and Department Chair, University of Wisconsin - River Falls, 2020 Inductee //

Some responses have been edited for clarity and length.

SPECIAL FEATURE

Nonlinear Careers of Scientists through History

by Corinne Mona, Librarian, AIP Niels Bohr Library & Archives

For some, the path to a career in science can be straightforward: good grades in high school science classes lead to a college degree in science, which leads to work in science. Indeed, many acclaimed scientists have taken a similar route. But this isn't the only option. In fact, you may be surprised to learn that whether by necessity or because of personal interests, these four prominent scientists didn't always have science as their primary focus or source of income. Though we can't say for sure how things might have been different if they had only pursued science, it's clear that their varied careers gave them flexibility and life experience that helped make their big scientific contributions possible.

MARIE CURIE, GOVERNESS

Though Marie Curie (1867–1934) is best known as a French scientist, she was born in Warsaw as a Polish national named Maria Skłodowska. Both of her parents were teachers and at first did well for themselves, but by the time she was a teenager, her family's economic situation was in a precarious place. Her mother died when she was 10, and her father's career suffered because his pro-Polish sentiments clashed with the ideology of the Russian Empire, which was in control of Poland at the time. He was fired multiple times and demoted to progressively worse positions so that there wasn't much money to put toward Curie and her siblings' higher education.

ABOVE: Marie Curie. Credit: AIP Emilio Segrè Visual Archives, W. F. Meggers Gallery of Nobel Laureates Collection.

Not to be discouraged, she and her older sister, Bronya, made an agreement: each would work to support the other's educational expenses. At the age of 17, Curie became a private tutor to pay for Bronya's tuition at a medical school in Paris. After two years, she found a better-paying position as a governess for the children of a beet-sugar factory agriculturalist in a village north of Warsaw. In addition to his children, she was allowed to teach the uneducated village children, and her employer even encouraged his eldest daughter to join her as a teacher. This was quite progressive of Curie's employer, as this activity was seen by Russian authorities as treasonous and if discovered, was punishable by imprisonment or deportation to Siberia. She eventually fell in love with the adult son of her employer, who refused to allow an engagement. Despite the heartbreak, Curie completed her three-year term as governess in order to honor her commitment to fund her sister's education. She filled empty hours with self-study and was also able to study with a chemist at the beet factory. Curie's father and sister were eventually able to set aside money for her studies, and in the fall of 1891, at the age of 23, she enrolled at the Sorbonne in Paris as Marie.

ALBERT EINSTEIN, PATENT EXAMINER

It may be comforting to know that Albert Einstein (1879–1955) had struggles as a youth—struggles that might seem significant but that clearly did not deter his contributions to science. Like Marie Curie, he had political trouble: he renounced his German citizenship and became a Swiss citizen in order to avoid conscription, and he later moved to the United States and became an American citizen to avoid persecution as a Jew in Europe during Hitler's regime. He did well in school but dropped out of high school, as he was "disgusted by rote learning and martinet teachers," and he later failed his entrance exams to the Swiss Institute of Technology. Although

ABOVE: Albert Einstein in 1921. Credit: AIP Emilio Segrè Visual Archives, Segrè Collection.

ABOVE: Maria Mitchell (second from left) works with telescopes outdoors with a group of students, circa 1878.
Credit: Vassar College Library, courtesy of AIP Emilio Segrè Visual Archives, *Physics Today* Collection.

Einstein successfully graduated from a teaching college, he was passed over for academic positions and was forced to survive as a temporary teacher in near poverty.

Happily, he had connections that got him a better job in the Swiss Patent Office. The comfort and stability of the job, along with the mildly stimulating task of examining mechanical patents, allowed Einstein the mental space to contemplate problems in physics. He even purportedly picked up his violin while at work to help him think. During this period of his life, he met regularly with friends, especially Swiss engineer Michele Besso, to read and discuss science and philosophy. While employed at the patent office, he started thinking heavily about gravity (ha!), and these musings eventually became his theory of relativity. He successfully submitted his doctoral thesis to the University of Zurich while working at the patent office, and after seven years as a patent examiner, in 1909 he quit his patent post and was appointed associate professor of physics at the University of Zurich. Though he was no longer a full-time patent man, patents continued to play a role in Einstein's life; he prepared court opinions on patent disputes from 1915 to 1925, and he applied for patents for refrigerators and hearing aids he designed in the late 1920s.

MARIA MITCHELL, LIBRARIAN

Maria Mitchell (1818–1889) was the first American scientist to discover a comet. Born on Massachusetts' Nantucket Island to a library worker mother and an amateur astronomer father, she adopted both pursuits in her own life. Her parents ensured that she got a good education, which was not always a guarantee for girls at the time. Her father personally undertook her instruction in astronomy, mathematics, surveying, and navigation. At the age of 16, she opened a math and science school for girls. In 1836 Mitchell became the first librarian of the Nantucket Atheneum, the island's members-only library (it became a public library in 1900 and is still the primary library on Nantucket to this day).

In August 1841, during her tenure as librarian, the Atheneum hosted Nantucket's first antislavery convention, a three-day event that featured Frederick Douglass and William Lloyd Garrison as speakers.

Similarly to Marie Curie and Albert Einstein, Mitchell's job as a librarian afforded her the opportunity to think about science and much more. During her 20 years as a librarian, she spent many hours each day reading, with nights reserved for time at the nearby observatory that her father built. Though she became famous for her comet discovery, Mitchell was trailblazing in many other ways. She was likely one of the first professional women to be employed by the US government due to her work on the US Coastal Survey; she was a founder of the American Association for the Advancement of Women; she was involved with antislavery and suffrage movements; and she frequently published her scientific work in journals that usually published only men's research. Mitchell became the first female professor of astronomy at Vassar College in 1865, specializing in the surfaces of Jupiter and Saturn. Standing against social norms, she made sure her female students came out at night to use the telescopes, and many of these female students were also later published in scientific journals.

SAMUEL MORSE, ARTIST

Perhaps you've heard of Morse code? Samuel Morse (1791–1872), of Morse code and telegraph invention fame, supported his college studies in religious philosophy, mathematics, and science at Yale by painting. After graduation, he decided to pursue painting full time, and in 1811 he went to London to study at the Royal Academy of Art. In 1815 he returned to the United States with the intention of becoming a professional artist. Despite his talent and moderate success, he wasn't able to establish the kind of prestige he hoped for, and he worked mostly as an itinerant portraitist. In 1824 he had a breakthrough when he won the commission from the City of New York for a portrait of Gilbert du Motier, Marquis de Lafayette. *The Marquis de Lafayette* (1825) commemorates the French war hero's role in the American Revolutionary War. Riding on the success of this portrait, Morse cofounded the National Academy of Design and afterward continued to work as an artist and professor of painting and sculpture at the University of the City of New York.

ABOVE: Samuel Finley Breese Morse, self-portrait, 1812. Credit: National Portrait Gallery, Smithsonian Institution.

Morse's interest in both the arts and sciences influenced his knack for invention. In 1822 he invented a marble-cutting machine for sculpture construction. Sadly, while on tour for *The Marquis de Lafayette*, he learned of his wife's sudden death days after it happened. This inspired him to find new ways of speeding up communication, and he started tinkering with electrical circuits. Eventually, he filed patents for his version of the telegraph in 1837 and started developing Morse code in 1838. //

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The Society of Physics Students congratulates this year's recipients and thanks the generous ΣΠΣ and SPS donors whose support makes these awards possible.

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The SPS Summer Internship program offers 10-week positions for undergraduate physics and astronomy students in science research, education, outreach, and policy with organizations in the greater Washington, DC, area. Students are placed in organizations that use the interns' skills to engage with the community and promote the advancement of physics and astronomy.

Charlotte Bimson
Case Western Reserve University
AIP Mather Public Policy Intern

Sonja Boettcher
University of Nevada Reno
Physics Today Science Writing Intern

Maia Chandler
Swarthmore College
SPS Science Outreach Catalyst Kit (SOCK) and AAPT Intern

Evan Erickson
Massachusetts Institute of Technology
NIST Research Intern

Kaden Gammon
William Jewell College
NIST Research Intern

Kai Hostetter-Habib
Princeton University
AIP History Intern

Collins Kariuki
Pomona College
NIST Research Intern

Mujtaba Khalid
Las Positas College
APS Innovation Intern

Amanda Maeglin
Vanderbilt University
APS Public Engagement STEP UP Intern

ABOVE: The 2024 SPS Interns. Photo by Jessica Sansarran.

Piper Malczewski
University of Colorado Denver
NIST Research Intern

Jenna Mastropolo
High Point University
AIP Mather Public Policy Intern

John Miri
Harvard University
AIP Science Policy News Intern at FYI

Brynn Schierenbeck
Cornell College
NIST Research Intern

Jaden Sicotte
George Washington University
STScI Research Intern

Reidyn Wingate
Massachusetts Institute of Technology
APS Education Programs Intern

Charles Wszalek
Embry-Riddle Aeronautical University Prescott
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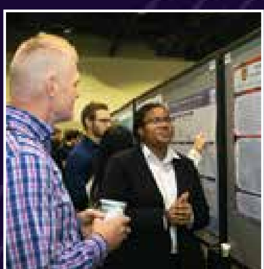

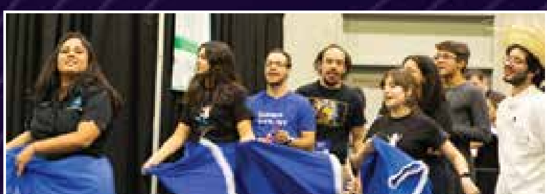

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