

Radiations

FALL
2025

The official publication of Sigma Pi Sigma



Filling the
Classroom-
to-Career Gap

Olympic Champion
Edwin Moses Runs
His Own Race

How Physics
Prepares You
for Anything

Finding
Awe in the
Balance



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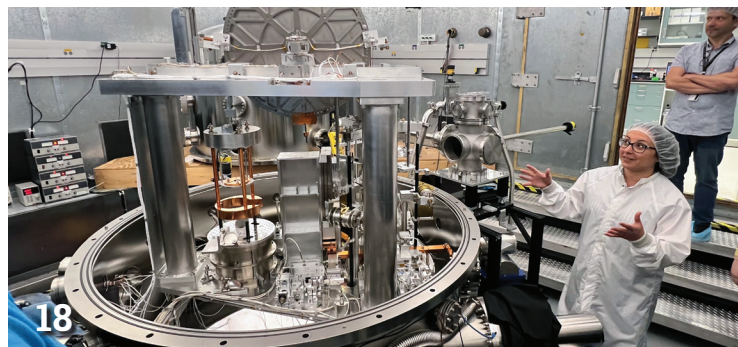
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Drawing on his background in astrophysics and computer science, Ben Lee studies artificial intelligence and new ways to search digital collections held by museums, libraries, and archives. Photo by Shawn Miller.

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STUDENT LEADERSHIP Drives Change

*By John-Ryan C. Lawrence, SPS Associate Zone Councilor for Zone 13 and
SPS Chapter Vice President, Texas A&M University-Kingsville*

Chief among my goals as SPS Associate Zone Councilor for Zone 13, located geographically in the great state of Texas, is to establish clear and durable lines of communication and cooperation between the zone's SPS chapters. I also aim to promote the sharing of information, ideas, philosophies, and operational plans among SPS chapters in all zones.

As an extension of that objective, I hope to expand student engagement not only with SPS itself but also with Member Societies and Affiliates of the American Institute of Physics, home to SPS and Sigma Pi Sigma. Organizations such as the American

Astronomical Society and the American Geophysical Union are among those that offer significant professional opportunities for students. As a benefit of their SPS membership, students receive complimentary membership in two physical science societies. I strongly encourage my colleagues, and all students reading this, to actively participate in both SPS and their selected societies.

My secondary objective is to promote and reignite the spirit of cooperation between SPS and the International Association of Physics Students (IAPS). SPS has historically been active in IAPS; however, during the COVID-19 pandemic, that collaboration fell by the wayside. I have been working for the past year with the SPS office and the IAPS Executive Committee to reestablish and revolutionize that cooperation for the present-day student landscape. This would provide opportunities for SPS members to step up their global engagement and interact with like-minded physics students from around the world.



John-Ryan C. Lawrence

Get Support for Inductions and Chapter Activities

Sigma Pi Sigma Chapter Project Awards of up to \$600 are awarded to chapters to support inductions or other engaging activities that include alums or promote Sigma Pi Sigma on campus or to the public. Learn more at students.aip.org/chapter-project-award.



ABOUT AIP

As a 501(c)(3) non-profit, AIP is a federation that advances the success of our Member Societies and an institute that engages in research and analysis to empower positive change in the physical sciences. The mission of AIP (American Institute of Physics) is to advance, promote, and serve the physical sciences for the benefit of humanity.

Member Societies

Acoustical Society of America
American Association of Physicists in Medicine
American Association of Physics Teachers
American Astronomical Society
ACA: The Structural Science Society
American Meteorological Society
American Physical Society
AVS: Science and Technology of Materials, Interfaces, and Processing
Optica
The Society of Rheology

Other Member Organizations

Sigma Pi Sigma
Society of Physics Students

Connect with Sigma Pi Sigma



LinkedIn
[linkedin.com/groups/142619](https://www.linkedin.com/groups/142619)



Instagram
[instagram.com/spsnational](https://www.instagram.com/spsnational)



AIP
Foundation
foundation.aip.org

In addition to being an associate zone councilor, I also serve as a student ambassador for the American Physical Society, where I work to actively promote the study of physics, and STEM in general, to both my academic colleagues and the greater community. I have taken on other student leadership roles as well, such as my university's Criminal Justice Club President.

My diverse career interests—engineering and criminal justice—represent a subtle rebellion against mainstream academia, which encourages its members, particularly students, to silo themselves into a single topic for their entire careers. I have found that working in both fields simultaneously allows me not only to exercise my academic freedom but also to approach challenges, such as those related to public safety, as both an engineer and an end user. Students have the youthful vigor necessary to operate across boundaries and beyond the walls of siloed fields.

A major issue I have been advocating to resolve relates to what I believe is a fundamental incompatibility between the traditional models of academic career progression and actual career progression in my two areas of study. Both are highly practice-centric fields. The traditional progression of bachelor's degree to master's degree to PhD to faculty appointment, while the gold standard for many natural sciences and social sciences, falls short when applied to the engineering and criminal justice spheres. The current system produces professors who have little to no industry or field experience, yet are responsible for training the next generation of practitioners in the field.

To address this issue at home, I have leveraged my position in student government to advocate for my institution to hire faculty who have real-world industry experience. The majority of students in engineering and criminal justice will enter the workforce upon graduation, and it is incumbent upon schools to tailor their curriculum and instruction toward the needs of these students by hiring faculty who hold academic qualifications and also relevant professional and industry experience.

Students are perpetually the demographic that stands to make the greatest impact on the academic fields and industries they are preparing to join. We have our entire careers ahead of us, and we are in the unique position of having one foot in and one foot out of our respective industries. From this perspective, we can identify dysfunction in systems and industries that might be dismissed by those already embedded in the field and take initiative to effect real change in our organizations, institutions, and industries.

Over my tenure in student leadership, I have come to realize that nearly any challenge I face is almost certainly one a previous student leader faced during their tenure. So I readily encourage student organizations, including SPS, to maintain effective lines of communication with alumni, especially former officers. My message to alumni is this: The best way to support your SPS chapter may come after you walk the stage at graduation. The long-term health of a chapter is tied to its ability to maintain institutional memory. Alumni engagement is critical to sparking and sustaining leadership in every new generation of students that passes through an SPS chapter. •



Be a Resource for SPS Chapters

Join the SPS and Sigma Pi Sigma Alumni Engagement Program—a database of participants willing to be speakers, panelists, tour guides, and mentors for SPS chapters. Visit students.aip.org/alumni/become-a-mentor.

Get Engaged in Science Policy. Here's How to Start.

By Lindsay Milliken, Associate Director of Public Policy Research and Analysis, American Institute of Physics

The Trump administration's actions over the course of this year have sent shock waves through science agencies and the research community in the United States. Federal science funding is being withheld, international students' visas are in jeopardy, and universities are under increasing pressure to comply with government demands. While Congressional majority leaders have appeared reluctant to push back against the White House, recent budget negotiations in the House and Senate show there is interest in mitigating potential harms.

Science advocacy has an important role to play in encouraging lawmakers to protect science programs. But particularly for those with little experience in policy, it is difficult to know where to start. Luckily, there are many resources and organizations that are well positioned to help empower scientists interested in getting involved. Universities and major scientific societies have public affairs offices that advocate on behalf of their communities, and these offices can better target their efforts if they know how federal actions are affecting individuals. You can also reach out to lawmakers on your own. Whether you are participating in a grassroots campaign or approaching your lawmaker directly, there are a few simple steps to jumpstarting engagement with congressional staff.

1. Know the Details

To be an effective advocate and resource for lawmakers' staff, you must understand the policy landscape of your issue. You are well positioned to make an impact when you can answer the following questions.

- Which government agencies fund your research? Which agencies enact policies that impact your field?
- Which members of the US Congress represent your institution and place of residence in the Senate and House? (Not sure? Check out [congress.gov/members/find-your-member](https://www.congress.gov/members/find-your-member) to find out.) What are your members' priorities? Have they spoken on record about the issue?
- What are the most recent news stories about your issue? How they are relevant to your members' districts or states?



Lindsay Milliken.

Scientists active in policy often use their membership in professional associations such as the American Association for the Advancement of Science (AAAS), the American Physical Society (APS), the American Astronomical Society (AAS), and the Institute of Electrical and Electronics Engineers (IEEE) to track the latest developments in Congress. These organizations' public affairs and government relations websites will often have information about their activities, advocacy priorities, and information about how to get involved. In many cases, they can also guide and coordinate grassroots actions such as by leading letter-writing campaigns, advising on how to craft an effective message, and organizing visits to the offices of members of Congress. Other rich sources of information include science policy news outlets like *FYI* from AIP, *ScienceInsider* from *Science* magazine, and *Nature*, and community-building organizations like the National Science Policy Network (NSPN). Lastly, along with local and national news outlets, members' websites and the congressional science committees also provide a lot of information about current legislative priorities.

2. Kickstart Connection

Don't be afraid to simply reach out to your local members' offices to request a meeting to discuss your issue. Keep in mind that staffers are busy and must juggle portfolios of many policy issues which often do not overlap. They also receive dozens of emails every day from constituents asking for their help or attention. For this reason, it is best to be direct, polite, and concise in your emails, and don't be afraid to email a staffer a second time if they have not responded. In your meeting, include details on the practical impact of your research and how it benefits the local community. Use personal stories and a few key data points to quickly establish context for your issue to the staffers. In selling the importance of your research, never suggest that someone else's research should be deprioritized.

3. Keep It Going

You should position yourself as a key resource on your issue and aim to make it as easy as possible for the staffer to understand its importance. Promptly follow up your meeting with helpful resources, such as relevant reports, news articles, and easily understandable data. Find reasons to keep in touch roughly every month. Send the staffer new research findings, upcoming events, or relevant news articles and identify any opportunities for them to get more involved in supporting your issue.

With these three simple steps, you can start building productive relationships with lawmakers' staff and elevate the importance of the physical sciences in the US. •

MEET RON KUMON,

the Newly Elected President of the Society of Physics Students

Please join us in welcoming the new SPS president, Ron Kumon!

Kumon is an associate professor of physics at Kettering University in Michigan, where he's been the SPS and Sigma Pi Sigma advisor for the past 14 years. During that time, his chapter has received 14 Outstanding Chapter Awards, ten Distinguished Chapter Awards, two Chapter Research



Ron Kumon.

Awards, and a Blake Lilly Award. Kumon previously served for six years as the zone councilor for Zone 7, during which he facilitated many zone meetings, started a zone website, established a student zone council, and chaired the SPS Council Governance Committee.

As president, Kumon plans to study how to further improve the value that SPS provides to its members, build connections with SPS alumni and encourage local chapters to do the same, and advocate for the future of the fields. "We all need to work collectively to advocate for strong support for physics and astronomy programs so that students can continue to achieve their graduate school and career goals," he says.

Kumon received his BS in physics and mathematics from Michigan State University and a PhD in physics from The University of Texas at Austin. His research interests are broadly themed around biomedical ultrasound, optical microscopy, and nondestructive evaluation of materials. He listens to jazz in his spare time and is a licensed amateur radio operator. •

Stay Up-to-Date on Science Policy

- *FYI*, aip.org/fyi
- *ScienceInsider*, science.org/news/scienceinsider
- *Nature*, nature.com
- National Science Policy Network, scipolnetwork.org
- Congressional Science Committees, aip.org/fyi/congress-fills-out-leadership-of-science-committee
- APS Science Policy and Advocacy, aps.org/initiatives/advocate-amplify/policy
- AAS Policy Blog, aas.org/advocacy/policy-blog

SPS & Sigma Pi Sigma Memories: Your Favorite Moments

Compiled by Rianna Ehrenreich, SPS and Sigma Pi Sigma Programs Engagement Associate

What is your favorite memory from your SPS and Sigma Pi Sigma days? *Radiations* asked, and you answered. Take a walk down memory lane as you read these reflections, and share your own with us at sigmapisigma@aip.org. Some responses have been lightly edited for length and clarity.

"My favorite memories are of an outreach program we ran yearly around Halloween called Spooky Science Day. We would dress up in costumes and do physics demos for kids in the community (and give out candy, of course)."

- Aidan Bachmann, inducted at the University of Rochester in 2023

"We went to Denver for the 2019 APS meetings. The plenary talks were amazing, and going out to restaurants with the SPS club was so fun. But the best was attending a talk on the mass of the neutrino given by my oldest daughter, Sereres Johnston, who was doing postdoc work at Argonne National Laboratory at the time. Not many undergrad physics students have a PhD daughter trailblazing for them. Later, in 2022, I received my BS in physics alongside my youngest daughter, Lisa Johnston, who was graduating with degrees in physics and math.

We are a family who loves SPS and AIP for sure!"

- Dana Johnston, inducted at Andrews University in 2016

"My favorite memory has to be putting on planetarium shows for the community during the total solar eclipse we had here in Ohio. We had four sold-out shows, each seating around 150! People of all ages and backgrounds came together and were united by an interest in physics. Being part of the planning and execution of that event will forever hold a big place in my heart."

- Ashley Zelina, inducted at Kent State University in 2024

"Mine is playing Risk at Brookhaven National Laboratory."

- Dan Shirkey, inducted at Clarkson University in 1978

"Mine is helping organize our chapter's annual Sigma Pi Sigma Undergraduate Research Symposium. Attendance was great, and there were great talks and posters."

- Anran Zhao, inducted at the University of Virginia in 2024 •

SPS Summer Internship Adds New Host Sites in 2025

by Mikayla Cleaver, SPS Programs Coordinator

The SPS Internship Program started in 1999 with a single intern. Over the years, the number of interns—and the variety of positions offered—has steadily grown. SPS now brings around 15 undergraduate interns to Washington, DC, every summer, with placements in science outreach, history, policy, writing, and research at various organizations, labs, and agencies. SPS administers the program, hosts joint orientation and concluding sessions, and holds many professional development and community-building activities throughout the season.

In addition to placing interns with returning hosts—the American Institute of Physics (AIP, home to Sigma Pi Sigma), the American Association of Physics Teachers, the American Physical Society, the National Institute of Standards and Technology (NIST), and the Space Telescope Science Institute—this summer's program included internship positions with five new hosts!

American Astronomical Society

Position: TEAM-UP Together Intern

The American Astronomical Society (AAS) is an international organization of professional astronomers, astronomy educators, and amateur astronomers. AAS is a key partner in TEAM-UP Together, an initiative by several professional societies (including SPS) to drive systemic change in the physical sciences community and improve graduation outcomes, including among African American students. This summer an SPS intern worked to ensure that undergraduate students, especially those in the target group of the TEAM-UP Together program, are aware of and can benefit from TEAM-UP Together resources.

Lawrence Livermore National Laboratory

Position: AI Laboratory Guide for Physics with Smartphones Intern

Over the past five years, Lawrence Livermore National Laboratory (LLNL) in California has developed a curriculum that leverages smartphone technology for physics education in high school and college labs. The next phase of this initiative aims to integrate recent advances in artificial intelligence (AI) with mobile sensor technology. This summer an SPS intern worked remotely from Washington, DC, (and a few days from Livermore, California!) to create a platform that guides students through an array of experiments while providing real-time feedback and enhancing critical thinking.

National Science Board

Position: AIP Mather Public Policy Intern

The National Science Board (NSB) is the governing body of the US National Science Foundation and serves as an advisor to Congress and the president. This summer an AIP Mather Policy intern contributed to the day-to-day policy work at NSB, as well as longer-term, policy-focused projects. The intern also supported NSB meetings, attended policy events on Capitol Hill, and gained experience in broad, federal-level science and technology policy.

United States Department of Defense

Position: Office of Cost Assessment and Program Evaluation (CAPE) Intern

CAPE, the Office of Cost Assessment and Program Evaluation, is charged with providing senior leaders in the Department



SPS summer intern Kevin Siaw at the United States Geological Survey. Photo by Siaw.

of Defense (DOD) with independent, unbiased, and fact-based decision support. This summer an SPS CAPE intern worked at the Pentagon, supporting the DOD's Space and Intelligence (SPIN) Division by analyzing program and budget data. The intern gathered and analyzed data from open sources and government-owned data sets related to topics of strategic interest, such as the balance of commercial and government space assets and the lifecycle costs and utility of different systems.

United States Geological Survey

Position: Research Intern

The United States Geological Survey (USGS) is a federal science agency that collects and analyzes earth, water, biological, and mapping data. This summer an SPS intern joined a research team developing and applying petrographic thermal indices. Measuring the fluorescence color of sedimentary organic matter can be a proxy for thermal maturity, which is helpful for predicting the locations of hydrocarbon resource volumes and petroleum system properties and for calibrating burial history models. The intern assisted in microscope data collection, data analysis, and interpretation in the context of developing this new standard test method. •

Interested in Learning More?

Visit the YouTube channel @PhysicsStudentsAIP to see the 2025 Summer interns give their final presentations or check out their online journals at students.aip.org/internships.

2025 Individual Award and Scholarship Recipients

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

Scholarships

Scholarships of \$2,500 to \$6,000 are given by SPS and Sigma Pi Sigma each year to individuals showing excellence in academics, SPS participation, and additional criteria. Learn more about the scholarships and recipients at students.aip.org/awards.

SPS Jocelyn Bell Burnell Outstanding Leadership Scholarship

Abra Geiger
Cornell University

SPS Leadership Scholarships

Peter Bendel
University of Wisconsin - River Falls

Edward Berman
Northeastern University

August Childress
University of Central Arkansas

Samantha Kelchen
Coe College

Gyeongmin Kim
Carnegie Mellon University

Catherine Prabish
Rhodes College

Sigma Pi Sigma Leadership Scholarship

Ruth Willet
Pennsylvania State University

AWIS Kirsten R. Lorentzen Award

Sponsored by the Association for Women in Science

Valentina Villalobos
University of North Florida

Aysen Tunca Memorial Scholarship

Katherine Hazelwood
Rhodes College

Herbert Levy Memorial Scholarship

Sanket Jadhav
California Lutheran University

Anneke Van Regenmorter
University of Utah

LLNL-AIP Leadership Scholarships

Sponsored by Lawrence Livermore National Laboratory

Larom Segev
Harvard University

Luke Xia
University of California, Irvine

Peggy Dixon Two-Year Scholarship

Olivia Tamer
Green River College

SPS Future Teacher Scholarship

Rosie Durland
Utah Valley University

SPS and AAPT Mary Beth Monroe Memorial Scholarship

Larra Fouch
East Tennessee State University

SPS-Google Scholarships

Sponsored by Google

Joseph Fogt
Hope College

Levi Hancock
Brigham Young University

John Hargy
Southern Adventist University

Jahzeel Martinez
Drexel University

Sunny Rasmussen
University of Utah

SPS Award for Outstanding Undergraduate Research

These awards are made to individuals for outstanding research conducted as an undergraduate. Winners are awarded \$2,000 to present their research at an AIP Member Society meeting and receive \$500 for themselves and \$500 for their SPS chapter. Learn more at students.aip.org/sps-award-for-outstanding-undergraduate-research.

Katarina Matic
University of San Diego

Rohit Raj
Juniata College

Apply for SPS Chapter Awards!

Applications are due Nov. 17.

Future Faces of Physics Awards of up to \$600 support projects that promote physics and astronomy across cultures.

Marsh W. White Awards of up to \$600 support projects that promote interest in physics and astronomy.

SPS Chapter Research Awards of up to \$2,000 support imaginative chapter research activities likely to strengthen the chapter.

Sigma Pi Sigma Chapter Awards of up to \$600 support local or regional chapter inductions and events that build community or promote awareness of the society.

students.aip.org/awards

2025 SPS Summer Interns

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. Learn more at students.aip.org/internships/program-details.

James Addison III

Lamar University
SPS Careers Toolbox Intern

Maia Chandler

Swarthmore College
AIP Physics Today Science Writing Intern

Riley Christopher

Davidson College
Lawrence Livermore National Laboratory AI Laboratory Guide for Physics with Smartphones Intern

JJ (John) DeFeo

Michigan State University
AIP Mather Policy Intern - National Institute of Standards and Technology (NIST)

Rosie Durland

Utah Valley University
American Physical Society STEP UP Intern

MJ (Mia) Keller

University of Rochester
Space Telescope Science Institute Research Intern

Saniya Leslie

Georgia State University
American Astronomical Society and TEAM-UP Together Research Intern

Jenna Mastropolo

High Point University
AIP FYI Science Policy News Intern

Grace Nehring

Rhodes College
AIP Mather Policy Intern - NIST

Sunny Rasmussen

University of Utah
Department of Defense Office of Cost Assessment and Program Evaluation Intern

Kavin Siaw

Brigham Young University - Idaho
United States Geological Survey Research Intern

Kalen Stefanick

Simpson College
AIP Niels Bohr Library & Archives / Center for History of Physics Intern

Naomi Wagner

Oglethorpe University
American Association of Physics Teachers / SPS SOCK Intern

Zhane Yamin

University of Michigan
AIP Mather Policy Intern - National Science Board •



The 2025 SPS Summer interns and staff. Photo by AIP.

How a Sigma Pi Sigma Workshop REIGNITED MY PHYSICS JOURNEY

by Jolene Duso, Systems Engineer, VIM Technologies, inducted into Sigma Pi Sigma at Siena College in 2018

When I registered for the Sigma Pi Sigma alumni professional development workshop, I expected to network and discuss challenges revolving around the current STEM job market. What I discovered instead was a transformative space bursting with opportunities to reflect on my connection to the field and inspiring me to leap into exploring who I am as a systems engineer with a physics degree.

The workshop focused on professional development and life after a BS in physics and generated exactly the kind of honest, practical dialogue that physics graduates desperately need. It also showed us, as SPS alums, how to access helpful resources. Physics students often emerge from undergraduate programs with deep theoretical knowledge but a limited understanding of how their skills translate to diverse career paths. This workshop offered a way for us to address our experience gaps and consider the question, How can we use our skills—and physicists have many—to create financial security in any socioeconomic or political atmosphere?

In today's economic landscape, undergraduate physics students and alums may find some uncertainty in the job market. One might pose the question, Does a physics degree equip you with the skills to progress even in a recession? I urge you to accept where you are now but to also envision where you'd like to be professionally, then work toward that goal regardless of the market. Since that is easier said than done, it is important for us alums to share our stories with current students and ignite conversations about traversing the job market.

My path after graduating was rocky. I took the first job I could secure, which was about eight months after graduating, as a high school physics teacher. Teaching was not my dream job. I cut my teeth at an all-boys school and was only a few years older than some of my students. The experience was rough but taught me the importance of vision, especially during the always-draining parent-teacher conferences, and patience. I needed the support of mentors, such as my undergraduate academic advisors, and chats with other recent physics graduates as I continued looking for the right fit.

It took me two more years to land something more closely aligned with how I saw myself—an engineer. That first engineering job came in the form of third shift at a radiopharmacy. From there I spent as much of my time learning as I could, and I eventually landed in systems engineering, where I happily am today.

We need to share the stories, even the tough ones, of how we got to where we truly want to be. We need to talk about the real job market experiences of physics graduates, among ourselves and with physics students. Job posting sites and networking conferences may not accurately provide these perspectives, and it is incredible that SPS is tackling this head-on by reaching out to alums.

There are many fields looking for the skills that physics graduates have, but it takes alums giving back to their local chapters via seminars and SPS meeting visits to provide the fresh outside perspectives necessary to keep the flame of the next generation alive. By offering both strategic career guidance and genuine personal connections, we are capable of imparting significant change.

Perhaps the most significant outcome of my workshop experience was discovering that my path is leading me toward medical physics. The intersection of physics principles and medicine has always intrigued me, and participating in the workshop crystallized how my systems engineering background could serve the world in ways I hadn't anticipated. This realization was profound, demonstrating how exposure and community can foster meaningful and life-changing conversations. •



Jolene Duso.



Getting Involved is Easy!

Are you interested in becoming more active as a Sigma Pi Sigma alumni and being the first to hear about these opportunities? Make sure your email is up-to-date by filing out this form!

by James Addison III, 2025 SPS
Careers Toolbox Intern and SPS
Member, Lamar University

FEATURE

When I graduated high school, I wanted nothing more than to be a mechanical engineer. I wanted to design and work on aircraft and maybe even find a job in motorsports. But as I began the spring semester of my first year of college, I found myself questioning my plan. It wasn't the coursework itself that was the problem—it was the unknown. I began to waver. I was disappointed by the lack of guidance on what an engineering career truly involves. I had a hard time just trying to get in contact with my advisor, let alone arranging an in-person meeting to discuss feeling lost and uncertain.

At that moment in my life, I truly began to feel unseen—like just another piece of paper in the eyes of my advisors. So I decided to look at other majors. I wanted to find a home where I could get the challenge of an engineering degree but also feel wanted and valued. My heart leaned toward physics, so I met with the physics advisor and made the switch to becoming a full-fledged physics major. This was one of the best decisions I ever made. I found warmth and growth and care in the physics department, and most of all, I felt seen as a student.

I fell in love with physics. What really interested me was using math to solve problems. Eventually, I found myself wanting to seek out an internship or do research. I looked high and low for opportunities. Thankfully, after many rejections, I found success in the Lamar University Summer Undergraduate Research Fellowship program, also known as SURF. Winning this would allow me to conduct research during the summer of 2025 on a topic of my choosing. Right around that time, a spot in physics education research opened up in the department. Hoping to have a career in the field, I gladly took it and found fun and a nice flow doing education-related work.



James Addison.

Filling the Classroom- to-Career GAP

Shortly after I started, my research professors recommended that I apply for an SPS summer internship. I had no clue whether I would be selected or if the proposal I submitted for my SURF research topic would be approved, but I had faith. In the end, my SPS internship application and my SURF research proposal were approved—so I did both.

At SPS I served as the Careers Toolbox Intern. The toolbox is a resource hub created by SPS to guide undergraduates and early career physicists through career exploration and preparation. My main job was to modernize the toolbox so it meets students' needs in the evolving job market. Currently, its static PDF format limits its ability to reach the audience that needs it most. I helped move the toolbox toward an internet-based platform that anyone can use at any stage of their career to search for exactly what they need and leave feeling accomplished and confident.

The toolbox fills the gap I experienced before switching to physics, when I felt unseen and clueless about how to translate classwork into career traction. Now I have the power to help physics students combat that uncertainty by giving them access

to a resource that replaces that confusion with confidence. My wish is for the toolbox to become a central hub for those in need of career help—one they can use as their guide when they're lost in the sauce of today's job and grad school market.

This work has given me a new point of view on a career in physics education. I've discovered a passion for student career development and feel as if I've been given a once-in-a-lifetime opportunity to meet amazing people, including my wonderful mentor and the director of SPS, Alejandro de la Puente. In the future I hope to find my footing in the field of physics education and attain not just a job but work I am truly passionate about. •

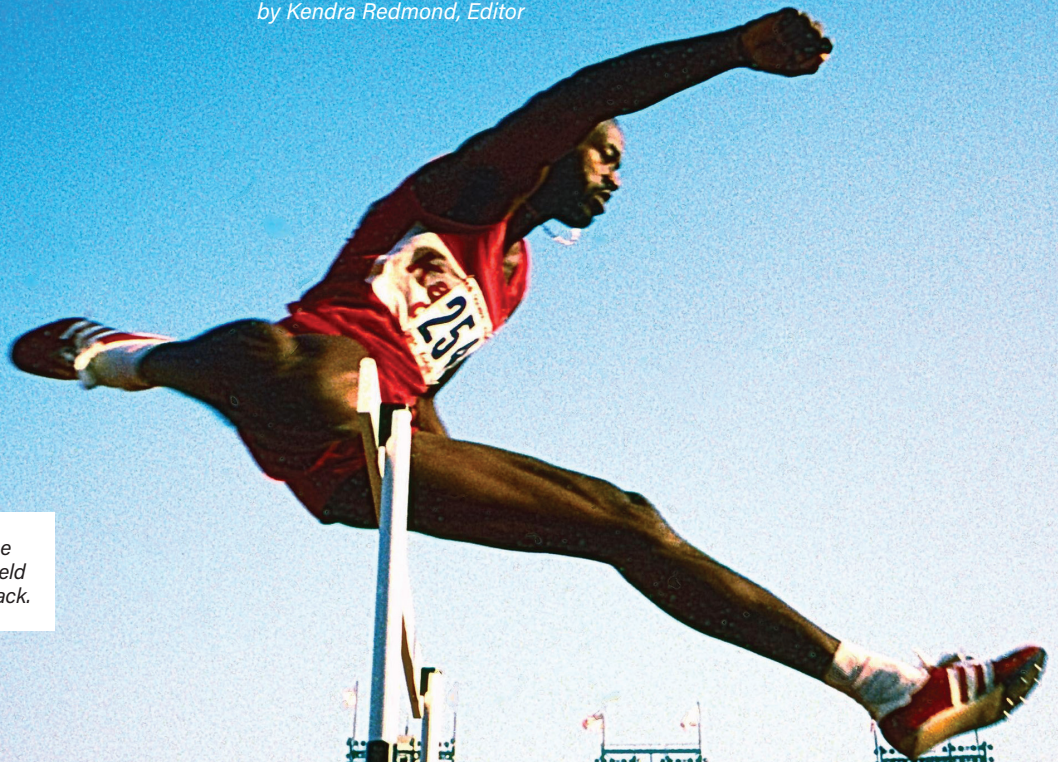
The SPS Careers Toolbox

The Careers Toolbox offers interactive career-planning worksheets, resume-building guidance, interviewing tips, and more—all with physics students in mind. Download the toolbox at students.aip.org/plan-your-future, and keep an eye out for an online version coming soon!

Olympic Champion **EDWIN MOSES** *Runs His Own Race*

by Kendra Redmond, Editor

Edwin Moses competes at the 1984 US Olympic track and field team trials. Photo by PCN Black.





Edwin Moses stands atop the podium after setting a new world record in the 400-meter hurdles at the 1976 Olympics in Montreal, Canada. Michael Lyle Shine won silver for team USA and Yevgeni Gavrilenko won bronze for the Soviet Union. Photo by KPA/ZUMA Press. Copyright (©) 1976 by KPA.



In May 1976, physics major Edwin Moses met with Hugh Gloster, the president of Morehouse College. The school's track team—already on the chopping block—needed \$3,000 to send Moses and a volunteer coach to the national championship and Olympic trials in the 400-meter hurdles. It was a race Moses had run just three times, but he had the fastest time in the world.

"Do you really think you're going to win a gold medal?" asked Gloster, who knew very little about track.

"Dr. Gloster, by the time I get to the Olympic Games, I'll be able to break the world record and win the gold medal," Moses responded, detailing his meticulous training plan.

He must have been convincing; he left the office with \$3,000. And, true to his word, he returned as an Olympic champion who held the world record.

Some might call Moses headstrong—a quality that he accepts and credits for much of his success in running and in physics.

As a kid, Moses enjoyed reading his father's anatomy and biochemistry books, along with the Encyclopedia Britannica. He fell in love with science and took as many math and science classes as he could in school. Especially chemistry.

"I was brilliant in chemistry. I took two years in high school and organic chemistry before I got to college," Moses says. The professor from Central State who taught Moses in a summer organic chemistry class had to create an advanced lab just for Moses and a classmate. Bored at the pace of the class, they had started making their version of bang snap fireworks and putting them on toilet seats and doorknobs as pranks. "Everything was out of control," Moses laughs. "He had to take us and put us in a whole different lab, give us other stuff to do that was matching our aptitude."

At the same time, Moses developed a love for running the 400-meter race and high hurdles in track. He was good, but not great, he says. Still awaiting a growth spurt, he won events at some major meets but didn't garner enough attention to secure a college scholarship.

Moses entered Morehouse College as a chemistry major and walked on to the track team. With little money and no track of their own, the team trained on another school's concrete track, repeating the same drills over and over again. Moses had finally started growing, and the repetitive stress was too much for his legs. He told the coach he couldn't do the drills—and was booted from the team.

"But he couldn't kick me off the track because the track belonged to another school, and I could go there anytime I wanted," Moses says. "And so I just kept training and running, doing what I did." When the team went to the track, so would he.

Moses created his own training plan, recording detailed notes about each run and analyzing them later. He dug deep into the science of running, nutrition, and stretching on his own. And he kept



Edwin Moses shares his story with physics and astronomy undergraduates during the 2024 TEAM-UP Together Student Experience Conference. Photo by AIP.

improving. The coach eventually noticed and began to enter Moses in meets. Still, Moses took direction only from himself.

Moses's tendency to do things his own way also caught up with him academically. He and a professor went head-to-head—not on the answers to chemistry questions but on how to *do* chemistry. "I was doing it right and getting the right answers, but he didn't like my methodology," Moses says. Pulling rank, the professor lowered Moses's grade. In response, Moses switched to physics.

Managing the most difficult major at Morehouse and competitive running was challenging.

By Moses's second year at Morehouse, the track coach quit. Practice

started at 4 p.m., but the team's first task was to find an open track. "We'd send out scouts to see if there was a track [free], and they would find a pay phone to call back to the track office and tell us whether the track was open or closed." Often, the team didn't even get to a track until 5 p.m. Moses's physics classmates had already studied for a couple of hours, relaxed, and had dinner by the time he was ready to hit the books.

"It was tough, but I was focused. I didn't do fraternities. I didn't do any of the clubs. I didn't have time to hang out. I always had a backpack with books in it," he says. "I'd stay up till two in the morning every night, and then get up at six to go run. I'd take naps during the day."

The track team eventually recruited a volunteer coach named Lloyd Jackson. He'd run track but wasn't really a "coach." Still, he was enthusiastic and committed to the team, and he counted as a chaperone. "We had to have someone who could rent cars," Moses recalls.

He didn't set out to run the 400-meter hurdles, but in the fall of 1975, Jackson suggested Moses try it at the Southern Intercollegiate Athletic Conference track tournament. In honor of his hero, John Akii-Bua of Uganda, the 1972 Olympic gold medalist in the 400-meter hurdles, Moses agreed to give it a shot.

"I ran a time of 50.1 seconds, which was a world-class time," he says.

In less than a minute, he'd gone from an unknown in the event to an Olympic trial qualifier. It was a goal he'd never considered before in a race he'd never run before. He qualified in two other events as well, but decided to focus on the hurdles.

With a singular focus, he trained. And trained. By the time he reached the games in Montreal, Moses was ready.

"The whole thing was really choreographed," he says. "I knew exactly what I was doing. I knew the training regimen. I knew how to rest and save my energy." For six months he'd prepared for exactly what to do when the gun went off on July 25th, 1976, at 5:30 p.m., the Olympic finals.

The next 47.63 seconds changed the entire trajectory of Moses's life. By 5:31 p.m., he was an Olympic champion with a world record.

"That came from going to a school like Morehouse College," he says. The historically Black college had around 1,100 students at the time, and its supportive, collaborative environment made all the difference for Moses. "The energy level that we had in the level of academics, preparation, nurturing, being around professors that really care . . . You [didn't] have to struggle and fight," he says. It was a community in which he could really focus.

When he arrived back at school that fall, the track team wasn't on the chopping block anymore.

Moses continued competing—and winning—while at Morehouse, graduating with a BS in physics. He became a test engineer at General Dynamics after graduation, then took a leave of absence to prepare for the 1980 Olympics. By then he'd broken his own world record twice and was running at his absolute best.

In January of 1980, however, President Jimmy Carter announced that the United States would boycott the Moscow Olympics in response to the Soviet Union's invasion of Afghanistan. It was crushing news, but Moses continued training, running the European circuit, and supporting himself through endorsements. He didn't watch the 1980 Olympics but went on to beat the winners of his event in subsequent races. The US Olympic team later received Congressional Gold Medals for their sacrifice.

Moses took gold again at the Los Angeles Olympics in 1984, basing his training program on years of personal data and analysis—scientific methodology, he says. No one else was using logbooks yet, but he noted the details of each training run: weather, wind, track dimensions, heart rate, distance. "I've run 27,000 miles in my life, enough to go around the equator, all of it logged," he says. When he got a computer, he turned the data into spreadsheets and graphs to maximize his training, in addition to pioneering the use of electronic monitors, ice baths, and other innovative techniques now widespread in the world of professional athletes.

For this bottom-up approach, Moses credits his experience at Morehouse. The classes used grad school textbooks, he recalls. The students had to do everything with a slide rule and pencil and paper and keep equations, formulas, and identities in their heads. No multiple choice, no shortcuts. "It was an exercise in how to be excellent," Moses says. "We were pre-

pared that way, the old-fashioned way."

Between August 1977 and June 1987, Moses won 122 consecutive races—a record-breaking winning streak spanning nine years, nine months, and nine days. In 1988, Moses returned to the Olympics for the last time, winning bronze in Seoul, South Korea, despite beating his previous Olympic times. It was one of the rare occasions when runners edged by him in the 400-meter hurdles.

"I loved running, loved the training process, loved the piece where you're just improving little by little. And it's measurable. You can measure everything," he says. "I wasn't afraid to train. And so I was the one who went to the top."

Although he holds physics close, Moses never returned to General Dynamics or work in STEM. After retiring from professional running, he earned an MBA and spent a few years working for an investment firm. However, he has spent most of his career working with organizations, think tanks, and foundations to improve sports and improve the world through sports. He's received an honorary doctorate and countless national and international awards and honors.

Moses is a writer, speaker, advocate, diplomat, and chair emeritus of the US Anti-Doping Agency, which he helped start. He's also the founding chair of the Laureus World Sports Academy, a philanthropic organization supporting programs all over the world that use sports as a tool for social change. Morehouse now has a track named for Moses, and he's an active member of the campus community. In 2024 he was a keynote speaker at the American Institute of Physics TEAM-UP Together Student Experience Conference.

"Those kinds of things are more important to me than the medals. At the end of the day, I never even think about the medals," he says. "That was my job. That's not who I am." •

Finding Awe IN THE Balance

by Trevor Owens, Chief Research Officer, AIP*

Photo 1. Credit: Trevor Owens. You can view this photo in the AIP's Visual Archives at <https://repository.aip.org/dr-darine-haddad-shows-nist-4-kibble-balance>.

In those wonderful moments when I run into friends and we have the opportunity to catch up, we often engage in the time-honored tradition of sharing photos on our phones. When it's my turn to scroll, chances are you'll see shamelessly touristy photos of my wife and I kayaking through the canals of Gdansk or shots of our rescue dog Iggy. Recently, I've added a new series into this highlight reel of my life: two photos I took on a tour of the National Institute of Standards and Technology (NIST).

I've long heard tales of the incredible work that takes place at NIST in Gaithersburg, Maryland, but it was only recently that I saw this work for myself. The entire tour was fascinating, but my encounter with the NIST-4 Kibble Balance is the thing I can't stop thinking about. So let's get to the photos.

In photo 1, Darine Haddad, a researcher in NIST's Fundamental Electrical Measurements Group, invites us to observe the elaborate balance for measuring mass.

The hulking assortment of shining gears, tubes, and rivets sits atop tons of concrete in a room-size Faraday cage. The driving concept behind the design is that to measure mass using unchanging fundamental constants, you ultimately want to do so through mass-energy equivalence. It turns out that the most precise way to measure mass requires using fundamental lessons about the quantum properties of individual photons.

In photo 2, Haddad shows us a green foam wedge that slopes from one side to the other and has a bit of a bulge in the middle. The wedge is a three-dimensional model of the warping of space-time *in that room*.

A gravimeter on the other side of the room continuously measures the acceleration of gravity within that space. Most people tend to think of gravity as effectively constant, or at least consistent in a specific location. But, of course, at the scales and in the contexts in which physicists and astronomers concern themselves, that is of-

ten not the case. When you build a device that can measure a 1-kg mass to within two-millionths of 1 percent, variances in gravity at a given moment in time—for example, from shifts in the earth's tides—need to be considered. The scales of this balance shift and tip with the slightest movement of the massive things around us, including the moon.

Standing there, I acutely felt myself on the sphere of the world in relation to the moon. Everything felt a little smaller and closer together as several fundamental physics concepts converged in this space, part of what it takes to make very precise measurements.

But the gravimeter is not in the exact location where the balance registers its measurements. This is where the green wedge comes in. To translate a gravity measurement on one side of the room into what is happening at that moment a few feet away, inside the balance, you have to model how space-time is warped in that room.

The room is mostly underground. As I understand it, the low end of that wedge is low because the wall that Haddad is facing has soil on the other side. In contrast, the wall behind her backs up to other work spaces. The different materials affect gravity in ways visualized using the green wedge model. The visible bulge illustrates the effect of the powerful 1-ton magnet that operates inside the balance, which is also warping space-time.

When I heard this, the hairs on the back of my neck stood on end, not dissimilar from when I stared down the epochs etched into the walls of the Grand Canyon. Who knew something like this was waiting for me in an office park in Gaithersburg, Maryland? This massive mechanism right out of a steampunk hallucination can weigh a gram at levels so precise that it requires, and makes visceral, an understanding of the warping of space and time by gravity and electromagnetism. This device is only possible because of advances in our understanding of quantum mechanics and Planck's constant. The balance is itself the result of a dialog between breakthroughs in the physical sciences going back centuries.

This specific device played a role in that history. Proposed by British physicist Bryan Kibble in 1975, the Kibble balance made possible the 2019 transition to defining the kilogram with universal constants instead of a physical artifact.

None of this was fated. If scientists like Kibble had not forcefully made the case for this approach, things could have gone in a different direction. Indeed, there was active debate in the scientific literature in the 1990s about how best to replace the artifact-based standard for mass with a fundamental constant. The other leading proposal involved counting every individual atom in a 1-kg sphere of silicon-28. Experiments were run. Papers were presented. Careers were made. Devices were constructed.

This is where I found awe in the balance and why I pull these photos out at



Photo 2. Credit: Trevor Owens. You can view this photo in the AIP's Visual Archives at <https://repository.aip.org/dr-darine-haddad-explaining-nist-4-kibble-balance>.

parties and family events. What I saw was every bit as incredible as the towers at Torres del Paine, or the perfect, regal fur on our little Pomeranian, Wendy.

Haddad, that little green wedge, and the NIST-4 Kibble Balance represent all that is so awe-inspiring about the nature of NIST's quest in metrology. As they work toward increasingly precise methods for measurement, all manner of counterintuitive fundamental breakthroughs in how we understand the universe come into play. The contents of this room gifted me my first direct embodied experience understanding aspects of relativity and quantum mechanics that I had previously understood in more of an abstract, thought-experiment sort of way.

Because not everyone can visit the balance, I wanted to share my experience—and these photos—here with you, along with gifting them to AIP's Emilio Segrè Visual Archives, where they will join some 30,000 other photographs documenting the lives, work, and accomplishments of physical scientists in the 20th and 21st centuries.

This collection of openly available photos, based on an original donation

of Nobel laureate and amateur photographer Emilio Segrè's personal photo collection, has grown through donations from a wide range of scientists and science professionals. A core strength of this collection is its inclusion of both formal and candid photos of physical scientists. If you have photos that speak to your own personal experiences with people, places, and communities in the physical sciences that you would like to consider gifting to this collection, the team at AIP's Niels Bohr Library & Archives would love to hear from you. •

Add Your Photos to the Collection!

To view AIP's Emilio Segrè Visual Archives, which now includes these photos, visit repository.aip.org/emilio-segre-visual-archives-general-collection.

Learn how you can gift photos to the archives at aip.org/library/ex-libris-universum/adding-your-photos-to-the-story-of-science-is-now-easier-than-ever.

How Physics Prepares You FOR ANYTHING

A Q&A with Evgeni Gousev, Senior Director, Qualcomm; Chair, Edge AI Foundation; and Trustee, AIP Foundation

Interview by Kendra Redmond, Editor

What did your career trajectory look like?

I am a physicist by training, and I'm a physicist by heart.

I have a master's degree in applied physics and a PhD in solid-state physics. I took a postdoc in the Laboratory for Surface Modifications at Rutgers University and then became a research professor there. We worked closely with AT&T Bell Laboratories and IBM's T.J. Watson Research Center. IBM offered me a job, and that was my bridge from academia to industry.

At IBM I worked on solid-state problems in microelectronics and transistors. In field-effect transistors, a very thin insulator layer, known as the gate dielectric, separates the semiconductor

from the gate. As devices become smaller, the thickness of the gate dielectrics becomes thinner—we're talking atomic dimensions. Eventually, quantum mechanical tunneling kicks in, and power consumption increases exponentially. We developed high-K dielectric materials to address this problem.

The scale of devices today wouldn't be possible without the breakthroughs we made back in the early 2000s. It gives me great professional satisfaction that almost every person on this planet carries a phone that has at its heart an innovation my team and I developed.

In 2005 I moved to my current company, Qualcomm. I've worked on many projects there: electromechanical devices, optical devices, and human interface devices. Lately, I've been working on artificial intelligence and machine learning. Power efficiency, scalability, and sustainability are big topics of our research.

My heart is in physics, my soul is in technology and innovation, and my passion is making positive impacts by bringing technology to the world. It all started in high school, when I was a kid falling in love with physics.

Was there a particular topic that got you hooked on physics in high school?

We had a small telescope at school that I used to borrow. I don't think it was

technically allowed, but I had a great teacher and she trusted me. I remember being on the roof, watching the planets. The telescope was good enough to see some of Jupiter's rings and satellites. Physics was a lens that allowed me to look at what was happening around me at a deeper level and understand how the world was interconnected.

You've said, "A physics degree prepares you for anything." What do you mean by that?

Physics is the foundation of modern technologies. Degrees in materials, electrical engineering, and computer science tend to be more applied, but a physics degree provides deep depths of knowledge. Physics also gives you the ability to connect the dots in the world, to see how things are linked by physical laws. That helps you learn quickly. And finally, the ability to think critically is really important.

Physicists are trained to solve complex problems, often of an interdisciplinary nature. This skill is becoming increasingly important in today's fast-changing world, especially with the emergence of machine intelligence. I believe that physics and physicists will play important roles in advancing AI, and AI tools will greatly enhance the scientific discovery process.



Evgeni Gousev.

How can physics students and mid-career physicists prepare for jobs outside of academia?

At the macro level, people see barriers between fields. They might see a job in computer science and think it's not for them, a physicist. Yes, the fields are separate, but they're not infinitely separate. They are connected, and people can move between them.

If you'd like to move into data science or machine learning, you already have 90 percent of the skills. You just need to diversify a little and learn some skills specific to that field. First, review job ads and identify what you need to learn. Then bridge that gap through online classes, internships, tutorials, or other resources. Tackle that 10 percent to grow your confidence, diversify your resume, and develop the required skills.

If you're in academia or a government laboratory, collaborate with industry as early and frequently as possible. Find its pulse and identify the problems that need solving. Collaborating will also help you establish contacts that can help with a career change.

Humans often don't make big changes due to insecurities or fear of the unknown. I'm here to say that there are barriers, but it's very possible to cross them, especially if you believe in yourself and your skills. •

DEREK BREHM:

Applying Physics Outside the Field

by Korena Di Roma Howley, Contributing Editor

When Derek Brehm left the Marines to start college, he hadn't yet decided what he should study. Then he began reading popular science books that left him with questions only a physicist could answer. His next step became clear. "Nothing brought my imagination to life like physics," he says.

He studied astrophysics at George Washington University, where he used machine learning to classify celestial objects using early classification algorithms. He then went on to study theoretical physics at Johns Hopkins. "I was not a good theorist," he says. "I had good ideas, but I was slow at making progress."

After three years, Brehm switched to experimental particle physics. Research he conducted at CERN included looking for signatures of theorized particles. He found that the data science techniques involved in analyzing this information was a better fit for him, something a former professor had once predicted. "One piece of advice is to take other people's advice," Brehm says with a smile.

Soon after graduation, Brehm was alerted to an opportunity in the Cost Assessment and Program Evaluation office at the US Department of Defense. Today, he's an operations research analyst for the office, which provides the department with data used to support strategies and draw up budgets. Among Brehm's colleagues are chemists, biologists, economists, and fellow physicists.

The work allows Brehm to use the skills he developed when conducting statistical analysis and designing particle experiments. "I'm still solving problems," he says. "I still do programming and data science. I just analyze different things."

An example case might involve looking at whether the Defense Department's buildings and platforms are resilient in the face of climate change. How, for instance, does the changing salinity of the ocean affect US ships? Based on his findings, Brehm is then tasked with developing a range of possible solutions. "I think about the problems critically, break them down, and consider how I might solve them, step-by-step," he says.

Brehm's division receives new assignments each year, and the promise of fresh topics and analytical techniques appeals to the lifelong learners that most PhDs are, he says. Still, unlike academia, it's an environment that values timely answers over comprehensive ones. As a PhD physicist there's a tendency, Brehm says, to attempt to fully solve a problem by examining every possible detail. Instead, he offers policymakers and government leaders a mostly correct result that might take another 18 months to fully explore.

"You don't have time to search out all the nooks and crannies," he says. "You need to get a close enough answer that will help someone get to two or three possible solutions. The details that are fun and exciting are sometimes not what's needed."

For those interested in work of this kind, Brehm advises first being open to a career outside academia. "There are a lot of opportunities in the private and public sector for a PhD physicist," he says. "You know how to do analysis. You know how to work with machine learning algorithms. Now you can just apply it to something else." •

The views of the interviewee are his own personal views and are not necessarily the views of the Department of Defense or of the United States Government.



Derek Brehm.

Recognizing OUTSTANDING SERVICE

by Kendra Redmond, Editor

Service is one of the four pillars of Sigma Pi Sigma, essential to the fabric of the society. Through Outstanding Service Awards, the SPS and Sigma Pi Sigma Executive Committee recognizes people who have gone above and beyond in their service to the fields of physics and astronomy, the societies, or their members. Recipients are nominated by members for service at the local, regional, or national level.

Beginning in the spring of 2020, the COVID-19 pandemic led to a lull in SPS chapter activities at many schools, as classes moved online and group meetings halted. By the time students could safely return to campuses and clubs, many experienced SPS chapter leaders had already graduated, leaving new students to rebuild and redefine their chapters. The two most recent recipients of SPS Outstanding Service Awards, Landon Boone and Ty Stromberg, carried out that challenge with passion and purpose.

Matthew (Landon) Boone

Nominated by Tatiana Allen, University of TN-Chattanooga

When Landon Boone started at the University of Tennessee at Chattanooga (UTC) in the fall of 2021, he quickly became active in SPS, working with UTC's new SPS advisor, Professor Tatiana Allen, to revive the chapter. During his first semester, Boone coauthored an SPS Chapter Research Award proposal to build a working LEGO model of the Kibble watt balance, based on the balance used by NIST, the National Institute of Standards and Technology, to redefine the kilogram (see page 18). The funding was awarded, and Boone enthusiastically led his peers in the project over the following year. You can read about their efforts on the SPS website at students.aip.org/observer/legos-metrology-and-plancks-constant.

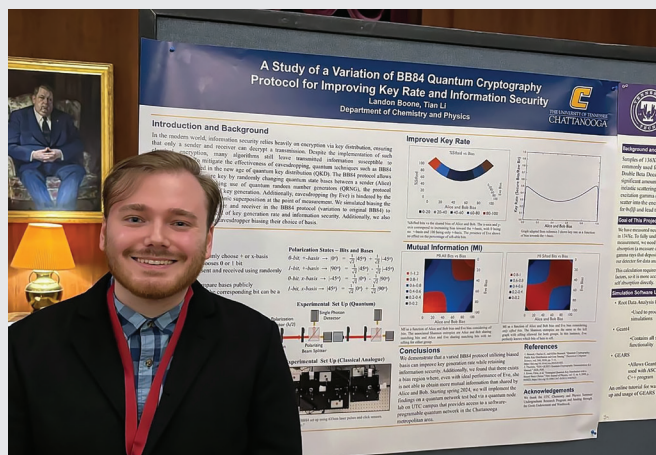
During his time at UTC, Boone also served as vice president and president of his SPS chapter, increasing chapter membership threefold, planning outreach activities, and leading additional SPS research projects. He maintained high academic achievements while also conducting research and presenting at conferences. He was inducted into Sigma Pi Sigma in the fall of 2023.

"I cannot overestimate the impact that Landon has made on the department, the physics program, our SPS chapter, fellow students, and the multitude of people during the physics outreach events," wrote Allen in Boone's nomination letter. "He is a deep and careful thinker and a true intellectual, who loves to inquire."

Boone's citation reads, "For his service to the UTC Chapter of the Society of Physics Students and the Physics Program; for being a true leader who helped revive the Chapter after the COVID

pandemic and played a critical role in making the Chapter a thriving and successful community of students."

This fall Boone will begin graduate school in physics with a concentration in quantum information science and technology at the University of Tennessee at Knoxville.



Landon Boone.

Nominate Someone Today

To nominate a student, faculty member, staff member, or alum for an Outstanding Service Award, please visit students.aip.org/sp-s-outstanding-service-award.

Ty W. Stromberg

Nominated by Lt. Col. Benjamin Roth, United States Air Force Academy

When Cadet Ty Stromberg took charge of the Physics and Astronomy Club at the United States Air Force Academy (USAFA), he didn't just restart the club—he took it to a whole new level. This was on full display in 2023 when, under his leadership, the club hosted more than 800 attendees on the USAFA planetarium grounds for a morning of games, telescopes, information booths, space history, and viewing of a partial solar eclipse. For the April 2024 total solar eclipse, Stromberg again took the lead, helping to organize an intricate data collection initiative involving 25 club members, four data streams, and two states as part of a NASA-funded citizen scientist program.



Ty Stromberg.

During his two years as cadet in charge, Stromberg launched a range of STEM outreach programs—from star parties at the campus observatory to visits to local schools—while also working to reduce attrition in STEM at the Academy and engage his peers in scientific inquiry. At the same time, he conducted research on ground-based satellite observations and space domain awareness, and in 2025, he helped the USAFA Astronomical Research Group and Observatory (ARGO) secure its place as the 2025 USAFA Research Team of the Year.

“His visionary leadership transformed a period of dormancy into a vibrant hub of scientific exploration, inspiring countless cadets and significantly impacting the Academy’s STEM outreach,” wrote Roth in Stromberg’s nomination letter. “Ty has fostered a culture of scientific reasoning and leadership.”

Stromberg’s citation reads, “For his exceptional service in revitalizing the USAFA Physics and Astronomy Club (SPS Chapter), demonstrating visionary leadership, and inspiring widespread scientific engagement”

This fall he will begin a master’s degree in atmospheric sciences at the Air Force Institute of Technology. •

ΣΠΣ BENEFITS

FELLOWSHIP

- Gives access to alumni through your local chapter and the national Sigma Pi Sigma network
- Connects you to SPS chapters around the world with a one-year SPS membership
- A lifetime subscription to *Radiations*, the publication of ΣΠΣ

CAREER DEVELOPMENT

- Provides exclusive networking opportunities with over 80,000 current members
- Invites you to participate in the Physics and Astronomy Congress
- Facilitates leadership and career development workshops and events for both students and professionals
- Amplifies your contributions to the scientific community and to your professional field

SERVICE

- Awards your service to chapters and individuals
- Supports local and global outreach for societal impact
- Enables support for students by helping professionals host internships and provide mentoring
- Enables advocacy for the physical sciences and its communities

LIFELONG CONNECTIONS

- Nurtures a welcoming and empowering physical sciences community
- Forges long-term collaborations and friendships
- Celebrates everyone’s unique journey

Sigma Pi Sigma exists to help students and professionals transform themselves and others into catalysts for empowering communities, unique journeys, and lifelong connections.

students.aip.org/sigma-pi-sigma





The DIGITAL HUMANITIES Expert

by Ben Lee, Assistant Professor, University of Washington Information School

I'm an assistant professor in the Information School at the University of Washington (UW). My research is focused broadly around artificial intelligence (AI) applications and new ways of searching digital collections held by libraries, archives, and museums. I think of my work in the context of digital humanities and computing cultural heritage. It's a very interdisciplinary environment: I do work that is computational in nature while also drawing from the humanities.

Currently, I work with both digitized and born-digital archives, such as the End-of-Term Web Archive. Every four years

there's an effort to crawl certain .gov and .mil domains—such as federal agency websites—to preserve their content for posterity. This results in massive web archives that contain hundreds of millions of PDFs. I'm excited about how we can go beyond basic keyword searches and reimagine the visual content embedded within these documents.

I majored in astrophysics and mathematics with a minor in physics at Harvard College. In addition to coursework, I did research on telescope survey pipelines, addressing questions such as how we identify stars in crowded images like those of globular



Service Archive—an archive that also contains records for my family—using computer vision. It was this project that led me to the computational techniques that I continue to use to this day.

After my fellowship at the Holocaust Museum, I was excited to explore these methods further and started my PhD in computer science at UW. I was fortunate to be an innovator-in-residence at the Library of Congress while working on my dissertation, and I created a project called Newspaper Navigator. Here, I applied a lot of the ideas that I was working on at the Holocaust Museum to a collection of 16 million newspaper pages called *Chronicling America*. The goal was to use machine learning to extract all of the visual culture embedded within these pages, from photographs to maps, and reimagine how people can search the images visually. After defending my PhD, I returned to the Library of Congress for a yearlong fellowship with the Kluge Center. From there I started as a faculty member at UW's Information School.

It's a really exciting time to be in digital humanities. In addition to the long tradition of existing approaches, new methods with AI are changing how we understand our collective cultural heritage. In combining technical and humanistic standpoints, digital humanities is also a perfect place to examine the ethics of AI and datafication. I'm encouraged to see a lot of genuine interest in digital humanities, with so many people doing exciting work in the field.

Physics is a fantastic starting point for thinking about and exploring new ideas and new careers. I actually took no computer science courses during undergrad. My astronomy and physics research and coursework are what led me to the path that I'm on today. Having a background in physics and math has enabled me to grasp coding and machine learning and has paid off enormously. Although the telescope images that I worked on as an undergraduate are ostensibly very different from digitized newspapers or government documents, I'm using what I learned in my time as a physics student every day. Working with telescope survey pipelines—understanding how we handle large volumes of images, how we process them and extract usable information—is not much different from trying to extract useful information from large volumes of archival images in order to make them discoverable.

When it comes to career possibilities, I believe that both curiosity and a willingness to consider different paths can open new doors. Having an interest in history or computer science doesn't mean that physics isn't useful anymore—you can use a little of everything. And it's not just me who feels this way. I've worked with mentors and colleagues across all stages of my career who have seen interdisciplinary thinking and collaboration not just as something to explore, but also as something to embrace. My physics background has allowed me to see things differently, and I'm forever grateful for this! •

clusters, where deblending stars is a challenge. It was through this research that I first became interested in image processing.

In college I took a course on digital humanities, and when I graduated, I spent a year working at the United States Holocaust Memorial Museum on a digital humanities fellowship. My grandmother survived the Auschwitz-Birkenau concentration camp, and spending that year at the Holocaust Museum was deeply meaningful and important for me both personally and professionally. During my time at the museum, I became interested in how we can understand and search archives in new ways. I worked on a project to categorize millions of documents related to victims of Nazism in the International Tracing

The Wonderful and Notorious "TWIN PARADOX" of Special Relativity

by Dwight E. Neuenschwander, Professor Emeritus, Southern Nazarene University

When we first hear of it, the “twin paradox” of special relativity can be a real puzzler, and it can remain unsettling even after one has passed a special relativity course. This article describes the situation that creates the apparent paradox, identifies the implicit but incorrect assumption that makes the paradox seem serious, and offers a resolution.¹ I assume the reader is familiar with a few basic principles of special relativity, including the invariance of the speed of light in a vacuum, spacetime diagrams, proper time, time dilation, and the invariance of the spacetime interval.

I'll borrow a vivid mental picture from Taylor and Wheeler's *Spacetime Physics* by imagining two inertial reference frames: the lab frame that uses coordinates (t, x) , and the coasting rocket frame that employs coordinates (t', x') . Let the coasting rocket frame move with constant velocity v relative to the lab frame. The coasting rocket's world line from event A to some event B, as plotted in the spacetime diagram of the lab frame, is shown in Fig. 1. To record times, arrays of clocks synchronized within each frame are set to read zero at event A, where the origins of both coordinate systems coincide.² It is crucial to realize that the world line AB of the coasting rocket forms the t' -axis of the coasting rocket frame's coordinate system. Because the speed of light c is invariant, $c = \Delta x / \Delta t = \Delta x' / \Delta t'$, it follows that the world line of a light ray emitted from event A lies halfway between the space and time axes when those axes are measured in the same units. In this discussion, time will be measured in years and distances in light-years. Therefore, when we project the rocket's (t', x') axes onto the (t, x) axes, the world line of the light ray is halfway between the t' and the x' axes, and halfway between the t and x axes. Notice that event B in the rocket frame is simultaneous with event C in the lab frame, as shown in Fig. 1. This is so because the line BC is a spacelike interval in the rocket frame—line BC is parallel to the x' -axis in Fig. 1. But for the lab observer, event C is simultaneous with other events, such as event E in the coasting rocket frame.

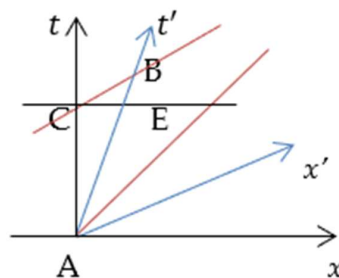


Figure 1. The world line AB of the coasting rocket as mapped in the lab frame's spacetime diagram. The red line that is halfway between the (t, x) and (t', x') axes represents the world line of a beam of light that was emitted from event A. Lines that are parallel to their respective x and x' axes describe spacelike intervals, and events on these lines are simultaneous in their respective frames.

The Paradox—And Its Resolution

A set of twins, Bonnie and Clyde, is born on Earth (the lab frame). They live on Earth for 20 years, at which time Clyde embarks on a journey in his spaceship (the coasting rocket frame) to the star Zeta that, in the Earth's reference frame, is three light-years (3 c-yr) from Earth. Clyde promises to return to Earth as soon as he reaches Zeta and to do so at the same speed as the outbound trip. Suppose this speed is $v = \frac{3}{5}c$ relative to Bonnie. Therefore

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}} = \frac{5}{4}. \quad (1)$$

Let the Earth-lab frame be an inertial reference frame,³ and let the lab's x -axis be the line from Earth to Zeta. Let Clyde's driver's seat define the coasting rocket frame's origin, $x' = 0$, with the x' -axis parallel to the x -axis.

Event A in Figs. 1 and 2(a) denotes the event where Clyde departs from the Earth. For event A, we have, respectively, the lab frame and coasting rocket frame coordinates $(t_A, x_A) = (t'_A, x'_A) = (0,0)$. Let event Z denote the event where Clyde arrives at star Zeta. Event Z occurs in Bonnie's frame at $x_Z = 3 c \text{ yr}$ and $t_Z = \Delta x/v = 3 c \text{ yr}/(3c/5) = 5 \text{ yr}$. Meanwhile, $x'_Z = 0$, because in Clyde's coordinate system, the star Zeta came to him, arriving at the rocket frame's origin. Clyde measures proper time⁴ between events A and Z, so the time dilation relation $t_Z = \gamma t'_Z$ becomes $5 \text{ yr} = (5/4) t'_Z$, which gives $t'_Z = 4 \text{ yr}$. The upshot is that between events A and Z, Bonnie ages five years according to her clocks, and Clyde ages four years according to his wristwatch. On the return trip, because the distances and speeds are the same as on the outbound trip, when Clyde returns to Bonnie at the reunion event R, Bonnie will be 30 years old and Clyde's age will be 28 years. So far, so good.

The apparent paradox arises when all of these events are examined from Clyde's reference frame. In the coasting rocket frame, in mapping events from A to Z, Clyde sees the Earth and Bonnie receding from him, and Zeta approaching with velocity $-3c/5$. Then from event Z to the reunion event R, Clyde observes Zeta receding and Bonnie approaching him at velocity $+3c/5$. One might be forgiven for assuming that upon Bonnie's return to Clyde, as observed by Clyde, she will be 28 and Clyde will be 30 years old. Hence the paradox: How can Clyde and Bonnie be both 28 and 30 years old?

The motion just described seems at first glance to be symmetrical, as shown by comparing Figs. 2(a) and 2(b)—shouldn't Clyde's motion as mapped in Bonnie's (t, x) spacetime diagram [Fig. 2(a)] be symmetrical with Bonnie's motion as mapped in Clyde's (t', x') spacetime diagram [Fig. 2(b)]?

As in all paradoxes that arise in special relativity, some unconscious assumption is made that contradicts the theory's postulates. Special relativity applies to inertial reference frames only—frames that undergo no acceleration. In the twin paradox, Clyde undergoes an acceleration. Relative to Bonnie, at event Z, his velocity changes from $+3c/5$ to

$-3c/5$. Throughout all of the events cited, Bonnie never accelerates. At event Z, Clyde jumps from the rocket frame, with its coordinates (t', x') that moves with velocity $+3c/5$ relative to the Earth frame, and boards the return rocket frame with coordinates (t'', x'') that moves with velocity $-3c/5$ relative to the Earth frame.⁵ Figure 2(b) is misleading because it suggests that Bonnie undergoes an acceleration when, in fact, she does no such thing. It is Clyde's acceleration at event Z that makes Bonnie's world line reverse direction in Fig. 2(b).

Referring to Fig. 3 now, a few noteworthy events occur simultaneously with event Z. Figure 3 maps the spacetimes of the outgoing coasting rocket frame's (t', x') axes and the return rocket frame's (t'', x'') axes, both projected onto the Earth-lab frame's

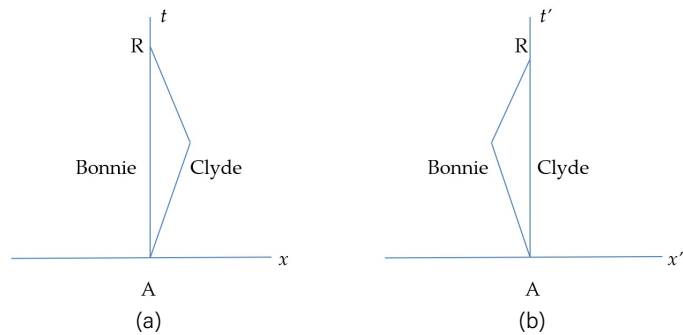


Figure 2. (a) The motion of Bonnie and Clyde as plotted on Bonnie's earth frame spacetime axes from event A to event R. (b) The motion of Bonnie and Clyde as plotted on Clyde's coasting rocket frame spacetime axes. Figure 2(b) motivates a false assumption, giving rise to the paradox.

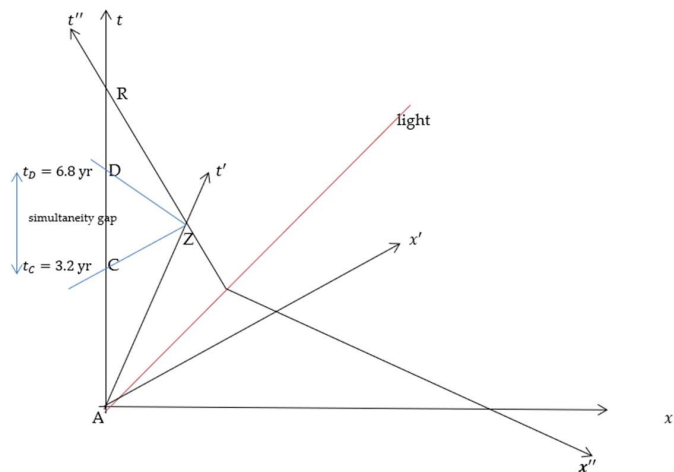


Figure 3. The earth-lab frame (t, x) , coasting rocket frame (t', x') and return rocket frame (t'', x'') coordinate axes. Bonnie's world line goes from A to R along the t -axis in the lab frame. Clyde's world line goes from A to Z in the coasting rocket frame, then from Z to R in the return rocket frame. In the coasting rocket frame, events Z and C are simultaneous (line CZ is parallel to the x' -axis). In the return rocket frame, events Z and D are simultaneous (line ZD is parallel to the x'' axis). The time between events C and D is the simultaneity gap. (The coasting rocket origin is placed on the red world line of light to show that the angles between it and the t' and x'' axes are the same.)

(t, x) axes. Recall that event Z occurs at $t_Z = 5$ yr in Bonnie's frame but in Clyde's frame, $t'_Z = 4$ yr. Furthermore, in Clyde's frame event Z is simultaneous with an event C that occurs in Bonnie's frame. We can find Bonnie's clock time for event C using time dilation: When Clyde's clock reads $t'_Z = 4$ yr, according to Bonnie, who reads proper time between events A and C (because both occur at $x = 0$), her clocks record $t_C = 4 \text{ yr}/\gamma = 3.2$ yr.

In addition, at event Z Clyde jumps from the coasting rocket frame to the return rocket frame. Within the return rocket frame, event Z is also simultaneous with event D on Bonnie's world line in the lab frame! When Clyde jumps from the rocket frame to the return rocket frame at event Z, the time interval between events C and D on Bonnie's world line introduces a simultaneity gap. Since event C occurred 3.2 years after event A according to Bonnie's clocks, event D in Bonnie's frame occurs 3.2 years before the reunion at event R, $t_D = 10 - 3.2 = 6.8$ years. The magnitude of the simultaneity gap as measured by Bonnie's clocks is $t_D - t_C = 6.8 - 3.2 = 3.6$ years.

Meanwhile, using data available to him aboard his rocket frame (presumably Clyde knew the 3 c-yr distance between Earth and Zeta before he left Earth), Clyde knows that when he rejoins Bonnie at the reunion event R, she will have aged 10 years according to her clocks. To see how he knows this, apply the invariance of the spacetime interval,

$$c^2(\Delta t')^2 - (\Delta x')^2 = c^2(\Delta t)^2 - (\Delta x)^2, \quad (2)$$

to the first half of the journey, from event A to event Z. Inserting A-to-Z data, Eq. (2) can be solved for Bonnie's time Δt :

$$c^2(4 \text{ yr})^2 - (0)^2 = c^2(\Delta t)^2 - (3 \text{ c yr})^2, \quad (3)$$

which gives $\Delta t = 5$ yr halfway through, so that Clyde can predict that at event R, Bonnie will have aged 10 years according to her calendar.

At the reunion event R, Bonnie will have celebrated ten birthdays since event A and Clyde will have celebrated eight birthdays since event A. The "twin paradox" seems paradoxical because the scenario's description implicitly assumes that both Bonnie and Clyde are always in their respective inertial reference frame for all events between A and R. Bonnie does indeed remain in one and only one inertial lab frame all the way from A to R, but Clyde's transition from the coasting rocket frame to the return rocket frame disqualifies him from being in the same inertial frame from A to R. In addition, the simultaneity gap illustrates the robustness of Albert Einstein's original thought experiment about the relativity of time as approached through the noninvariance of simultaneity.⁶

Seeing them reunited at event R, let us toast Bonnie and Clyde on their reunion after Clyde's voyage and raise another 18 toasts to their ten and eight birthdays, respectively!

1. Practically every textbook on special relativity describes the twin paradox. See, for example, John Brehm and William Mullin's *Introduction to the Structure of Matter* (Wiley, 1988)—I have borrowed their numerical parameters because they result in especially simple calculations; Edwin Taylor and John A. Wheeler's *Spacetime Physics* (Freeman, 1966, 1992); Anthony French's *Special Relativity* (Norton, 1968); and Paul Tipler and Ralph Llewellyn's *Modern Physics*, 5th ed. (Freeman, 1988); among many others.

2. The clocks at different locations within a given inertial frame can be synchronized as follows: Set a clock reading zero at the origin, clocks at $x = \pm 1$ m reading $t = 1\text{m}/c$, and so on, but do not let the clocks run yet. When all necessary clocks are arranged, send a light pulse from the origin, and when that light reaches a clock, it begins running. In this way, all the clocks distributed across the x -axis will be synchronized. Events throughout the reference frame have their time and position coordinates recorded locally, and a sequence of events can be traced globally from this data.

3. To a good approximation, the v^2/r accelerations due to Earth's spin on its axis, its orbit about the Sun, and the solar system's orbit around the galactic center are negligible in this application.

4. Recall that the proper time between two events is the time interval between them as measured in the reference frame where the two events occur at the same place. In other words, if $\Delta x = 0$ then Δt is the proper time.

5. These notes do not consider Clyde's initial acceleration that got him up to speed at event A or his deceleration following the reunion at event R—the acceleration at event Z is sufficient to make evident the role of acceleration in resolving the paradox. But those initial and final accelerations can be rendered irrelevant anyway by having Clyde get a running start before event A and coming to stop after event R. Nor do we need to consider the rate of change of Clyde's acceleration (his "jerk") at event Z to make the point that it's the existence of the acceleration itself whose neglect makes the adventures of the twins seem, at first glance, paradoxical.

6. Recall Einstein's thought experiment about the train being struck by lightning on both ends [see Albert Einstein, *Relativity: The Special and General Theory* (Crown, 1961), pp. 25–27]. Einstein showed that the reception of the two flashes of light, if simultaneous to the ground-based observer, is not simultaneous for an observer riding on the train.



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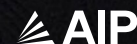
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