the SPS Observer

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TABLE OF CONTENTS

SPRING 2024 ▪ VOLUME LVIII, ISSUE 1

FEATURES

SPECIAL FEATURES

DEPARTMENTS

ON THE COVER
Attendees check out a partial solar eclipse (using safe solar viewers) during an event the University of Vermont SPS chapter helped put on in October 2023. Photo by Patrick Charron.

Astronomy and Physics: A Unified Journey

by Hannah Jang-Congell, At-Large Member, SPS Executive Council, and Program Scientist, NASA

When people ask me the difference between being an astronomer and an astrophysicist, I like to say that it's whether you want to talk to the person sitting next to you on a plane. If you tell people you're an astronomer, they usually get excited and ask lots of questions. If you say you're an astrophysicist, they tend to say, "Oh," and end the conversation. If you've ever struggled with a tough physics problem set, you can probably relate to this reaction.

Perhaps it says something about me that I usually call myself an astronomer, even though I swear I'm really an introvert.

As a physics major, I was drawn to astronomy by the number of open questions in the field: How do stars and galaxies form? What is the universe made of? What are planets around other stars like? Because we can never visit these objects due to the vast distances in outer space, we have to study them remotely. We do this by assuming that physics must be the same everywhere across the universe. It's a fascinating puzzle to tease out the physical nature of planets, stars, and galaxies solely by what we can detect remotely. Quantum mechanics tells us how to interpret lines in the spectra of objects. General relativity tells us about the nature of black holes and gravitational waves. Basic mechanics tells us how we can measure planet masses from the Doppler shifts of stars.

Astronomy is just one of the many fields that a background in physics opens up for people. Sure, there's condensed matter physics, biophysics, medical physics, nuclear physics, and other fields with "physics" in their names, but there's also engineering, information technology, and education, just to mention a few. Even if you don't end up pursuing a physics- or astronomy-based career, the problem-solving skills you gain from such an education will help you in many other fields. (Learn more about possible careers by visiting the Careers Toolbox at spsnational.org/sites/all/careerstoolbox.)

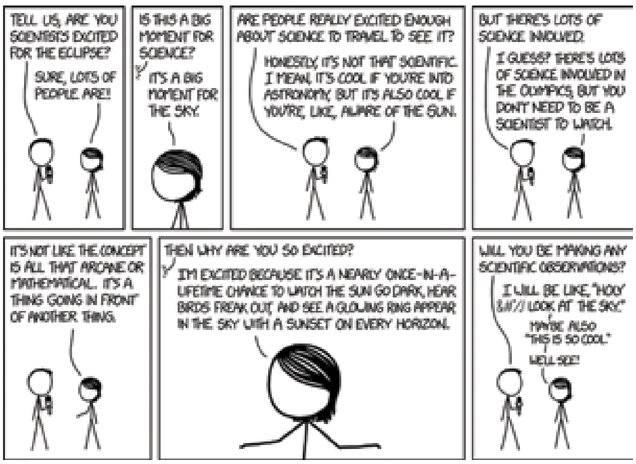
Future career prospects aside, there's fun to be found in physics *right now*—the simple joy in understanding how the universe works, pride in solving a tricky problem, and the camaraderie of collaborating with your peers. SPS is about all these things, and about building a community to celebrate them. This is why I continue to work with SPS and support its mission, even though I've left academia and no longer work directly with undergrads—so that any student with an interest in physics or astronomy, regardless of their background, can feel like they belong and are welcome in the community.

On a related note, I was excited when SPS amended its bylaws a few years ago to explicitly include astronomy in its description. I don't feel like I left physics to pursue a career in astronomy, and it's nice to be officially recognized as part of the fold.

As this issue of the *SPS Observer* was being finalized, a rare astronomical event took place across a wide swath of North America. I hope you could see the total solar eclipse and that it helped you appreciate astronomy and physics even more. I am looking forward to experiencing this amazing event with my family and friends in Rochester, New York. Experiencing one is simply phenomenal and awe inspiring. Maybe this is why people find astronomy so accessible—anyone can look up at the sky and find wonder. //

ABOVE: Hannah Jang-Congell.

BELOW LEFT: Image credit: xkcd.com/1877, expletive modified.

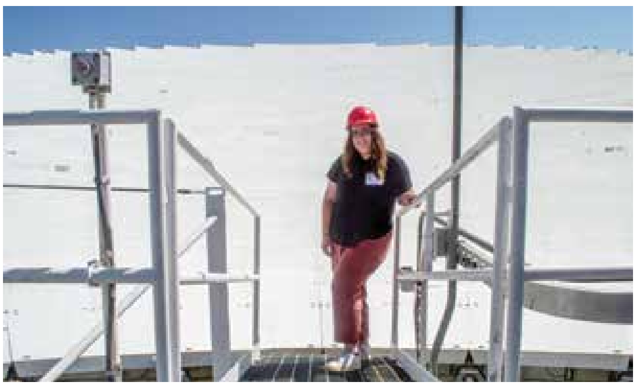


How to Thrive in a Summer Program

by Kaitlyn Sheriff, Associate Zone Counselor, SPS Council, and SPS Chapter President, Lycoming College

The National Radio Astrology Observatory—that's right, *Astrology*—existed for approximately three days. When my research cohort learned about a tradition in which summer students working at National Radio Astronomy Observatory (NRAO) locations prank their sites, we knew we wanted to go big. The hardest part was probably renting and transporting a ladder from Home Depot tall enough to allow us to change the building's sign. The University of Virginia (our site) needed a utility truck with a lift to undo our modifications.

If you're heading to an REU (Research Experience for Undergraduates) or internship this summer, I don't necessarily recommend pranking your summer research location, but I do recommend having some fun!



At my NRAO REU last summer, I studied a high-mass X-ray binary system, reducing data from the Very Large Array (a radio astronomy observatory) and writing Python code. I had invaluable professional experiences, such as when my mentor walked me through the process of writing proposals for the Very Large Array and helped me develop my professional writing and presentation skills. I also went to the top of the Green Bank Telescope, pranked the NRAO, attended a Washington Nationals baseball game, walked through Thomas Jefferson's home, and picked fresh peaches at an orchard. Balancing work and downtime is important to success. Too much work can easily lead to burnout, but too much downtime can prevent you from accomplishing your goals.

As you get ready to embark on your own summer research adventure, consider these practical tips that I learned from my journey.

Set Clear Goals. What do you most want to get out of this experience? Whether it's obtaining research experience before graduate school, expanding your knowledge of programming languages, or exploring a new technique, establishing a clear, overarching goal will guide your efforts and help you maintain your focus throughout the summer.

Foster Connections. Strive to create meaningful connections with your summer cohort and mentors. Have shared experiences and create a supportive community that can learn and grow together. The relationships that you build in a few short months may grow into future collaborations and career opportunities.

Embrace Adaptability. One of the largest hurdles to overcome in a summer program may be accepting that research is unpredictable. Setbacks, especially in the beginning, occur all the time. View them as opportunities in disguise—overcoming challenges fosters a mindset for lifelong learning and professional growth.

To make the most out of your professional research experience, seize the moment and prioritize your personal experience, too. Living in a new place presents the perfect opportunity to explore! Take time on weekends to catch a baseball game with peers or go on a hike and watch the sunrise. Venture out of your comfort zone and discover what the local community has to offer. You may soon find a favorite Saturday morning farmer's market, coffee shop—or even Home Depot. //

ABOVE LEFT: Kaitlyn Sheriff stands near the top of Green Bank Observatory. Photos courtesy of Sheriff.

LEFT: Kaitlyn Sheriff and her group commemorate the brief existence of the National Radio Astrology Observatory.

Reviving Interest in a Campus Observatory

by Sasha Toole, SPS Chapter Copresident, Mount Holyoke College

Williston Observatory sits on the edge of Mount Holyoke College's campus, an unknown entity to most students. The building hosts only one class and otherwise stands empty in the wake of a struggling astronomy department. But this hidden gem holds potential for fascinating explorations into the starry night. When the observatory recently acquired new user-friendly telescopes, our SPS chapter saw a golden opportunity to revive the landmark, which was at risk of being destroyed.

On ten Saturday and Sunday nights over the course of a semester, our SPS chapter hosted open hours at the Williston Observatory. We invited students, staff, and members of the public to attend.

On clear nights we helped attendees view celestial objects through the new Unistellar eVscope telescopes. The telescopes are user-friendly—you can control their GPS-based positioning system through an app. Attendees also looked through the observatory's hallmark 24-inch Ritchey-Chrétien reflecting telescope at objects in the solar system, and they enjoyed cider donuts as we described the objects they were seeing and answered questions.

On cloudy nights, we gathered in the observatory's classroom with snacks and hot beverages to watch sci-fi media, including the movie *Interstellar* and episodes of *Star Trek*.

Through these events, we generated interest in the Williston Observatory and demonstrated its value not only for students but also for any curious mind. Many of our open hours had great turnouts, and they caught the attention of neighboring Smith College, Hampshire College, Amherst College, and the University of Massachusetts Amherst. Moreover, we have received countless requests to continue hosting open hours.

Our chapter has enjoyed sharing the joys of the observatory, the oldest academic building on campus, with students from inside and outside of our astronomy and physics departments. One evening the entire lacrosse team came to observe, the majority of which did not even know there was an observatory on campus! It was a privilege to bring interest back to the observatory, and we hope to hold more events in the future. //

TOP LEFT: SPS members show off the new telescopes. All photos courtesy of the Mount Holyoke College SPS chapter.

TOP RIGHT: One of the new telescopes reveals a stellar view of M51, the Whirlpool Galaxy.

ABOVE: SPS members pose in the Williston Observatory.

GET MONEY FOR CHAPTER OUTREACH EVENTS

To facilitate this project, the Mount Holyoke SPS chapter applied for and received a Marsh W. White Award from SPS. These awards, of up to $600, are available for chapter programs or events that promote an interest in physics or astronomy among students or the general public. Applications are due November 15. Learn more at spsnational.org/awards/marsh-white.

Behind the Scenes of a Conference for Women in STEM

by Emma Cartney and Emma Chambers, SPS Members, Allegheny College

TOP: Emma Chambers shares her research with attendees during the conference poster session. All photos courtesy of the Allegheny SPS chapter.

MIDDLE: Keynote speaker Nicola Dent, CEO of Optical Filters, talks about her experience working in industry.

ABOVE: Alexis Pleskovitch talks about women in STEM.

Allegheny College's Women in STEM conference is a local biannual event modeled after the larger Conference for Undergraduate Women in Physics (CUWiP) hosted by the American Physical Society. Our goal is to increase inclusivity in the science disciplines.

The conference has evolved from a physics-focused event to include a wider range of STEM topics, and it is geared toward students from groups underrepresented in STEM who are on campus and attending area high schools. The one-day meeting includes guest speakers from a variety of backgrounds, panels featuring Allegheny undergraduates and alumni, and a poster session.

While planning our most recent conference, the search for speakers proved difficult—Allegheny is in a rural community in northwestern Pennsylvania—but we ended up with a full lineup. We reached out to Optical Filters, a company with a location in town, and Nicola Dent, the CEO, enthusiastically agreed to speak. As our keynote speaker, she provided insight into the industrial and business side of science. Fulya Kıroğlu, an astronomy PhD candidate at Northwestern University, joined us virtually to talk about her research and experience as a woman in astronomy. Our third speaker was courtesy of Skype a Scientist (**skypeascientist.com**), a program that connects scientists from almost any field with students from kindergarten to college. Beth Hudak, a research chemist at the Naval Research Academy, met with us and shared what it's like to work on scanning transmission electron microscopy in a national laboratory.

A few Allegheny alumni also gave talks at the conference. Juliana Sebolt, a graduate student at the University of Pittsburgh, talked about her work with quantum computers; Alexis Pleskovitch talked about her Allegheny senior thesis project and how we can promote inclusivity in STEM, both inside and outside the classroom; and Heidi Mach talked about teaching primary education before entering graduate school.

During the poster session, four undergraduate students presented research they had conducted at Allegheny or during a summer research opportunity, on topics in biology, chemistry, physics, and psychology. The session allowed fellow undergraduates and high school students to see some of the research opportunities available on campus and beyond.

During breaks, meals, and crafting sessions, participants mingled and networked with one another. Many expressed gaining valuable insight into the opportunities available at Allegheny, in graduate school, and in the workforce. We enjoyed planning and hosting this event and seeing its positive impact on our community. //

Angela Hight Walker:

From Small-Town Dreamer to Nanoscience Leader and Mentor

by Molly McDonough, Cochair, 2025 Physics and Astronomy Congress Executive Planning Committee, and PhD Student, Pennsylvania State University

Angela Hight Walker, senior scientist and project leader in the nanoscience spectroscopy group at the National Institute of Standards and Technology (NIST), is a strong proponent of mentorship. Over her years at NIST, Hight Walker has mentored more than a dozen postdocs and countless undergraduate and graduate students. But growing up in small-town Ohio, she didn't have any scientist role models.

Although Hight Walker didn't know any scientists, she enjoyed learning chemistry and physics in school. She attended college close to home, at Capital University in Bexley, Ohio, and pursued a bachelor's degree in chemistry with a minor in physics. While there, she began working on physics research projects for a faculty member who eventually helped Hight Walker get a summer research fellowship.

Hight Walker's research experiences in college ultimately led her to graduate school at Wesleyan University, where she earned a PhD in chemical physics—with the same group she had done a summer research fellowship with as an undergraduate. Her research involved using microwave spectroscopy to probe energy-level transitions in weakly bonded gas-phase molecules, which provided insight into their structure and dipole moments. She loved working on spectroscopy, because studying the signatures of molecules you can't see is like a puzzle, she says.

After completing her PhD, Hight Walker went on to do a postdoc at NIST in a gas-phase microwave spectroscopy group. She was familiar with the group from attending conferences as a graduate student and was thrilled to work with scientists whose talks she had been inspired by. She has been at NIST ever since.

After five years with the group, NIST made a strategic decision to decommission the gas-phase spectroscopy program. Most of Hight Walker's colleagues were at retirement age, but as an early-career scientist, she needed to pivot. She joined a professional development program at NIST and worked in the director's office, which allowed her to see how NIST was run and network with scientists from across the institute. As part of her role, she took the meeting notes for new programs. A particular program caught her eye in the early 2000s—a nanotechnology initiative. She put forward a plan to return to her love of spectroscopy in alignment with NIST's new strategic goals, using Raman spectroscopy to study quantum nanomaterials.

In her new research, Hight Walker began characterizing nanotubes, then unrolling tubes to study graphene, and then moving more broadly to 2D materials. Now she studies magnetic materials. Her overall approach to this work is to add a little more complexity to systems over time. This allows her to be at the forefront of new materials systems as they are discovered.

ABOVE: Angela Hight Walker. Photo credit: NIST.

As she does research and oversees projects, Hight Walker always makes time to invest in others. "Mentoring to me is more important than anything that I do," she says. She hopes that when she retires, people will say that she "had an environment in the lab that was conducive to learning," and where people were free "to try new things, to screw up, to break stuff, and to learn."

When seeking a mentor as a student, Hight Walker recommends looking for "someone who you see treating people so well it catches your eye."

Hight Walker has two other pieces of advice for current undergraduates. "My biggest advice is to do research. I had very little exposure to these ideas or doing research," she says. "I couldn't have even imagined what I'd be doing."

Her second piece of advice? Find a community, especially if you're a woman. "You need a community—people, friends, and colleagues," she says. "It's the relationships that make it all work." //

Hyo Jung Park.

An Empowering and Knotted Journey into Polymer Physics

by Hyo Jung Park, 2023 SPS Awardee for Outstanding Undergraduate Research, and Graduate Student, Perimeter Institute for Theoretical Physics

Think of beautiful objects we see in our lives. Many of them, in categories from architecture and ornaments to hairstyles, are *knots*.

What do knots have to do with physics and astronomy?

Knots naturally arise in many physical systems and are closely linked to the systems' behaviors. For instance, random bursts of electromagnetic fields on the sun's surface lead to tangled coronal loops that can be modeled by knots.[1] DNA strands are often found knotted, and their knot structures can affect biological processes.[2] In polymer materials (bunches of long-chain molecules), some properties of the materials, such as viscosity, are sensitive to the entanglement of polymers.[3]

In many systems like these, studying the knotted components helps us understand the behavior of the collective systems. This is what motivated my research—using knots made of polymer chains, I studied the motion of individual knots and how they relate to knot structures or topologies.

My research on polymer knots started during an unusual time, July 2020, when the COVID-19 pandemic had just begun. I had flown back home from my college to South Korea, disappointed because my summer program, which was to be my first formal research experience, had been canceled. I looked for other opportunities, but most summer programs had been canceled due to the pandemic or had no open positions.

With the thinnest straw of hope, I reached out to professors and researchers at universities, inquiring about opportunities. After what felt like an eternity, I heard back from Anna Lappala, a theoretical polymer physicist at Harvard University. I couldn't believe that I got a reply and could do physics research during that turbulent time! Despite my concerns about conducting entirely remote research and studying a subject that was completely new to me, the project gradually gained momentum and developed into a full research project that would continue through the next two years.

My first task was to construct different kinds of knots and make them move. We weren't in a lab, so building knots meant a lot of theory work and computer coding. See Fig. 1 for some of the knots I created.

To study how the knots moved, we used molecular dynamics simulations. They're efficient in predicting the complex motions of atoms and large molecules like our polymer knots. In the simulations, the knots' movements were powered by Brownian motion and springlike harmonic interactions between particles in the knots. Due to these "internal" forces, knots could move on their own without any external pushes acting on them. (In Fig. 1, arrows show the dominant motions of the knot particles.)

The knots jiggled and twisted continuously, and I analyzed how each knot topology moved. In comparing the motion of different knots, I found interesting results: The dynamics of a knot largely depended on its structure, and knots within the same topology class showed similar types of dynamics. What's more, depending on their topologies, some knots repeated their motions over time, which I termed having "quasiperiodicity."

Dr. Lappala and I were excited since these results may help scientists better understand polymer systems like glass, which often contain many knotted parts.[4] Our work may also enable scientists to control individual knot molecules, which could be applied to biomedical engineering and nanotechnology research that uses knots as "machines" to achieve certain tasks.[5]

Working on this project for two years has left me with invaluable experience and lessons. I participated in the entire research process, from project building to paper writing[6] and presenting. Attending a physics conference had always seemed like a faraway dream, but now I have attended multiple and presented a poster at one. Bringing my work out into the world was scary, but discussing my research with other physicists was incredibly rewarding and empowering.

I loved this process so much that I decided to pursue a PhD in physics after graduating from Smith College and, ultimately, a research career. I had often worried whether I would make a good researcher, but this experience taught me to focus on what I can do and to believe in myself. Now, when that self-doubt creeps in, I remind myself not to underestimate my abilities and that hard work will eventually pay off.

My experience was more meaningful thanks to the guidance of my research mentor, Dr. Lappala. She gave me incredible support and encouraged me to leave my comfort zone and explore my interests. Her inspiration kept me on track as I conducted fully remote research through the challenging times of the pandemic.

My journey in physics research was empowering. And now, if anyone asks me how to get knotted with physics, I know how to answer: Thread yourself into physics research! //

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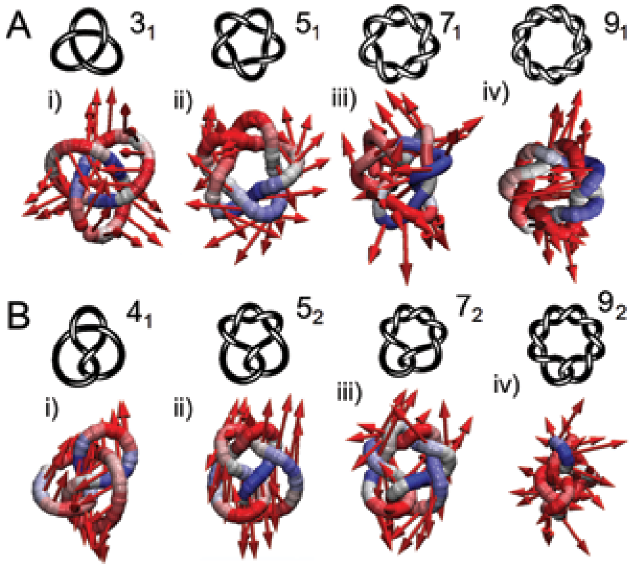
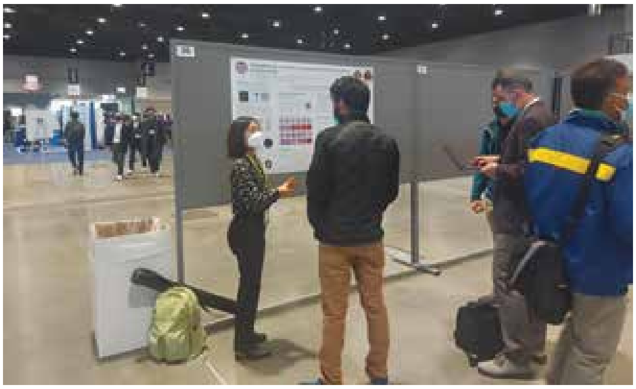


Figure 1: Some of the knots Hyo Jung Park created for her research project. The arrows show the dominant motions of the knot particles. Image courtesy of Anna Lappala.



ABOVE: Hyo Jung Park shares her research at the 2022 American Physical Society March Meeting. Photo by Ariana-Dalia Vlad.

SPS AWARD FOR OUTSTANDING UNDERGRADUATE RESEARCH

Outstanding Undergraduate Research Awards recognize individuals for exceptional physics or astronomy research conducted as an undergraduate. Winners receive $1,800 in travel funding to present their research at an AIP Member Society meeting, $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.

FEATURE

COMBATING BURNOUT

in Physics and Astronomy

by 2023–24 SPS Council Burnout Committee Members Kiril A. Streletzky, SPS President, Stephanie Howell, Associate Zone Councilor for Zone 14, and Robert Laughlin, Associate Zone Councilor for Zone 6

Burnout isn't a new concept for students. However, the COVID-19 pandemic that shut down many aspects of life in 2020 exacerbated the sense of burnout among physics and astronomy students. It dramatically affected their personal and academic lives and their postgraduation plans, and simultaneously shut down many of their support systems, including local SPS chapters and other clubs.

SPS and its governing body, the SPS Council, saw evidence of a devastating effect on SPS chapters. Work halted, applications for awards bottomed out, zone meetings were canceled, and fewer students (and faculty) could volunteer on the SPS Council. Chapter report submissions dropped 24% between 2019 and 2021. When SPS chapter leaders were asked why, the most common answer was burnout.

ABOVE: Illustration by Emma Hataway.

Because of these and other troubling signs, the 2020–21 SPS Council dug into the issue. At the Centennial Physics Congress, originally planned for 2021 but postponed until 2022, SPS leadership asked the more than 1,000 undergraduate attendees representing almost 260 colleges and universities to reflect on the challenges they face. Students selected, from a long and carefully composed list, the two most significant issues. The most frequently chosen were burnout (40.6%) and mental health (24%).[1]

As a committee tasked by the SPS Council with examining student burnout and proposing strategies to improve chapter health, we encourage all SPS members to take the following steps:

1 COMPLETE THE BURNOUT SURVEY AND SHARE IT WITH YOUR MEMBERS

We designed a survey to gather data on (1) the extent of burnout, (2) the manifestation of burnout, and (3) the ways burnout affects people from groups historically marginalized in the physics and astronomy community. Informed by the data, we will be identifying ways to combat undergraduate burnout within our community. The survey will likely bring light to issues unique to the discipline and to students (and faculty) from marginalized groups. We plan to use this information to advocate for diversity, equity, and inclusion (DEI) initiatives, as many are under threat across the country. Please support this effort by scanning the QR code on the right and taking our survey, and by encouraging your chapter members to do so.

The SPS Council Burnout Committee that worked on the survey included: Thayne Dean, Noah Everett, Emma Hataway, S.H., Larry Isenhower, Aiden Keaveney, R. L., Rachel Nere, Zahin Ritee, K.S., and Matt Wright. Special thanks to Anne Marie Porter from AIP for her support in finalizing this survey.

2 SHARE HELPFUL RESOURCES WITH YOUR CHAPTER

In 2021, the SPS Council compiled helpful resources and passed a statement on mental well-being in response to the persisting mental health crisis in the community. We encourage you to share these with your chapter members, post the resources in your chapter's gathering place, and make them easily accessible to everyone. In addition, please compile and share institution-specific mental health resources with your members. To read the statement and access the resources, please visit spsnational.org/about/governance/statements/mental-well-being.

3 HOST ACTIVITIES THAT PROMOTE MENTAL AND PHYSICAL HEALTH

One way to combat burnout is to follow seemingly simple advice for a healthy life, such as prioritizing your physical health. As the semester gets more stressful, many physics and astronomy students stay up late, stop exercising, work while they eat meals, and indulge in junk food. SPS chapters can combat this by holding park days, group hikes, soccer games, and potlucks that encourage physical health and reduce stress. Chapters can also host events to share healthy study habits, help members set reasonable expectations, and reinforce that setting boundaries and resting is essential, even as work piles up.

4 CELEBRATE SUCCESSES

Some students get discouraged by a lack of meaningful positive feedback on their work and a grind that can feel never ending. A good way to combat this is to celebrate chapter members for their accomplishments—finishing exams, finishing grad school applications, receiving awards or acceptances, presenting research, or making it through a particularly tough week. Consider creative ways to highlight individual members on your chapter's social media, in the department newsletter, at chapter meetings or events, or in other formats.

SPS chapters cannot eliminate burnout, but they can help members reduce and manage burnout in healthy ways. We encourage chapter leaders to work together and find creative ways to cultivate welcoming environments that encourage student growth, reduce stress, and support each other during the daily grind and in times of crisis. Through SPS communities we can improve the experience of each student and help one another develop tools and support systems to keep burnout at bay. //

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"The first time I took a more advanced physics class I was not prepared at all. I did not know enough basics to succeed. Not knowing this, I tried anyway. I worked seven days a week only on that one class. Quickly, I got so burnt out that the thought of starting the next day would make me cry and my brain would just stop processing information. I would keep trying to get things done but my brain would not allow me to work. Had I known this was not normal, I would have reached out for help sooner." – *Sophia Amidi*

GET HELP

If you or someone you know is in a mental health crisis, please seek help. The following resources are free and available 24/7 from the comfort of your home. Call 911 in an emergency.

- Wikimedia Foundation maintains a list of mental health resources and crisis lines by country at meta.wikimedia.org/wiki/Mental_health_resources.
- **Crisis Text Line:** Text "HOME" to 741741 anytime for free crisis counseling.
- **Grad Resources, National Grad Crisis Line:** Call (877) GRAD-HLP, and find resources for free counseling and more on the website gradresources.org.
- **Support on social media:** The 988 Suicide and Crisis Lifeline will help you contact social media platforms directly if you're concerned about a friend's social media postings: 988lifeline.org/help-someone-else.
- **988 Suicide and Crisis Lifeline:** Call or text 988 from anywhere within the United States for free and confidential help with a mental health crisis.
- **Thrive Lifeline:** Text (313) 662-8209 to access support from qualified crisis responders in STEMM (science, technology, engineering, mathematics, and medicine). Learn more at thrivelifeline.org.
- **Veterans Crisis Line:** Call (800) 273-TALK (8255) and press 1, or text to 838255 for a free, confidential resource that connects veterans with trained responders, 24 hours a day, seven days a week.
- **Tip:** Save a picture of these resources on your phone so they're always within easy reach.

FEATURE

A Decade of Creating SCIENCE HISTORY TEACHING GUIDES

by Joanna Behrman, Assistant Public Historian, Center for History of Physics

For more than 10 years the Center for History of Physics (CHP), with the help of SPS summer interns, has been sharing previously untold stories from physics and astronomy history with students and the public through teaching guides. CHP is part of the American Institute of Physics (AIP), the parent organization of SPS, and supports the scholarly community's efforts to document, investigate, and understand developments in modern physics and their impact on society.

CHP created the first *Teaching Guides on History of the Physical Sciences* in 2013 to help diversify how physicsts are represented in the classroom. Today we have more than 50 available online for K–12 teachers, college professors, and anyone else who wants to learn about the diverse historical community of physical scientists and share it with others.

The collection grows every summer through the work of graduate research assistants and undergraduate SPS interns—14 so far! Most of these interns split their time between working for CHP and the Niels Bohr Library & Archives, which is also part of AIP. Every summer our corner of AIP is reinvigorated with their infectious energy. To mark the tenth anniversary of the teaching guides, I reconnected with some of our former interns. Here are some of their reflections.

Why did you decide to do an SPS internship?

I was trying to figure out my place in physics. I had completed a summer research project in astrophysics following my freshman year and found that I wasn't genuinely engaged with the work. I started looking for ways to try out alternative paths I could take with my physics degree. This led me to explore the idea of teaching physics or working in physics education. When I heard about the SPS internship program, I thought it would be a great opportunity to work on a physics education project and explore different opportunities within physics.

—Brean Prefontaine, 2015 SPS Intern, Physics Education Research Postdoc, Duke University

I was immediately drawn to not only the diverse set of experiences offered through the internship, but also the opportunity to live in the DC area for a few months with a great group of people.

—Simon Patané, 2014 SPS Intern, Systems Engineer III, Redwire Space

What skills or lessons did you learn through the internship?

This internship changed me and my life in ways I never expected, even before I was an intern. I interviewed for the 2018 cohort and did not get in. But what changed me forever was a question in my interview. An AIP staff member asked me, "What are you proud of?" At the time, I wasn't doing research, didn't feel like I was excelling in classes, and was struggling to feel proud or like I had accomplished anything of merit. . . . I dug deep and recognized that I was a good friend, classmate, roommate, and teammate. Every day, I got myself out of bed and worked hard. That was all worth being proud of. After this perspective change, I became a better student and went from trying to fit this perfect physics student model I had been striving to achieve to refocusing on what I loved to do and pursuing what made me happy.

—Catherine Ryan, 2019 SPS Intern, Program Specialist, National Hydropower Association

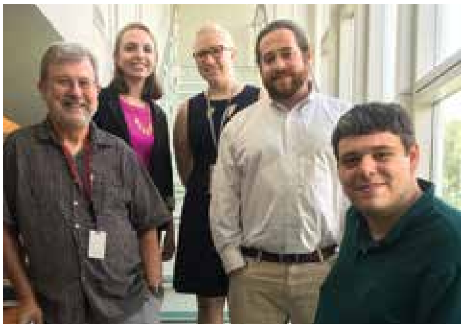
ABOVE: The 2014 teaching guide team breaks for a photo, (L-R) SPS interns Jacob Zalkind and Simon Patané, and graduate research assistants Sharina Haynes and Serina Hwang Jensen. Photo by Greg Good.

BE AN SPS SUMMER INTERN

The SPS summer internship program offers 10-week, paid positions for undergraduate physics and astronomy students in science research, history, 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.

BROWSE THE TEACHING GUIDES

From "African Americans and Life in a Secret City" to "When Computers Wore Skirts," you can browse the CHP Teaching Guides at aip.org/history-programs/physics-history/teaching-guides/browse. These teaching guides meet national educational standards, can fit into social and natural science courses, and are available for free. They are great resources for SPS outreach events, meetings, and lesson planning!



ABOVE: The 2016 teaching guide team poses in the library, (L-R) then AIP History Center director Greg Good, SPS interns Victoria DiTomasso and Samantha Spytek, and graduate research assistants Lance Burch and Stephen Neal. Photo courtesy of the American Institute of Physics.

What is a good memory or two you have from that summer?

I remember writing a *Physics Today* article about Eunice Foote and interviewing some of the people who helped publicize her story. I was so nervous and was far out of my comfort zone, but the interview subjects reassured me and encouraged me. It made me feel like I was part of the science history community and that we were all working together to share the stories that have been overlooked. It felt really special to be part of a team working to correct history.

—Maura Shapiro, 2021 SPS Intern, Science Writer, American Institute of Physics

My first great memory was when the CHP and Niels Bohr Library & Archives staff digressed in a meeting and spent time trying to find the location where a photograph of Jane Dewey was taken based solely on the background. It was amusing hearing all of our ideas as we bounced them off of one another and incredibly exhilarating to finally pin down the exact location of the photo. Another good memory was my last memory—as I finished my final presentation, hearing from Joanna Behrman, my mentor, how well I'd done and feeling it myself was a boost of confidence in myself, my work, and my skills as a librarian and physicist that I hadn't expected.

—MJ Keller, 2023 SPS Intern, Physics and Astronomy Student, University of Rochester

What aspect of the teaching guides did you work on?

We took previously created guides and updated them to follow a format known in physics education research as 5 E (engage, explore, explain, extend, and evaluate), consolidated all guides and corresponding resources into one large database, identified Next Generation Science Standards for each lesson, and worked with the website division to update the page and make it accessible and easy to use. We also each made a few lessons of our own.

—Samantha Spytek, 2016 SPS Intern, Physics Teacher, Academies of Loudoun

I delved into the captivating stories of two remarkable women physicists: Émilie du Châtelet and Katherine Clerk Maxwell. As an intern, I was tasked with choosing teaching guide topics …, performing extensive research on the women, and creating teaching guides about them for an age group of my choice (I chose grades K–2). I made the teaching guides, including their supplementary materials.… I LOVED doing the historical research and the content creation, making these women's stories come alive for the students.

—Emma Goulet, 2022 SPS Intern, Quantum Physics Cultural Exchange Teacher, Library of Tibetan Works & Archives, Science for Monks and Nuns

These responses have been edited for length and clarity; full responses are available on the Niels Bohr Library & Archives blog Ex Libris Universum at aip.org/history-programs/niels-bohr-library/ex-libris-universum. //

FEATURE

A Night at GREEN BANK OBSERVATORY

by Jordan Miller, with Patrick Herron, SPS Reporters, Cleveland State University

The day before the 2022 Physics Congress officially began, a small group of undergraduate astronomers and physicists gathered in Washington, DC. We were eagerly awaiting a bus that would take us to Green Bank Observatory (GBO) in West Virginia, home to the world's largest fully steerable radio telescope.

The drive to the observatory took about four hours, but seeing the Appalachian Mountains dressed in full fall colors made the trip more enjoyable. As we pulled into the observatory parking lot, we could see the mammoth structure that is the Green Bank Telescope.

After dropping our things in the dorms where we'd be sleeping that night, we walked over to the Green Bank Science Center for dinner. There we met Sue Ann Heatherly, GBO's senior education officer. She gave a presentation on the history of Green Bank and taught us how to read a sky map of declination and right ascension. We would need this information to steer the smaller, 40-foot telescope we would have access to that night.

Then Sue Ann split us into two groups. One would explore the center exhibits while the other walked to the 40-foot telescope and learned to operate it; then we'd switch. Our group explored the center first. No matter how far into a science degree or career you are, playing with physics demos is always fun! We also went on a scavenger hunt. Someone had hidden ten toys shaped like spherical cows around the grounds, and whoever found the most would win a prize. After about an hour of exploring it was our turn to walk to the telescope.

As we moved away from the Science Center, the moon and the stars in the Milky Way were all that illuminated our path. About a mile—and a few sore necks—later, we arrived. Sue Ann escorted us into the underground control room, and we saw walls covered with drawings and messages from former researchers and students who have collected data there. We learned to steer, monitor, and collect data with the telescope by tuning it as you would an AM/FM radio. By the end of the training, we had "gathered our own little photons, and gave them purpose," as Sue Ann put it.

When Sue Ann left for the evening, she told us that we had free rein of the telescope and the Visitor Center all night. Everything was ours to play with and explore. She left us with the keys to a truck and told us to have fun! None of us expected this freedom, and we made a pact to stay up as late as possible and collect as much data as we could. By then it was about 9:30 p.m.

We collected hydrogen spectra from galaxies, quasars, and other random spots in the Milky Way, eventually taking a break to search for more spherical cows and admire the night sky from outside the control room. We bonded with other Physics Congress students from across the United States, talking about our college experiences and future goals. At one point, we found ourselves lying on the cold ground staring up at the night sky, admiring a view of the Milky Way that most of us had never seen before. We finally went to bed sometime in the early morning. We don't know the exact time since we couldn't have our phones—cell service causes too much radio interference.

A few hours later we woke up, a little sleep-deprived, and headed to breakfast. Today was the day we would experience the famous Green Bank Telescope. We split into small groups and paired with

ABOVE: PhysCon 2022 attendees gather in front of the Robert C. Byrd Green Bank Telescope at Green Bank Observatory in West Virginia. Photo courtesy of Brendan Diamond.

THE 2025 PHYSICS AND ASTRONOMY CONGRESS IS COMING!

Like the 2022 Congress, the 2025 Congress will feature one-of-a-kind tours, amazing speakers, and unforgettable experiences for physics and astronomy undergraduates. For details visit sigmapisigma.org/sigmapisigma/congress/2025.

October 30 – November 1, 2025 | Denver, Colorado

researchers, engineers, and technicians who worked on or with the telescope. They were our tour guides as we climbed the 485-foot-tall instrument.

We saw the telescope's control rooms, which contained aisles of electrical panels and complicated wiring responsible for pointing the telescope and collecting radio signals from distant galaxies. We took an elevator to the dish level, where we were able to get a better sense of just how big the telescope really is—the dish is 100 meters in diameter. The view from the top of the telescope was almost as impressive as the telescope itself.

As we descended, our time at Green Bank was coming to an end. We boarded the bus that would take us back to the Physics Congress, which would officially start later that day. We already knew that regardless of what else took place during the rest of the weekend, the visit to Green Bank would be our favorite part of the trip. //

REVEALED BY RADIO:

The Universe Has a Gravitational Wave Background

by Kendra Redmond, Editor

Last summer, using data from the Green Bank Telescope and other radio telescopes, international research teams announced evidence that a low-frequency gravitational wave background permeates the universe. Where it comes from and what it means are compelling questions without definite answers—at least not yet.

In 2015, the LIGO and Virgo instruments made the first direct detection of gravitational waves, a ripple in spacetime that radiated outward from the final milliseconds of a massive binary black hole merger. The "chirp" lasted around 0.2 seconds.

The 2023 detection was different. The data came from radio telescopes, not laser interferometers, and the signal wasn't a chirp. "It's like a humming, or like a rumbling, of gravitational waves through the whole universe," says Sarah Vigeland, a physics professor at the University of Wisconsin - Milwaukee who co-led this research for the NANOGrav Collaboration. And the signal gets stronger with time.

Scientists don't know what's producing the hum yet, says Vigeland. One theory is, "When you combine the gravitational waves produced by all the supermassive binary black holes in the universe, you get this hum," she says. There are other possibilities, too. The background may come from more exotic sources, such as cosmic strings, that are theorized to exist but not yet confirmed, she says. "That's part of why we're really excited."

Radio telescopes can't detect gravitational waves directly. They are sensitive to electromagnetic waves in the radio (and microwave) portion of the spectrum, not to ripples in spacetime. The connection lies in pulsars.

Pulsars are rapidly rotating neutron stars that emit beams of radio waves. The beams swing around like the beacon of a lighthouse with extreme precision, says Vigeland. "The kind that we use, millisecond pulsars, rotate hundreds of times per second, and you can time them down to better than a microsecond over the course of decades." This stability is key to detecting gravitational waves.

ABOVE: Sarah Vigeland.

Since gravitational waves distort spacetime, they impact how long it takes radio pulses to reach Earth. The changes are tiny but detectable. Other factors can also impact the timing of individual pulses, so researchers study arrays of pulsars to look for gravitational wave signatures. "If there's a delay in one [pulse] because of, say, the interstellar medium, it's not going to affect the other ones, because the pulses are traveling on different paths. But gravitational waves affect them all in a particular fashion," Vigeland explains.

NANOGrav's gravitational wave background result relied on data from 68 pulsars, but the number of pulsars they use continues to grow. Finding and characterizing more neutron stars is essential for reducing noise and advancing our understanding of the universe. Vigeland loves this element of the project. "Every stage of the experiment is more astrophysics. In LIGO, for example, they also have to worry about making their detector more sensitive. But when we do it, we're learning about astrophysics because our detector is made up of astrophysical objects," she says.

Vigeland encourages students interested in gravitational wave astronomy to get good at learning—while skills like programming and statistics are helpful, the field is young and evolving. "It's a really exciting time," she says. "We really are opening up a new window on the universe." //

BACKGROUND: In this artist's interpretation, a pair of supermassive black holes (top left) emit gravitational waves that ripple through the fabric of space-time. Those gravitational waves compress and stretch the paths of radio waves emitted by pulsars (white). By carefully measuring the radio waves, a team of scientists recently made the first detection of the universe's gravitational wave background. Credit: Aurore Simonnet for the NANOGrav Collaboration.

SPECIAL FEATURE

Impacted by Outreach

by Kendra Redmond, Editor

Visitors aren't the only ones who benefited from an SPS chapter's eclipse demos.

For many years the SPS chapter at the University of Vermont (UVM) has cohosted an annual Physics Phun Day with ECHO, its local science and nature center. The chapter brings demos to the center, sets up tables in a special event room, and shares its enthusiasm for physics and astronomy with visitors. Last October, Vermont was in the path of a partial solar eclipse, prompting a new collaborative event between ECHO, the SPS chapter, and the Vermont Astronomical Society that left a lasting impression on the chapter.

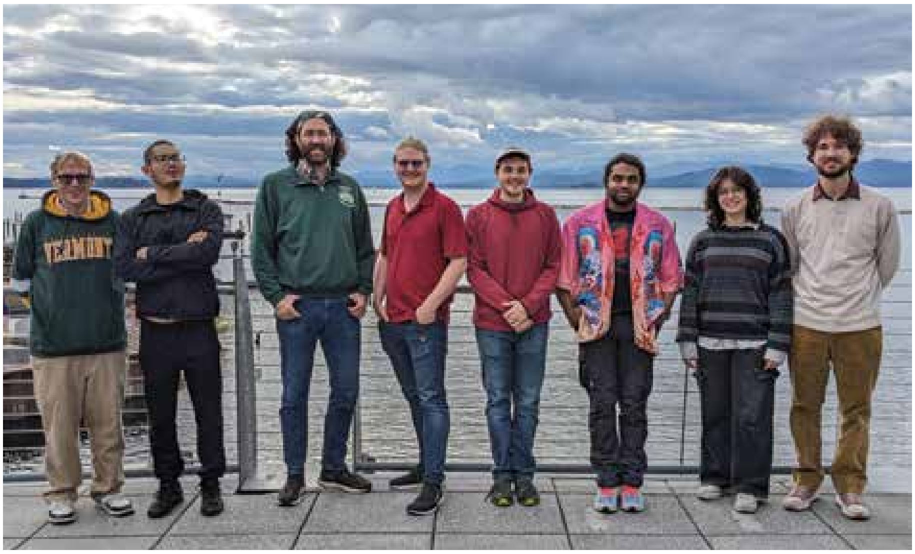
About a week before the event, SPS copresident Anders Holm-Brown, outreach coordinator Jeremy Elliott, and a couple of UVM physics faculty members met with ECHO staff to make plans. It was time well spent. The SPS leaders arrived with ideas for demos that might pair well with the eclipse, and ECHO staff helped refine the list based on their expertise. The ECHO staff "had a much better understanding of what was going to resonate with kids. That was really helpful for putting together a good event," says Holm-Brown.

Elliott, who plans to pursue an education-related career, concurs. "It's very beneficial to actually meet with people who do this professionally," he says. "We get to learn a lot about how to educate."

Resonating with kids doesn't mean avoiding complex topics, though. SPS copresident Sarah Phillips helped attendees explore the composition of stars using diffraction gratings and tubes of noble gases. Although it can be challenging to explain such concepts at a basic level, she found it gratifying to see the looks on the faces of kids—and adults—as they held up a diffraction grating and had a lightbulb moment.

"My mom always told me that she didn't have to take physics in high school, and so she didn't—because she thought she could never do it," says Phillips. She found sharing physics with the adults in attendance, some of whom may have believed they weren't smart enough to study physics, to be especially rewarding. "Being able to give them a little snippet of something that they can actually feel like they understand was really meaningful to me," she says.

For younger attendees, one of the main attractions was a spandex model of the universe on which attendees rolled marbles to simulate the sun and planets. Some kids



TOP LEFT: Visitors play with the spandex model of the universe at an SPS station during the eclipse celebration at Echo. All photos courtesy of Patrick Charron.

TOP: The University of Vermont cadre poses with a cloudy sky—thankfully the clouds broke for a nice view of the eclipse.

ABOVE: Attendees, such as this young visitor, could safely view the partial solar eclipse through a variety of instruments.

came in with such high energy that Holm-Brown, who was running the station, worried the demo might not survive. But when one young child asked him an "incredibly insightful" question about the beginning of the universe, Holm-Brown realized the kind of impact he could have. He engaged her curiosity, telling her what scientists think but explaining that they aren't sure yet and that maybe someday she will figure it out for us. "That was the single interaction that I remember the most," he says. "Not necessarily what was said, but just how it made me feel."

Along with exploring the center and the SPS demos, attendees were treated to a (fortunately) clear view of the partial eclipse. They gathered in a big outdoor area in the back of the center to look through eclipse glasses and view images produced by solar telescopes—from a cardboard solar scope to a high-tech setup brought by the Vermont Astronomical Society.

The SPS leaders say the event was a great way to build community in their chapter, get members out into the community, and learn more about education. It's also good preparation for the eclipse on April 8, 2024, for which UVM will be in the path of totality. The university expects a large influx of people for related events, and many SPS members will be busy helping things run smoothly.

Although an eclipse is an excellent excuse for science outreach, there's never a wrong time to share science. The UVM SPS chapter also participates in local science fairs, and other chapters take on classroom visits, after-school events, and community festivals. To fellow SPS chapters, Elliott says, "If you have the time and the resources, go do something for your community." Phillips agrees. "It's just such a valuable experience. I would say that anyone who has an opportunity to do community outreach should absolutely give it a shot." //

SHARE YOUR ECLIPSE EXPERIENCE

Did you experience the total solar eclipse on April 8, 2024? Host a viewing party? Get outraged at cloud cover? Submit your photos, stories, poems, and other reactions to SPS at sps@aip.org. Submissions may be included in the fall issue of the *SPS Observer*!

SPECIAL FEATURE

Annie Jump Cannon's Stellar Achievements

by Rianna Ehrenreich, Intern, SPS Office, and SPS Member, University of Rochester

LEFT: Rianna Ehrenreich.

ABOVE: Annie Jump Cannon works with equipment. Photo credit: Astronomical Society of the Pacific, courtesy AIP Emilio Segrè Visual Archives, *Physics Today* Collection.

For centuries astronomy was largely viewed as a man's study. So when the director of the Harvard College Observatory, Edward Pickering, needed people to classify and catalog the spectra of stars in the 1870s, he delegated the repetitive and unwanted task to a group of women he oversaw—referred to as "computers." It was here that Annie Jump Cannon, or as National Women's History Museum fellow Kerri Alexander refers to her, the "census taker of the sky,"[1] began her astronomy work.

Cannon graduated from Wellesley College in 1884 with a degree in physics. After taking time to travel and focus on photography, she joined Pickering's group in 1896. Classifying stars via their spectra was a disorganized process at the time due to a multitude of convoluted classification systems.

Cannon had a fantastic memory. As George Greenstein, an emeritus professor of astronomy at Amherst College, wrote, she "knew each star's spectrum as an individual,"[2] giving her unique insight as to how stars should be grouped. This talent was put to use in a 1901 publication where Cannon expertly revised a preexisting classification system. She reorganized the stars into categories O, B, A, F, G, K, and M according to the strengths of some of their absorption lines. Astronomers still classify stars based on this system.

At the time the relationship between star color, spectra, and temperature was unclear, but it turns out that Cannon was classifying stars by temperature (O is hottest, M is coolest). Cannon's system was the direct result of her intense work ethic and astronomical brilliance; she classified about 350,000 stars during her lifetime.

Cannon was published in 11 volumes of the first large-scale stellar catalog, the *Henry Draper Catalogue* (1918–24), and in its follow-up, the *Henry Draper Extension* (1925). She discovered about 300 variable stars and five novae. In 1911 she was promoted to curator of astronomical photographs for the observatory. Despite this, Cannon did not become an official member of the Harvard faculty until 1938, where she taught astronomy.

She received multiple honorary degrees and was the first woman to receive the Henry Draper Medal of the National Academy of Sciences and be an officer in the American Astronomical Society. Cannon was additionally a proud suffragist and voted one of the 12 greatest living women in America by the National League of Women Voters in 1923.

It's hard to believe that early in her career, Cannon was not allowed to use the telescope regularly, as some thought "it was dangerous for a woman to observe alone and inappropriate for one to spend the night with a man," according to Greenstein.[3] She overcame additional adversities as well; for example, by the time Cannon joined Pickering's group, she was deaf.

Cannon's contributions were likely limited as a product of her time. Female astronomers worked repetitive and often unrewarding jobs, quietly supplying data for male astronomers to analyze. Nevertheless, Cannon's genius set the stage for our current understanding of stars and stellar evolution. She continues to inspire astronomers, perhaps especially gender-minority astronomers, proving that nothing can keep us from the stars. //

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3. *Ibid*.

Paul Abbazia

BS in Physics and Computer Science, Rowan University

What he does

I'm a security engineer at SandboxAQ, a startup focused on artificial intelligence (AI) and quantum technologies. I'm part of the Quantum Security Group, which focuses on post quantum cryptography.

I wear many hats. I'm involved in software development, reverse engineering and binary analysis, research, and aspects of IT security. I also support our public sector efforts, as well as corporate security and R&D. Ultimately, we want to improve the state of cybersecurity and protect against emerging threats from quantum computers, which have the ability to break the public key cryptography schemes that underpin internet and communications security.

Prior to this position, I had roles at a couple of other startups; various government agencies, including DARPA and other parts of the Department of Defense (DOD) and federal government; and on a cybersecurity team at Sony.

How he got there

I had a knack for physics in high school and found it fascinating. I had awesome teachers and loved learning how the world works. Physics also helped me understand calculus, which seemed too abstract before it was tied to real-world examples.

I declared a computer science major in my sophomore year of college. At the same time, I had great physics professors who made class enjoyable, so I decided to double major in physics. This led to astronomy research and a 2008 SPS Summer Internship at NASA's Goddard Space Flight Center, which aided my understanding of statistics like physics had done for calculus. I struggled with mathematics at times—something I have in common with Einstein!

Cybersecurity wasn't really a big topic during my education. But my first job after college was in a DOD professional development program focused on aspects of cybersecurity. Over three years I took more than 800 hours of cybersecurity-related training and worked in interesting problem domains, expanding the breadth and depth of my hardware, software, and network cybersecurity knowledge.

ABOVE: Abbazia takes time to smell the flowers in 2023. Photo courtesy of Abbazia.

The best part of his job

Cybersecurity intersects with basically all aspects of life, given that everything has been computerized and networked, so it's truly an interdisciplinary field. Security means wildly different things depending on context, so it's important to learn about use cases in specific domains and sometimes about how computers interact with physical systems or impact the physical world. Every problem set includes opportunities to learn, conduct research, and apply new skills, so it's almost always interesting and engaging.

His advice to physics and astronomy students

Learn how to program. Even if you're not a developer, programming is automation, and you can likely automate something in your workflow. And if not, you can still interact with a lot of cool things by knowing how to program.

Professionally, a can-do attitude and a willingness to try new challenges will go a long way and open a lot of doors. You may not know how to do something, but you can learn. It's best if you can find someone to learn from, but don't let the lack of a mentor stop you from trying. Even failure provides success in the lessons and skills you learn.

Research can often be tedious, so set small, achievable goals, and document what you learn along the way. Better still, codify your knowledge into programs or scripts that both serve as documentation and allow you to repeat and iterate on what you've learned. And don't let "perfect" be the enemy of "good" either. An imperfect solution is better than not finishing the task or getting stuck on one thing. Finally, surround yourself with good people and take up interests outside of your professional life. //

Gravity Can't Get Me Down: Spinning Instruments to Space

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

I think many of us agree that space is cooler than cool. Ice cold even… It's got almost everything we could want to study. But it's really expensive to put instruments and materials into space—literally thousands of dollars per kilogram![1] Part of the reason is that we burn a lot of expensive fuel along the way. Some people, including those at the company SpinLaunch,[2] are exploring much cheaper ways of doing this. So here's the question:

Could we use a large centrifuge to spin something and, like a slingshot, just throw things into orbit around the earth?

I mean, SPS is the society for physics AND astronomy students, right?

How in the world (ha-ha) can we get a handle on a question like this? As students who have taken first-year physics courses might say, we need to know how much energy that would take. But they might also say that determining that is a little complicated. We spend lots of time in introductory physics (and parts of differential equations and advanced mechanics) discussing the importance of air drag. We know that it gets stronger as the speed of an object increases, from proportional to velocity at slow speeds to velocity squared at faster speeds (see Fig. 3).

We also know that if we drop an object like a sphere from a really high place, initially it will accelerate quickly because it is attracted to the earth. This phenomenon is described by Newton's law of gravitation.

As an illustrative example, let's say we drop something from the tallest building on the earth (see Figs. 4 and 5). Currently, that record is held by the Burj Khalifa skyscraper in Dubai, United Arab Emirates, which is 828.0 m (2,717 ft) tall. For context, it's about 1.5 times as tall as One World Trade Center in New York City and almost nine times taller than the Statue of Liberty. It's pretty darn tall.

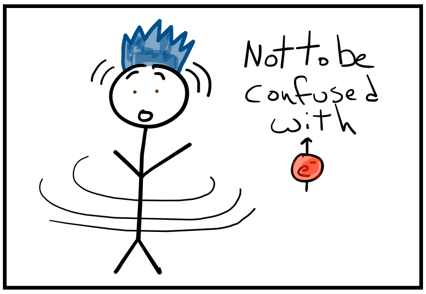

Figure 1. A dizzy astrophysics student. All images by Brad R. Conrad.

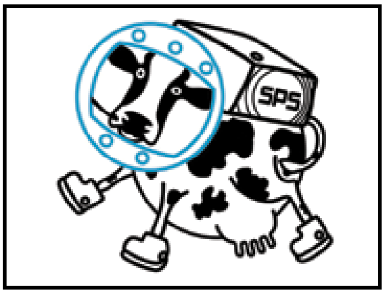

Figure 2. A spherical space cow, SPS's unofficial mascot.

Using some of the information in Fig. 4, how fast does the object accelerate when it starts to fall from the top of the building?

Once you determine the answer, consider this question: Does the height of the building strongly affect the downward acceleration?

When it starts to fall, the acceleration of the object is very close to what we calculate at ground level. You should get a difference of significantly less than 0.1%. But, more to the point of our initial puzzle, what would the acceleration be for an object at NASA low Earth orbit (LEO), or about 200 km above the surface of the earth?[4]

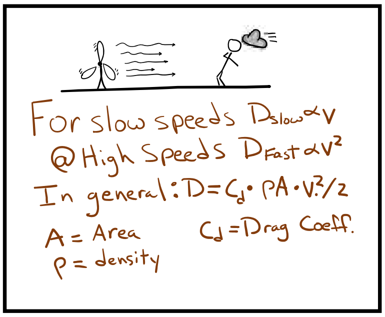

Figure 3. A person experiencing air drag. The force due to drag for slow speeds is $D_{slow} \propto v$ and for fast speeds $D_{fast} \propto v^2$. The drag equation is also given.

This is a really important question, because when something is in orbit, it is continually *falling around the earth*.

When we (theoretically) fire a cannon ball along some long path, the ball has to fall a little further down at the end of the path *because* of the curvature of the earth—the earth's surface is literally farther away from the trajectory of the cannonball. This becomes substantial for long distances, making the path of the cannonball a lot longer *because it falls more*.

Similarly, if something is in a spherical orbit, the earth's surface keeps moving away at the same rate the object is falling toward the earth *because* of its curvature. It's helpful for me to think of an orbit as continually falling. This idea helps us get one of the two key pieces of information we need to solve the energy problem: How fast would the object need to travel to keep falling around the earth at LEO altitude?

I suggest starting with Newton's second law and the definition of centripetal acceleration. You should get something a little smaller than 8.0 km/s, which is about 23 times the speed of sound in air. NASA and other space organizations use such a high altitude because the atmosphere is significantly less dense and the air drag decreases a lot.

Now let's get the second key piece of information: How much energy would it take to get the object from the earth's surface to LEO orbit?

We need to get our object up to a LEO altitude! The other half of the problem does set a high bar (ha-ha). While we could do a bit of calculus, we can actually use the information we already have and think in terms of potential energy (see Fig. 6). Interestingly, it requires significantly less energy to get the object up than it takes to speed it up to about 8.0 km/s.

Now it's time to put everything together. Using only what we've gone over here and a few modest assumptions, can you solve the puzzle?

If we used a large centrifuge, how fast would we need to spin the object to give it that much energy? Is that a reasonable approach? //

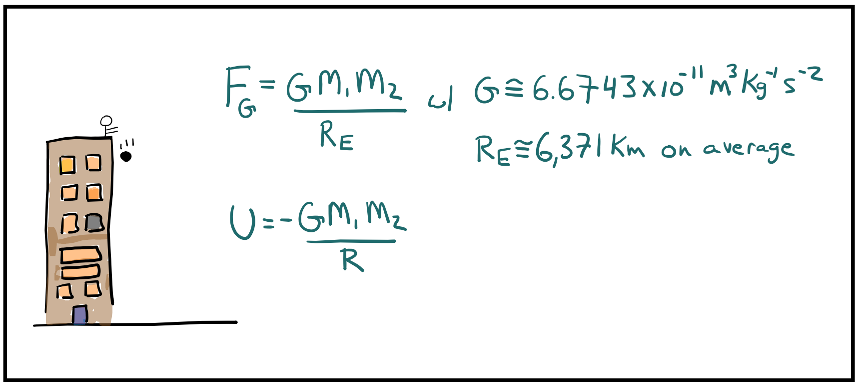

Figure 4. Newton's law of gravitation describes a dropped object falling. Here, G is the gravitational constant,[3] M_1 is the mass of the first object (the earth), M_2 is the mass of the second object, and R_E is the radius of the earth. The figure also shows the equation for gravitational potential energy U, where R is the distance between the two objects.

Figure 5. Burj Khalifa reaches into the sky. Photo by Riyas Mohammed on Unsplash.

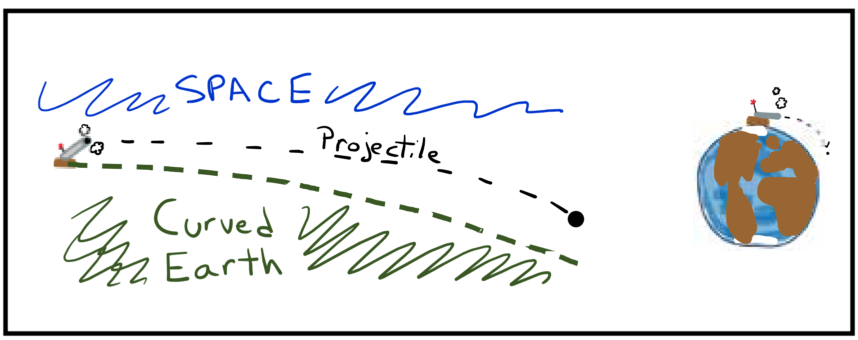

Figure 6. A zoomed-in sketch of an orbit showing that the earth is falling away from the object.

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2. Check out SpinLaunch's idea on YouTube at youtube.com/watch?v=RiALARM1xv0.
3. NIST, the National Institute of Standards and Technology, supports and provides standards and references for the United States, including work on fundamental constants such as the gravitational constant *G*.
4. Visit the Wikipedia article on low Earth orbits at en.wikipedia.org/wiki/Low_Earth_orbit.

A Student's-Eye View of SESAPS

At the 2023 meeting of the Southeastern Section of the American Physical Society (SESAPS), held at Eastern Kentucky University, undergraduate attendees deepened their understanding of physics, met like-minded peers, and explored new fields within the discipline. They heard eye-opening talks and participated in research presentations and poster sessions. Over the course of the three-day meeting, they learned the value of networking and engaging with fellow undergraduate students, researchers, and industry professionals.

Here, SPS student reporters recall favorite talks, reflect on finding belonging in the physics community, and discuss the conference's broader impact on academic and professional growth.

Anran Zhao,

SPS Member,
University of Virginia

I attended SESAPS to engage with local researchers and gain exposure to a wider range of physics subfields than my coursework has covered. My experience could not have been better.

As a third-year physics and computer science major, I enjoyed learning about quantum computing from Prasanna Date, an Oak Ridge National Laboratory physicist. Having no prior knowledge of the topic, I particularly appreciated Date's simple diagrams explaining the distinctions between quantum and classical computing.

During his talk, Craig Group, a professor at my school (the University of Virginia), discussed unique ways for people to become mentors in the field. "I am proud to be a mentor," he said. "It has become the most important part of my career." Though this surprised me, it also made sense. I've always thought that research and teaching come first for a university professor, but as someone who has been mentored by Professor Group, I know firsthand that he genuinely cares about the success of the students he works with.

Leah Broussard, another physicist at Oak Ridge National Lab, concluded her talk on neutron experiments with a surprise announcement—news outlets recently reported that her research had "discovered a portal to a parallel universe." Although sadly not true, the audience laughed at this example of a clickbait title gone wrong. Another fun moment was when Broussard mentioned the Mu2e experiment at Fermilab, which I had worked on during the previous two summers. It felt as if my research was getting a shoutout of sorts.

My favorite experience at SESAPS was meeting researchers who are investigating questions in physics related to topics I've worked on. It was thrilling to talk about my research with people who share my passion for physics, and I'm excited to attend more conferences in the future.

Mateo Cacheiro,

SPS Chapter President,
Tennessee Tech

I walk through the door, take a deep breath, and find my seat. Something indescribable makes me feel welcome. Maybe it's the presence of Mary Kidd, my classical mechanics professor and the session chair. Or it could be that Professor Larry Engelhardt, a close friend of my summer research advisor, is on the panel. While both undeniably provide a sense of belonging, something else is also at play.

The session, a panel on workforce development, begins with a sense of anticipation. The panelists introduce themselves and pose a few questions to the audience, primarily regarding the role of mentors in the development of physicists. The panel isn't asking rhetorical questions. Instead, the inquiries are meant to spark valuable and impactful conversations, which lead to an unexpected shift in my perspective.

When I first walked in, I saw a room full of students, professors, and industry professionals. Full of highly distinguished individuals whom I would never expect to give me the time of day. Full of people who intimidated me and couldn't possibly see me as an equal.

I couldn't have been more wrong. In fact, this isn't even a panel discussion. It's a group of extraordinary physicists collaborating to achieve a greater goal. The open discussions introduce new ideas and encourage individuals to share their perspectives. Speakers are seen not as students or professors but as physicists. I frequently participate in conversations, and my ideas are welcome and respected. I feel connected to the physics community like never before.

At the 2022 Physics Congress, SPS members agreed that imposter syndrome is one of the most complex challenges facing physics and astronomy students today. The collaborative environment of this innovative panel session made me feel noticed and helped me to realize that even as an undergraduate student, *I am a physicist*. Saying that statement is one of the biggest steps in overcoming imposter syndrome, and sessions like this one can provide an environment for taking those steps.

Savion Johnson,

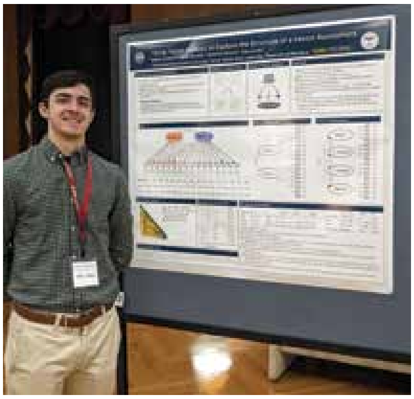
SPS Chapter Secretary, Vanderbilt University

My academic journey, deeply rooted in the study of nuclear physics, has been enriched by my role as the secretary of our SPS chapter and as an active member of the American Physical Society (APS). These roles have shaped my understanding of physics and fueled my passion for exploring its vast and diverse realms. This drive led me to SESAPS, an event that promised to be a convergence of knowledge, research, and innovation in the world of physics.

The wide range of topics covered at SESAPS—applied physics and engineering, cosmology, astrophysics, low-energy nuclear physics, laser physics, climate science, and diversity, among many others—provided an opportunity to delve into both familiar and unexplored areas and offered a comprehensive view of the field's current trends and research directions. Each oral session I attended opened new doors of knowledge and perspective, and pushed me to think more critically and creatively about my field of study.

The poster session was a highlight of my conference experience. While presenting my research on using machine learning to study the effects of quark-gluon plasma, I received valuable feedback from peers and experts. These interactions were learning experiences and a test of my ability to communicate complex ideas effectively.

Conferences like SESAPS provide both learning opportunities and platforms for inspiration and growth. They offer a chance to witness the frontiers of physics research, engage with thought leaders, and contribute to the ongoing discourse in the field. As I reflect on my experience at SESAPS 2023, I am filled with a sense of gratitude and motivation. //



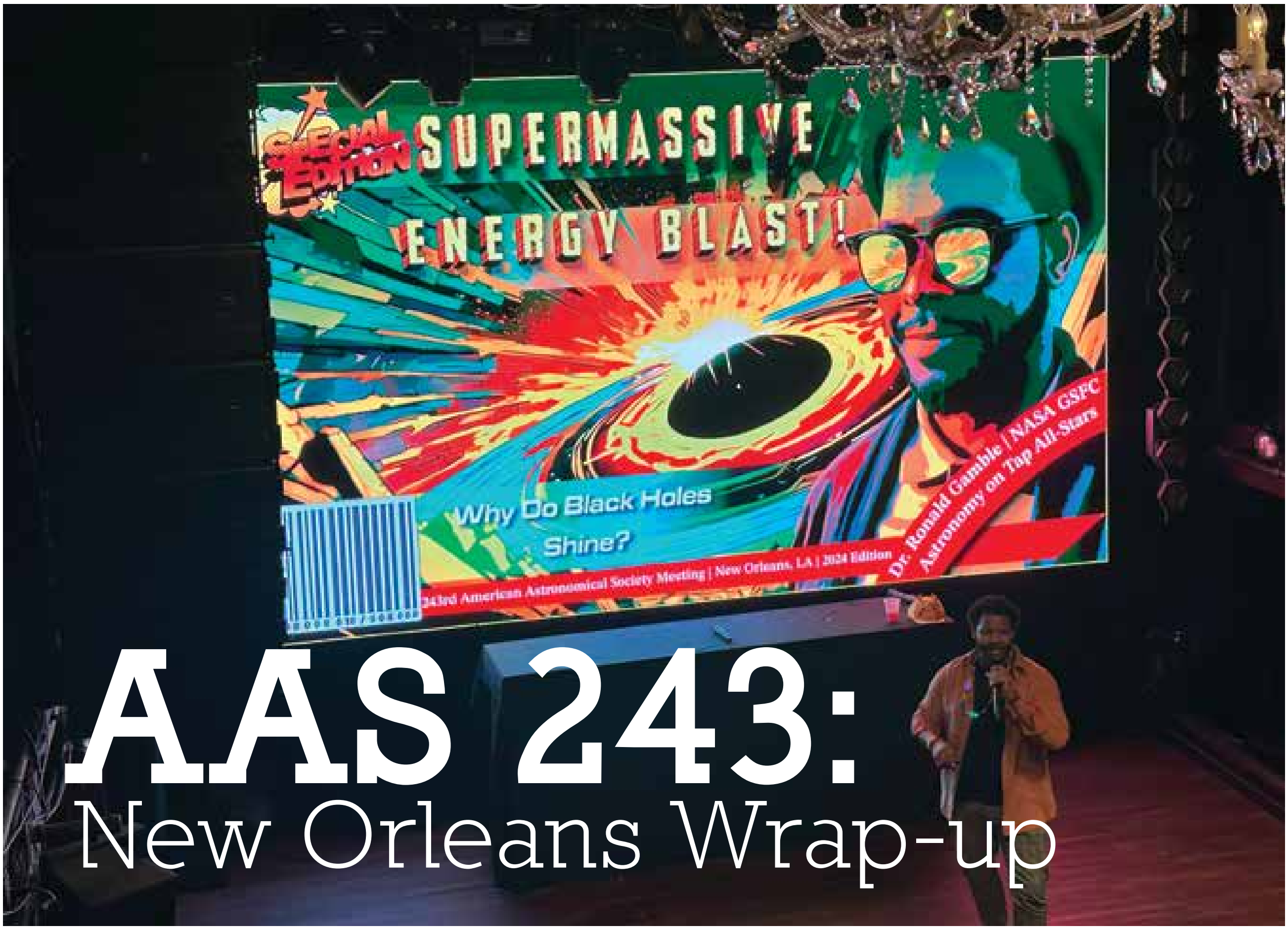
TOP: Attendees explore the SESAPS poster session. Photo by Anran Zhao.

ABOVE: Savion Johnson (back row, center) poses with the Vanderbilt nuclear physics research group at SESAPS. Photo by Matthew Lu.

LEFT: Mateo Cacheiro presents a factor analysis research project during the poster session. Photo by Mustafa Rajabali.

GET FUNDING FOR CONFERENCE TRAVEL

- **SPS Travel Awards offer partial travel support for SPS members to attend and present their research at a national meeting of an AIP Member Society. Applications are accepted on a rolling basis. Learn more at spsnational.org/awards/travel.**
- **SPS Reporter Awards offer partial travel support for SPS chapters or individual members to attend and report on professional physics meetings for SPS publications (like this one!). Applications are accepted on a rolling basis. Learn more at spsnational.org/awards/chapter-awards.**



AAS 243: New Orleans Wrap-up

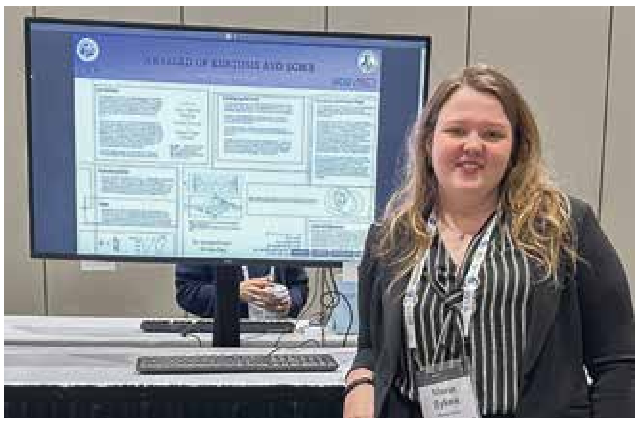
by Marie Olivia Sykes, SPS Reporter, Ursinus College

In 2024 the American Astronomical Society (AAS) is celebrating its quasquicentennial—125 years of existence! The anniversary celebration kicked off in January, when the society's 243rd Meeting, held in New Orleans, Louisiana, brought more than 3,500 astronomers together to share research and community. Attendees included professors, researchers, early career scientists, amateurs, and around 860 undergraduates.

I attended the meeting representing Ursinus College, where I attend school, and the University of Florida's International Summer Research Program in Gravitational Wave Physics, which I participated in last summer.

The conference consisted of plenaries interspersed with poster sessions and short talks highlighting research on exoplanets, stars, gravitational waves, and more, as well as time to mingle with other attendees. I presented a poster on my summer work, which included noise reduction for the Virgo interferometer and uncovering a portion of the gravitational wave background.

The AAS meeting also had special events. The night before the meeting officially opened, AAS hosted a grad school fair alongside an undergraduate mixer. New to the conference was a plenary dedicated to science policy that discussed the Supreme



TOP: NASA's Ronald Gamble begins an Astronomy on Tap talk, accompanied by comic book–style slides discussing black holes. Photo courtesy of Marie Olivia Sykes.

ABOVE: Marie Olivia Sykes presents her poster on the last day of the conference. All of the posters were displayed on a screen. Photo courtesy of Phia Morton.

Court reversing affirmative action in admissions. Notably, this year the International Astronomical Union's General Assembly is being held in Africa for the first time, so the organizers spoke about that. In addition, AAS partnered with Astronomy on Tap to organize dinner events on two nights of the conference. These were a hit, with more than 700 people in attendance on the second night.

In his Fred Kavli plenary talk, Stephen Taylor, an associate professor at Vanderbilt University, discussed how the NANOGrav Collaboration used an array of pulsars to detect a stochastic gravitational wave background (see page 15). Later, I asked him how he got to where he is today. "I remember getting really interested in astronomy during one particular summer," he said. "It was the 30th anniversary of the moon landing, and there was also a total solar eclipse in the UK. Space news was huge that summer, and I got hooked on astronomy!"

In high school, Taylor's school had a week during which students could shadow someone working in their field of interest, but when he said he wanted to be an astrophysicist, "they had no idea what to do with me! But I eventually got connected with a laser laboratory in Oxford, UK." That week he attended a public talk and heard "none other than Jocelyn Bell, who discovered pulsars, which would later become integral to my work!"

STUDENT PERSPECTIVES

Undergraduates at a conference of this size might be overwhelmed, at least at first. According to Dylan Hope, a senior from Cal Poly Pomona who presented research on bow shocks at the poster session, the meeting felt intense—especially as a first-time conference attendee. But Hope said it also revealed future opportunities. "Now that I've given my poster ... I feel a lot more confident about presenting my work."

Piper Lentz, a sophomore from the University of Massachusetts Amherst, presented a poster examining exoplanet orbit and mass fits. "I had high hopes, and the conference has exceeded them so far," she said, adding that the undergraduate mixer taught her about SPS, and she was interested in bringing the resources she learned about back to her campus.

Carlton Passley, a sophomore at Delaware State, participated in the National Radio Astronomical Observatory's (NRAO) National Astronomy Consortium. Passley presented a poster highlighting his work at Princeton University over the summer. His primary goal in pursuing research opportunities? "To broaden my perspective," he said. In preparation for a physics education career, he plans to explore a different research topic next summer to continue improving his skills.

Sophia Lanava, a senior from Bryn Mawr College and her SPS chapter's treasurer, said the meeting was great for those hoping to "connect with professionals in the field" and talk to people about grad school.

ADVICE FROM ASTRONOMERS

Conferences like AAS bring together those with all levels of experience, opening dialogues between institutions and across areas of astronomy research. I asked a handful of astronomy professionals about their paths, and here is what they shared.

"I got a degree in business before I got interested in physics and astronomy," said Lisa Storrie-Lombardi, president and observatory director for Las Cumbres Observatory. "It's never too late to actually change your mind about what you want to do." She also shared that getting hands-on experience can really help with decisions about what to do, especially when it comes to observing or being a theorist. "It doesn't have to be something dramatic," she said. "The earlier you can get that experience, the earlier you know."

Phillip Wiseman, a postdoc at the University of Southampton, had advice for undergraduates. "Enjoy it," he said. "It's easy to get stressed. It's easy to be overwhelmed. Everyone is. I've been a post doc for six and a half years. I still get overwhelmed and stressed. I still get imposter syndrome. My advisors still get imposter syndrome. Once you've accepted that everyone is feeling like an imposter, you can enjoy it."

ABOVE: Author Marie Olivia Sykes (third from left) reunites with summer research colleagues at AAS. Photo courtesy of Michaela Schwab.

Adam Mann, a space and physics reporter, shared this advice for people interested in science communication. "Figure out opportunities to write, whether that's at your school newspaper or taking classes about science communication," he said. "See if you actually like it, and [generally] do what interests you. I believe that nothing goes to waste. You will end up using it one way or another."

Dashon Jones, a graduate student at Rice University, got into undergraduate research by asking his school's only cosmology professor about their research and reading their papers. "If you reach out to people, if you show initiative, they're more than willing to take you," he said.

There was one common thread among all the researchers I spoke with: If you're interested in getting involved with research, go for it. //

ATTEND AAS THIS SUMMER

The 244th Meeting of the American Astronomical Society will take place June 9–13, 2024, in Madison, Wisconsin. For details, see aas.org/meetings/aas244.

Fall 2023 SPS Chapter Awards

Congratulations to the winners of the Fall 2023 SPS Chapter Awards. These awards are made possible in part by generous contributions from Sigma Pi Sigma members. For details on award-winning projects, visit spsnational.org/awards/chapter-awards.

FUTURE FACES OF PHYSICS

Future Faces of Physics Awards are made to SPS chapters to support projects that promote physics and astronomy across cultures and the recruitment and retention of people from groups historically underrepresented in physics.

Brigham Young University
From Quarks to Questions: Presentations for Underrepresented Youth
Levi Hancock (Leader)
Chris Verhaaren (Advisor)

Georgetown University
Physics Long Talk
Cecilia Ochoa (Leader)
Edward Van Keuren (Advisor)

Rhodes College
Egg Drop
Katherine Hazelwood (Leader)
Brent Hoffmeister (Advisor)

Stony Brook University
Peer Mentorship and Physics Café
Rudolf Popper (Leader)
Dominik Schneble (Advisor)

University of Central Florida
Pride in Physics: Nurturing Curiosity, Fostering Inclusivity
Caden Zaccardi (Leader)
Costas Efthimiou (Advisor)

SPS CHAPTER RESEARCH

SPS Chapter Research Awards support local chapter research activities that are imaginative and likely to strengthen the SPS program.

Florida Polytechnic University
Hydrothermal Treatment of Microalgae for Biofuel Production
Anand Dewansingh (Leader)
Sesha Srinivasan (Advisor)

Lawrence Technological University
Swinging Into Science
Alanna Makarchuk (Leader)
George Moschelli (Advisor)

Rhodes College
Putting It Together: Final Assembly and Testing of Custom Satellite Hardware
Jasper Scherz (Leader)
Brent Hoffmeister (Advisor)

San Diego State University
Development of an Acoustic Holography Demonstration
Faith Poutoa (Leader)
Matthew Anderson (Advisor)

University of Tennessee at Chattanooga
A LEGO-Based, Low-Cost Autonomous Scientist: Using Machine Learning to Derive the Henderson-Hasselbalch Equation
Matthew Boone (Leader)
Tatiana Allen (Advisor)

SIGMA PI SIGMA CHAPTER PROJECT

Sigma Pi Sigma Chapter Project Awards support inductions or chapter events that include alumni or expand recognition of the society.

Florida Polytechnic University
Student Induction and Alumni Celebration
Anand Dewansingh (Leader)
Sesha Srinivasan (Advisor)

Rhodes College
Service Award and Induction Banquet
Lauren Boughter (Leader)
Brent Hoffmeister (Advisor)

Saint Joseph's University
Sigma Pi Sigma Induction Ceremony
Nathaniel O (Leader)
Roberto Ramos (Advisor)

University of Central Florida
Sigma Pi Sigma Induction Ceremony
Olivia Bitcon (Leader)
Costas Efthimiou (Advisor)

University of Virginia
Sigma Pi Sigma Luncheon with Lighthouse Instruments
Claire Huchthausen (Leader)
Jency Sundararajan (Advisor)

MARSH W. WHITE

Marsh W. White Awards are made to SPS chapters to support projects that promote interest in physics and astronomy among students and the general public. The award is named in honor of Marsh W. White for his years of service to Sigma Pi Sigma and the community.

Appalachian State University
A Laser-Focused Approach to Optics Outreach
Jess Gerac (Leader)
Brooke Hester (Advisor)

Cleveland State University
Outreach Totality: Eclipse-Based Outreach and Teaching Experience
Patrick Herron (Leader)
Kiril Streletzky (Advisor)

Colorado School of Mines
Continuing Elementary School Engagement in Physics
Austin Crawford (Leader)
Charles Stone (Advisor)

George Washington University
Promoting the Fun of Physics
Amy Georgescu (Leader)
Gary White (Advisor)

Grand Valley State University
Physics in Action: Engaging with Clouds
Zachary Tyler (Leader)
Sofia Karampagia (Advisor)

Mount Holyoke College
Physics Phair
Sasha Toole (Leader)
Spencer Smith (Advisor)

Ohio Wesleyan University
Elementary Outreach
Malcolm Henderson (Leader)
Yunhua Ding (Advisor)

Saint Joseph's University
Where Art and Physics Collide: The Polage
Shayna Sit (Leader)
Roberto Ramos (Advisor)

Stony Brook University
Making Waves: A Hands-On Interference Lab for High School Students
Rudolf Popper (Leader)
Dominik Schneble (Advisor)

University of North Carolina at Chapel Hill
Visualizing Physics
Jasmine Elmrabati (Leader)
Dan Reichart (Advisor)

SIGMA PI SIGMA LEADERSHIP SCHOLARSHIP

The purpose of the Sigma Pi Sigma scholarship program is to support Sigma Pi Sigma members and to encourage the pursuit of high scholarship in physics and astronomy.

Logan Burnett
University of Alabama at Birmingham

Ronja Olsen
Hofstra University

Barkotel Zemenu
Yale University //

GET SUPPORT FOR CHAPTER ACTIVITIES

Have an idea for an event, outreach, or research project and need funding? SPS can help! Applications and advisor sign offs are due November 15.

- **Future Faces of Physics Award: $600 max**
  Supports programs designed to increase the recruitment and retention of people from historically underrepresented groups in physics and astronomy.
- **Marsh W. White Award: $600 max**
  Supports physics and astronomy outreach activities for grades K–12 and the general public.
- **Sigma Pi Sigma Chapter Project Award: $600 max**
  Supports Sigma Pi Sigma inductions or chapter events that include alumni or expand recognition of the society.
- **SPS Chapter Research Award: $2,000 max**
  Supports chapter research on physics and astronomy projects.

For information and award proposal templates, visit spsnational.org/awards/chapter-awards.

the SPS Observer
American Institute of Physics
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SPS Chapter Report

Submission Deadline: June 15

Importance of Chapter Reports

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

Qualify for SPS Recognition:

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

For more information on chapter reports, visit **www.spsnational.org/chapter-reports**.

Has your leadership changed since your last chapter report? Update your contact information with the SPS anytime at **www.spsnational.org/chaptercontacts**.

AIP

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