

Radiations

FALL
2019

The official publication of Sigma Pi Sigma



Empowering the Next Generation of Physicists

ΣΠΣ – Catalyst for Change
Bridging the Gap in Physics

Alumni Engagement Program



ARRANGE

speaking engagements at your next chapter or zone meeting



SHADOW

someone in a field of interest



LEARN

more about a career path, and so much more!

Browse through the available alumni profiles searchable by geographic location, discipline, level of engagement, and job sector.

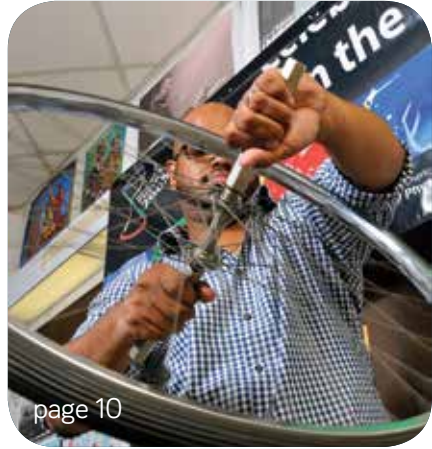
SPS alumni and Sigma Pi Sigma members:

Join now and submit your profile at spsnational.org/programs/alumni-engagement

Brittney Hauke

Graduate Researcher





ON THE COVER

Colorado Mesa University SPS chapter's 13th annual pumpkin drop. Photo courtesy of SPS National.

CONTENTS

6 Your Dollars At Work

- 62019 Individual Award and Scholarship Recipients
- 72019 SPS Summer Interns

8 Features

- 8 Daniel Whiteson: Equipping Kids to Answer Their Own Questions
- 10 Chicago State University: Equipping the Next Generation of Physicists
- 12 Better Science through Diversity
- 14 NSBP: Providing a Home for Physics Students
- 16 Physics Instruments Now & Then

20 Unifying Fields

- 20 Sigma Pi Sigma Favorites: YouTube Science
- 22 Sigma Pi Sigma – A Departmental Legacy of Friendship

24 Spotlight on Hidden Physicists

- 24 Rachel Erin Stuart, The Theologian
- 25 Tracy Williams, The Environmental Engineer and “Physics Drifter”

26 Elegant Connections in Physics

- 26 Empowerment and Eärendil’s Star

Departments

- 4 The Director’s Space
- 5 Chapter Profiles
- 29 2018–19 Sigma Pi Sigma Initiates

EDITOR

Kendra Redmond

MANAGING EDITOR

Kayla Stephens

CONTRIBUTING EDITORS

Korena Howley

Brad R. Conrad

COPY EDITOR

Cynthia Freeman

ART DIRECTOR

Aaron Hansen

LAYOUT DESIGNER

Hyun-Joo Kim

SIGMA PI SIGMA PRESIDENT

Jim Borgardt,
Juniata College

SPS PRESIDENT

Alina Gearba-Sell,
US Air Force Academy

SIGMA PI SIGMA/SPS DIRECTOR

Brad R. Conrad



Radiations (ISSN 2160-1119) is the official publication of Sigma Pi Sigma, the physics honor society, published twice per year by the American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3841. Printed in the USA. Standard postage paid at Columbus, OH. POSTMASTER: Send address changes to *Radiations Magazine*, Sigma Pi Sigma, 1 Physics Ellipse, College Park, MD 20740-3841.

Sigma Pi Sigma is an organization of the American Institute of Physics. It was founded at Davidson College, Davidson, NC, December 11, 1921. Member, Association of College Honor Societies. Contact us at [sigmapisigma@aip.org](mailto:sigmapi sigma@aip.org); telephone: (301) 209-3007; fax: (301) 209-3082.

Copyright © 2019, American Institute of Physics. Title registered in the US Patent Office. All rights reserved.

Engaging with *Your* Community

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

Sigma Pi Sigma was founded in 1921, and I would like to think that its founders would have been pleased to see how the linked societies we know today as Sigma Pi Sigma and the Society of Physics Students have spread widely and yet remained focused on supporting the next generation. The society's founders at Davidson College's alpha chapter, its original label, included both faculty and students. This sense of shared ownership between students and professionals permeates the way we continue to govern ourselves and are supported by the American Institute of Physics. Through national elections, the physics congresses, and a strong collaboration with professional societies that Sigma Pi Sigma members can participate in, the society remains relevant and connects us together as lifelong physical scientists.



A lot has changed within the community over the past 98 years. Physics, the way we learn physics, and Sigma Pi Sigma have evolved with the times. This issue of *Radiations* highlights some of that evolution, with our features focusing on "empowering the next generation," which can be interpreted in many different ways but gets to the heart of the Sigma Pi Sigma mission. Our field is a lens by which we can focus on the solutions we need to help each other thrive. The stories we share within this issue can help us consider the many facets of where we have come from, what it means to contribute to our society, and where we want to go as a community. These topics are mirrored in many of the program elements Sigma Pi Sigma hosts to support students, members, and the community.

Very recently I was reminded of how our past and ideals help to shape our future by one such program: the SPS internship program. I was able to watch 16 of the best and brightest students from across the country discuss science policy legislative processes on Capitol Hill, the history of diversity in the physical sciences, expanding bachelor's degree career options, cutting-edge research and policy at national labs, and everything in between. It was an amazing window into how the newest members of our community own not just the field's newest developments but the wide variety of places physicists can make a difference. Our history and traditions are the foundation upon which the future of the field will be built.

Our past traditions and future aspirations will be on full display at the upcoming 2019 Physics Congress. I hope that you have already made plans to join us November 14–16, 2019, in Rhode Island, but if not, on behalf of the SPS/Sigma Pi Sigma Executive Committee, I want to formally extend an invitation. This event is hosted by Sigma Pi Sigma and stems from the first national convention of Sigma Pi Sigma in 1928 at Davidson College. If you are not able to attend in person, please join us on November 16, 2019, as we livestream plenary talks by Dr. Jami Valentine-Miller and Dr. John Mather. ●



Please join us at 2:45 p.m EST and 7:45 p.m EST on November 16th for the
livestreaming of two 2019 Physics Congress plenaries:
www.youtube.com/user/SPSnational.

The William Jewell College Chapter: On the Shoulders of History

by Dr. Blane Baker, Professor of Physics, Sigma Pi Sigma 1986, and Megan Anderson, Executive Committee Member, Sigma Pi Sigma 2017

Visitors to the physics commons on the campus of William Jewell College, a private liberal arts college in Liberty, Missouri, often request a look at the departmental scrapbook, filled with collections of pictures and memorabilia dating to the founding of the college in 1849. Along with college history, the scrapbook has the names and pictures of all of the students and faculty who have been inducted into Sigma Pi Sigma.

The founding chapter, consisting of eight student members and two faculty members, was installed on May 20, 1930. The following year, Wallace Hilton—physics faculty member from 1946 to 1983, longtime SPS and Sigma Pi Sigma advisor, and 1979 Oersted Medal winner—was inducted along with two other students from the class of 1933. Since those early days, 409 total members have been added, including the three most recent inductees in April 2019. Nobel Prize winner Walter H. Brattain became an honorary member on April 26, 1979.

Today, one of the most popular pages in the scrapbook features the Sigma Pi Sigma inductees from 1986. Current students and alumni who look closely might recognize a familiar face—current Jewell faculty member Blane Baker, who has been contributing to the department since his days as a student. As an undergraduate at Jewell, Baker majored in physics and was active in both the Society of Physics Students and Sigma Pi Sigma. He began his stint as SPS and Sigma Pi Sigma advisor in 2005, succeeding his mentor, Don Geilker, who had served as an advisor since Hilton's retirement in 1983. Baker's six-year tenure on the SPS National Council and his Outstanding Chapter Advisor recognition are indicative of his investment in future generations of physicists.

Baker, along with colleagues Patrick Bunton and Maggie Sherer, have continued the longstanding tradition of engaging students in undergraduate research at Jewell. Over the past three years the department and chapter have also been highly engaged in outreach to public schools. In 2018–19 the chapter received a Society of Physics Students Future Faces of Physics Award to support enrichment and after-school programs by engaging elementary school students in physics activities on waves, light and optics, and solar energy.

The department promotes physics on campus by participating in events such as homecoming and by presenting physics demonstrations and serving donuts on the college Quad—affectionately known as Demos

& Donuts. Students and faculty have participated in science camps, physics demonstrations, and sustainability projects in the Texas border region, on Native American reservations in South Dakota, and in the countries of Thailand, Honduras, and Guatemala.

Each week the department hosts the Physics Minute, modeled after a similar activity started at Coe College. Students and faculty gather in the physics commons to listen to a one-minute summary of a topic in science, followed by casual conversations and ice cream. Former Sigma Pi Sigma members also regularly visit the department to reconnect and present on topics ranging from fundamental research to how the study of physics impacts career aspirations.

This Sigma Pi Sigma chapter has a rich history of scholarship, service, and fellowship, and, with a culture of engagement firmly established, should continue inspiring generations to come. ●



TOP: Sigma Pi Sigma induction class of 1986 at William Jewell College. Dr. Blane Baker is located in the front row, second seat from the left. Photo courtesy of the Sigma Pi Sigma chapter of William Jewell College.

BOTTOM: Sigma Pi Sigma members at William Jewell College today. Can you find Dr. Baker? Photo courtesy of Megan Anderson.

The American Institute of Physics is a federation of scientific societies in the physical sciences, representing scientists, engineers, educators, and students. AIP offers authoritative information, services, and expertise in physics education and student programs, science communication, government relations, career services, statistical research in physics employment and education, industrial outreach, and history of the physical sciences. AIP publishes *Physics Today*, the most closely followed magazine of the physical sciences community, and is also home to the Society of Physics Students and the Niels Bohr Library & Archives. AIP owns AIP Publishing LLC, a scholarly publisher in the physical and related sciences. www.aip.org

Member Societies

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

Other Member Organizations

Sigma Pi Sigma
Society of Physics Students
Corporate Associates

Connect with Sigma Pi Sigma



LinkedIn
www.linkedin.com/groups/Sigma-Pi-Sigma-physics-honor-142619



Facebook
www.facebook.com/groups/sigmapi sigma



Donate
donate.aip.org

2019 Individual Award and Scholarship Recipients

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

SCHOLARSHIPS

Multiple awards, ranging in value from \$2,000 to \$5,000, are made each year to individuals showing excellence in academics, SPS participation, and additional criteria. Learn more and see photos and bios of the recipients at www.spsnational.org/awards/scholarships.

SPS OUTSTANDING LEADERSHIP SCHOLARSHIP:

Evan Ulrich
Juniata College

Connor Pecar
Duquesne University

Roy Salinas
Abilene Christian University

AWIS KIRSTEN R. LORENTZEN AWARD SCHOLARSHIP:

Alexandra Detweiler
Illinois Institute of Technology

SPS LEADERSHIP SCHOLARSHIPS:

Jacob Adamczyk
Cleveland State University

Samantha Tietjen
Cleveland State University

SCIENCE SYSTEMS AND APPLICATIONS, INC., UNDERREPRESENTED STUDENT SCHOLARSHIP:

Swapnil Bhatta
University of Southern Mississippi

SPS FUTURE TEACHER SCHOLARSHIP:

Katie Syer
Augustana College

Martha Jesuit
Coe College

Kevin Fernando
University of Central Florida

AYSEN TUNCA MEMORIAL SCHOLARSHIP:

Ruth Willet
Kettering University

SCIENCE SYSTEMS AND APPLICATIONS, INC., ACADEMIC SCHOLARSHIP:

Lucas Hanson
Rutgers University

HERBERT LEVY MEMORIAL SCHOLARSHIP:

Roel Olvera
Texas Lutheran University

Kristiana Smith
Rhodes College

Nolan King
University of Texas at Dallas

Matthew Macasadia
Texas Lutheran University

PEGGY DIXON TWO-YEAR SCHOLARSHIP:

Vincent Thompson
Indiana University of Pennsylvania

SPS AWARD FOR OUTSTANDING UNDERGRADUATE RESEARCH

Awards are made to individuals for outstanding research conducted as an undergraduate. Winners are awarded \$1,800 to present their research at an AIP Member Society meeting and receive \$500 for themselves and \$500 for their SPS chapter. The runner-up receives \$400 to present their research at an AIP Member Society meeting. Learn more at www.spsnational.org/awards/outstanding-undergraduate-research.

WINNERS

Martha Jesuit
Coe College

Terance Schuh
The College of New Jersey

RUNNER-UP

Nolan King
University of Texas at Dallas

2019 SPS SUMMER INTERNS

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



Megan Anderson
William Jewell
College
The Society of
Rheology History
Intern



Isabel Bishop
Coe College
APS Public
Engagement Intern



Jacqueline Blaum
Iowa State University
APS Career Programs
Intern



Nour Ibrahim
Embry-Riddle
Aeronautical
University – Arizona
SPS Science
Outreach Catalyst Kit
Intern



Giavanna Jadick
Duke University
AIP Mather Public
Policy Intern – US
House Committee on
Science, Space, and
Technology



Jeremiah O'Mahony
Sarah Lawrence
College
Physics Today
Science Writing Intern



Anna Perry
Gettysburg College
AIP History of
Diversity in the
Physical Sciences
Intern



Andrew Phipps
Brigham Young
University – Idaho
APS Education &
Diversity Intern



Sariah Mevs Phipps
Brigham Young
University – Idaho
OSA Professional
Development &
Outreach Programs
Intern



Nolan Roth
High Point University
NASA Research
Intern: Space
Exploration



Catherine Ryan
The Pennsylvania
State University
AIP Niels Bohr
Library & Archives /
Education & Diversity
Intern



Amber Sammons
Illinois State
University
AAPT Teacher
Professional
Development
Programs Intern



Terance Schuh
The College of New
Jersey
NASA Research
Intern: Cosmic
Microwave
Background



Samantha Staskiewicz
The College of New
Jersey
AIP Science Policy
News Intern



Nicholas Stubblefield
Boston College
AIP Mather Public
Policy Intern – NIST



Joseph Tibbs
University of Northern
Iowa
NIST Research Intern

Daniel Whiteson: Equipping Kids to Answer Their Own Questions

by Jeremiah O'Mahony, 2019 SPS Summer Intern and SPS Member, Sarah Lawrence College



We all know a curious kid. They have the world to discover, and they can't help but ask questions. Today Dr. Daniel Whiteson is a high-energy particle physicist at the University of California, Irvine, but when he was younger, he was one of those kids. "I wanted to access the joy of science," Whiteson told *Radiations*, but he could only wonder about the things around him. He didn't have the tools to actively examine them.

Whiteson hopes that *Elinor Wonders Why*, a new TV show he and longtime collaborator Jorge Cham have developed for PBS, will give curious children those tools. It all ties into Whiteson's philosophy for answering children's questions, which he admits is a little unorthodox. "This is going to sound paradoxical, but try not to answer their question," he said. "Help them to answer it themselves."

In the show, Elinor and her friends will do just that. For the most part, they aren't going to rely on adults to help them figure things out. Instead, they'll take notes and form testable hypotheses about the phenomena that interest them. They will, in short, do science.

"We're hoping that kids are encouraged to think curiously," Whiteson said, "and that their parents and caregivers are more comfortable with that."

Even though the show is for kids, Whiteson and Cham, a cartoonist and former engineer, also have adults in mind. One goal for *Elinor Wonders Why* is to clue in parents and other caregivers on how to help kids refine their inquiries. That means "reflecting [kids'] questions back at them" and encouraging them to puzzle out answers for themselves.

"[T]his is an incredible opportunity not just to tell fun stories but to help encourage a generation of kids to be curious and be confident about asking questions," said Cham. "With all the challenges that we face, it can only help to have citizens that are actively curious and are not afraid to ask questions."

While conducting research for the show, Whiteson and Cham found that, along with parents, preschool teachers consistently felt



TOP: Elinor and her friends on a walk through the forest. Photo courtesy of Pipeline Studios, SHOE Inc.

LEFT: Daniel Whiteson. Image courtesy of the Department of Physics & Astronomy at the University of California, Irvine.

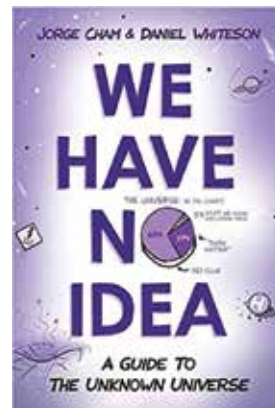
unprepared to answer kids' scientific questions. Like most PBS shows, *Elinor Wonders Why* is meant primarily to educate, and Whiteson hopes that Elinor's adventures will become teaching tools in the classroom.

The duo is particularly excited to bring their brand of science communication to PBS for the network's reach—specifically, to the children of low-income families. "PBS Kids plays an important role in the way [parents] raise their kids," Whiteson said. "It's an honor for us to be part of that process."

Elinor Wonders Why will teach children some science facts, but for Whiteson, it's more about showing kids how to productively grapple with their queries. "It's about science, but it's also about the process," Whiteson said. He notes that science is often considered a body of facts, when really, it's just as much about utilizing tools of inquiry to explore

the world—the tools he was looking for when he was a young child. "It's equally important to teach them that science is a way to answer their own questions," he said. ●

For more from Whiteson and Cham, check out their book, *We Have No Idea: A Guide to the Unknown Universe*, and their podcast, *Daniel and Jorge Explain the Universe*.



About Elinor Wonders Why

by Samantha Staskiewicz, 2019 SPS Summer Intern and SPS Member,
The College of New Jersey

Many networks have inspired young people to get involved in science through television shows featuring rocket ships, fun chemical experiments, outdoor adventures, and lots of math and facts. *Elinor Wonders Why* takes a unique approach, sparking scientific interest by starting at the root of science—curiosity. The show aims to inspire young people to ask questions about the world, express their wonders and problems, and use scientific skills to acquire the answers to their questions. Co-creators Daniel Whiteson and Jorge Cham use their backgrounds in physics and knowledge of research processes to shape the structure of the show.

Elinor Wonders Why follows a young rabbit, Elinor, through Animal Town, where she's accompanied by friends Ari the bat and Olive the elephant, as well as several other characters they meet through their adventures. When the crew of animals comes across something they don't understand, they work together to solve the problem, showcasing a variety of science and engineering principles. Along with the show's focus on science, *Elinor Wonders Why* delves into important aspects of community, such as diversity, respect, teamwork, and environmental awareness. Children can meet Elinor on the show's premiere date, Labor Day 2020.

105,000+ READERS CAN'T BE WRONG

PHYSICS TODAY

*Your colleagues are staying on the cutting-edge of
physical sciences' research with our exclusive, authoritative content.
Are you missing out?*

SUBSCRIBE
TODAY

physicstoday.org/sigmap

GET 12 ISSUES
FOR ONLY \$25

Chicago State University: Equipping the Next Generation of Physicists

by Kendra Redmond, Editor

Learning to solve Schrödinger's equation and calculate the potential of a charged sphere are essential parts of an undergraduate physics education. But for the physics faculty at Chicago State University (CSU), imparting knowledge isn't the end goal. The Department of Chemistry, Physics, and Engineering Studies has a larger aim—to prepare students to be competitive in a broad range of professional careers, including the health sciences, education, business, engineering, and research. In addition to high-quality teaching and engaging students in active learning, here are three ways the physics program prepares students for success:

1. Involving students in decision-making

At CSU, physics undergraduates have an important voice. They are real collaborators in the development of the physics program, says CSU physics professor Mel Sabella. For example, many undergraduates are peer instructors through the department's highly successful Learning Assistants (LA) program. LAs facilitate group discussions and classroom engagement in both lower- and upper-division courses. Often, they help develop lessons, choose problems, and provide feedback to faculty about what's working and what isn't.

Highly engaged undergraduates are valuable to everyone, according to Sabella. The students gain leadership experience and a sense of ownership in the program. Furthermore, they start to

develop a sense of themselves as science professionals capable of making meaningful contributions. "Involving [students] in leadership roles supports their development of science identity. This is especially important for students underrepresented in the STEM disciplines," explains Sabella.

Meanwhile, the faculty benefits from student insight. Most of the physics undergraduates at CSU come from the South Side of Chicago, so student leaders are intimately familiar with the experiences, cultures, strengths, and challenges of their peers. This enables them to offer perspectives and expertise on the student experience that many faculty members don't have.

2. Facilitating a diverse, supportive community

After a year at a different university and then a year off from school, Travante Thompson entered CSU juggling three jobs and a baby. "It just felt like home," he recalls of the department. The active learning focus suited him, but looking back Thompson most appreciates how the faculty members really worked with him as an individual. He came to CSU intending to transfer after two years to a school with an ABET-accredited engineering department but decided to stay after falling in love with physics and experiencing the supportive environment. He graduated with a physics degree in 2018 and is now a beam operator at Fermi National Accelerator Laboratory.



1: CSU physics alum Sean Gallardo exploring torque and angular momentum as a student. Photo by Brent Jones.

2: CSU alums Ebony Spells and Angela Moore exploring electric circuits with Dr. Andrea Van Duzor as part of their LA pedagogy course. Photo by Brent Jones.

3: Recent graduates Felicia Davenport (physics), Angela Moore (physics), and Nicolette Sanders (chemistry) as presenters at the 2016 American Association of Physics Teachers meeting. Photo by Mel Sabella.

4: Kara Young, a Chicago public school teacher and coinstructor of the CSU pedagogy course, helps LA Louis Isaac develop a physics lesson for high school students. Photo by Brent Jones.

5: Travante Thompson (left) and Donielle Miller working on E&M as CSU physics students. Photo by Mel Sabella.



That tight-knit community was the first thing Lionel Pittman noticed when he became a physics faculty member at CSU five years ago. “We know everyone in the department. We learn a lot about their livelihoods and what goes on in their lives,” he says. At times maintaining these personal connections requires a little extra investment, but it’s motivated by a strong desire to see every student succeed, says Pittman.

This strong sense of community isn’t an accident. It is fostered through classroom interactions, informal conversations, and organized department programs such as the LA program, a Society of Physics Students chapter, and a unique Chi Sci Scholars Program that supports cohorts of new chemistry and physics majors. One of the highlights of the scholars program is an off-campus retreat during which students and faculty cook meals together, talk, play games, and get to know each other. The department also works together each year on a program to support K–12 students, parents, and teachers in developing science fair project ideas.

“Building a community that trusts each other, that has strong relationships that aren’t just in the classroom... [these] are the really powerful things when you talk about engaging the next generation,” says Sabella.

3. Requiring research

All CSU physics majors do research. In fact, to earn a bachelor’s degree in chemistry or physics, students must complete a thesis based on at least 100 hours of directed, original research. The research can be conducted with a faculty member or as part of a summer program or internship, but it must be presented in written form and defended in front of a thesis committee.

A thesis requirement is unusual at the undergraduate level, in part because it requires a lot of faculty effort. However, the department deems it worthwhile because students develop so many important skills along the way. From communication to analysis and problem solving, these skills complement a traditional physics education and prepare students for the modern workforce.

Thompson spent two months at CERN in Switzerland during the summer of 2017 working on high-energy physics research with CSU professors Edmundo Garcia and Austin Harton. He also participated in a different kind of research during his senior year at CSU—a National Science Foundation–funded project to turn one of the CSU classrooms into an engineering lab space. Working with Pittman and Professor Archie Peters, Thompson led a small group of students in proposing a redesign for the space. Through these experiences he learned skills

Chicago State University At-a-Glance

Type of institution: Public

University enrollment: 2,964 (2018)

Student body: CSU is 69% Black and 68% female. Roughly one-third of the students are first-generation college students, one-third are traditional students, and one-third are nontraditional students.

Moving On & Looking Back

Felicia Davenport graduated from CSU last spring and is now pursuing a PhD in bioengineering at Georgia Tech. “I thoroughly enjoyed my time at CSU,” she reflects, attributing her positive experience in large part to the close-knit department and the supportive faculty. “I developed mutual feelings of respect and admiration for the faculty members that made me feel supported and safe within the department,” she says. She also credits the focus on “real world” skills for helping physics undergraduates turn into a team of collaborators. “[T]he students are eager to work together to help everyone achieve their own goals,” she says.

that are not typically taught in the classroom—presenting proposals to stakeholders, collaborative research, staying on budget—but are nevertheless key to successfully navigating a career. This is one of the things that makes CSU different from other departments, says Pittman. “[W]e are not only creating the next generation of physics graduates, but also people who are versed in research skills.”

Some might see these efforts as distractions that dilute the traditional physics education, but the program has a track record of success. CSU plays a national role in increasing diversity in physics, graduating high percentages of African American and female students. Physics bachelor’s degree recipients routinely go on to physics graduate programs, other STEM graduate programs, and STEM jobs. Many alumni stay connected to the department and return to give career talks to undergraduates. According to Thompson, it’s the place to go “if you want to go somewhere where the faculty will work their hardest to make sure that you learn the best way that you learn.” ●

The LA Program, Chi Sci Scholars Program, and the Laboratory Modernization Project are partially funded by grants from the National Science Foundation (DUE# 1524829, DUE# 1356523, DUE# 1712389) and the Department of Education.



Better Science Through Diversity

Cal-Bridge draws high-potential students into PhD programs in physics and astronomy

by Korena Di Roma Howley, Contributing Editor



In the winter of 2018, Dennis Calderon had recently returned to school after a three-year absence when he attended a seminar led by Dr. Amy Furniss, an assistant professor of physics at California State University, East Bay. Fascinated by the topic of the talk—an overview of Furniss's work on very-high-energy gamma rays that come from blazars—Calderon approached Furniss about joining her group. Two years later, he's set to begin a PhD program at The Ohio State University, where he'll continue astroparticle physics research while transitioning into the study of neutrinos.

Though Calderon had always been interested in physics, previous college studies had been disrupted by work commitments, a long commute, and financial difficulties. After leaving school, he hadn't planned to go back. While Furniss's seminar had rekindled his interest in physics, to see where that interest could take him, Calderon needed the kind of support he had previously lacked—and that's where Cal-Bridge came in.

"I almost can't even describe how amazing the program has been," he says. "I wouldn't be where I am today without Cal-Bridge."

Bridging the Gap

Founded in 2014 by Alexander Rudolph, professor of physics and astronomy at Cal Poly Pomona, the Cal-Bridge program supports students along their physics journey while increasing diversity in the field. Modeled in part after the Fisk-Vanderbilt Master's-to-PhD Bridge Program and funded by the National Science Foundation, Cal-Bridge provides full scholarships, mentorships, and professional development and research opportunities to undergraduate students from groups traditionally underrepresented in physics.

The bridge takes students from the California State University (CSU)

LEFT: Cal-Bridge scholars and their families enjoying an Angels baseball game.

MIDDLE: Cal-Bridge scholars go bowling after a workshop at the University of California, Santa Barbara.

RIGHT: Cal-Bridge scholars work on their graduate school essays.

system—which offers few doctoral programs—to the PhD programs in physics and astronomy available in the University of California (UC) system, though since the start of Cal-Bridge, students have also been accepted into and attended doctoral programs elsewhere.

Rudolph knew, based on the diversity of the CSU system and its 23 campuses, that the program would have a broad pool of talent to draw from. "I don't believe that the ability to be a successful physicist or astronomer is related to gender or race or ethnicity in any way," he says.

Both the students and the field as a whole benefit from a more representative community of scientists. "Most science now is done in teams," Rudolph says. "The image we have in our heads is the lone scientist in his lab—and it's usually a he ... Albert Einstein at his desk, Enrico Fermi in the lab. But in reality, almost everything we do in science nowadays is in teams."

And, he says, there's evidence that teams with members who have different perspectives—who come from different parts of society and have different backgrounds—are more productive. "Our field should reflect society, and I think we'll do better science if we get more people involved and have a more diverse population," he says.

What Rudolph calls a "holistic selection process" for choosing Cal-Bridge scholars involves looking at a number of characteristics that correlate with success, including academic potential. "We don't just look at the grades they have, but what we believe they can do," he says. "We also look for evidence of leadership ability, communication skills, and the ability to have long-term goals."

And the process takes into account the fact that women and minority students in physics face additional barriers and challenges. “Have they faced a lot of obstacles? is one thing we look at,” Rudolph says, “and the other is, How well do they overcome them?” The latter, he explains, reveals the grit and persistence it can take to succeed.

When medical issues forced her to withdraw for a semester from her undergraduate studies in astrophysics at San Francisco State University, Imani Ware remained determined to pursue her lifelong dream of becoming an aerospace engineer. She found support through her Cal-Bridge mentors, who helped her communicate with professors, obtain missed study material, and focus on her health and well-being. “They were there for me when I needed them and have given me the opportunity to return to my studies stronger than before,” she says.

For Cristilyn Gardner, now a PhD candidate studying exoplanets at the University of Wyoming, Cal-Bridge removed financial and other pressures, making it possible for her to accept internships and attend workshops, conferences, and a summer research program. “[Cal-Bridge] gave me confidence,” she says. “It put me in the mindset that I could achieve great things.”

The CAMPARE Difference

Two programs fall under the Cal-Bridge umbrella. The first is a partnership between the UC and CSU systems and more than 30 community colleges across the state. Cal-Bridge Scholars that transfer from a community college to a CSU and those recruited directly from CSUs, benefit from mentoring by faculty and research programs at UC and other campuses.

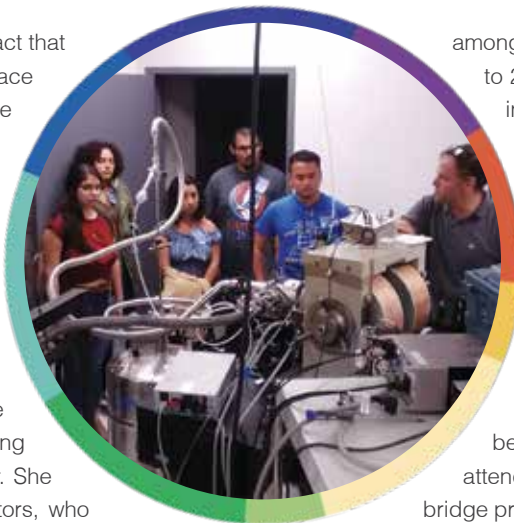
The other program, founded by Rudolph in 2009, is the California Minority Partnership for Astronomy Research and Education, or CAMPARE, which sends students from CSU and California community college campuses to summer research programs in physics, astronomy, astrobiology, and planetary science all over the country.

“Research experience has been shown to help motivate students to go on to get PhDs,” Rudolph says. In fact, of the students who have participated in CAMPARE and earned a bachelor’s degree, 65 percent pursued graduate studies in related fields.

Evan Nuñez is a Cal-Bridge scholar and physics major who recently graduated from Cal Poly Pomona and will be starting an astrophysics PhD program at Caltech this fall. Nuñez attended the University of Wyoming’s research program through CAMPARE, and while there, he says, he was able to live the astronomer’s dream—driving up to a telescope, taking data all night, sleeping through the evening, reducing the data, and then restarting the process all over again. “It turns out that I loved every single part of the experience,” he says, “even the tedious and difficult moments, which was a sign to me that I was going down the right path.”

Paying It Forward

Cal-Bridge participants also make it clear that the program has been, for them, about more than academics. It has fostered a sense of community



among and between each year’s cohort of scholars (up to 25 in past years). The existing students help the incoming class, which then does the same for those coming up behind them. And the impulse to pay it forward doesn’t end there.

Driven by their own experiences, Calderon, Gardner, and Nuñez all cited the dual UC and CSU mentorships as a highlight of the program. Each expressed a strong desire to mentor others, not just as time allows but as a focal point of their future careers.

“I want to go into academia—that’s always been a dream of mine,” says Calderon, who’ll be attending Ohio State through its own MS-to-PhD bridge program. But the biggest reason to teach, he says, is to follow in Furniss’s footsteps. “I want to do this for another student,” he says.

According to Nuñez, the mentoring Cal-Bridge provided reminded him that he wasn’t alone. “I always had [someone] I could talk to about how my classes were going, how my research was going, how I was coping with my transition as a transfer student,” he says. And looking toward a career as a research professor or staff scientist, Nuñez says he plans on returning the favor to future students.

Gardner says she feels passionate about the continuation of the program and the role she can play in mentoring others. “I really want to be [in] STEM outreach and mentoring younger kids and even undergraduates,” she says. “If I end up as a faculty member or research scientist...I still want to have some part in that.”

Because the program began in 2014 and participants enter as juniors, none of the Cal-Bridge scholars have yet completed a PhD program. But, says Rudolph, the 80 percent success rate they’ve had for getting into doctoral programs already far surpasses the typical CSU rate, and the quality of the programs is much higher.

“We don’t yet know about the long-term effect,” he says. “But I do have a lot of confidence that we’re going to have a big impact.” ●

TOP: Cal-Bridge scholars tour a physics lab during orientation at the University of California, Santa Cruz.

LEFT: Cal-Bridge North scholars at orientation, September 2018.

RIGHT: Cal-Bridge South scholars at orientation, September 2018.

Photos courtesy of the Cal-Bridge program.



National Society of Black Physicists: Providing a Home for Physics Students

by Kendra Redmond, Editor



"I wasn't really sure what I was in for," laughs Elon Price as she recalls her first National Society of Black Physicists (NSBP) conference in 2016. At the time, she was just getting into upper-level physics classes as an undergraduate at North Carolina State University. "It was nothing short of an amazing experience to see so many black physicists," she says. "It was the best thing I could have done so early in my career, because it gave me a sense of community and the encouragement I needed to continue."

At that NSBP meeting, more than 150 undergraduates, graduate students, and physics faculty gathered at Fermi National Accelerator Laboratory for plenary talks, interactive panel discussions, student research presentations, and networking sessions. The meeting offered a change of scenery for Price, one of three black students in her physics department. She immediately felt welcome and comfortable. She left inspired.

That experience helped Price land a research position and prompted her to become active in the physics community inside and outside of her department. She's attended two more NSBP conferences since then, as well as larger, topical physics meetings with several thousands of researchers. Topical meetings offer a wealth of opportunities and resources because of their sheer size but can leave some attendees feeling out of place.

"[I]t was so much larger and felt a lot less personal," says Price about one such meeting. "There was just me and a very small group of people of color. That kind of brought me back to reality a little bit."

African Americans are significantly underrepresented in physics compared to other fields, and even more so when compared to the general population. The NSBP promotes the professional well-being of African American physicists through efforts aimed at preparing students for success, increasing the number of black physicists, and increasing the visibility of physics contributions by minorities in the field.



Joshua Burrow earned his physics bachelor's at Morehouse College, a historically black college, in 2012. He attended his first NSBP meeting in 2015 in Baltimore, Maryland. Even though at the time he was attending a historically black college, being surrounded by so many black physicists left an impression. "I felt welcomed by the African American physicists and the allies of our community, and I left inspired to pursue a doctoral degree," he says. Now a graduate student at the University of Dayton, a predominantly white institution, Burrow says that he appreciates NSBP gatherings even more.

Today, Price is a member of the NSBP student council, and Burrow is the student representative to the NSBP board. As NSBP student leaders,



they are spearheading an effort to establish NSBP chapters on college and university campuses to promote an ongoing sense of community among members. They are also collaborating with the National Society of Hispanic Physicists (NSHP) to plan a student leadership conference for physics undergraduate and graduate students in 2020.

For minority students studying physics, Burrow recommends getting involved in an organization like the NSBP or NSHP. “They provide a sense of hope and belonging and a place where you can build a good network,” he says. To those in the majority, Price suggests spreading the word about these organizations to students who may benefit. She found out about NSBP when a faculty member sent a meeting announcement around by email. “I felt isolated and sort of accepted it,” she says. “When I went to NSBP I definitely felt less isolated, and I didn’t think to do that myself.” ●

Related Resources

- American Indian Science & Engineering Society– www.aises.org
- Conferences for Undergraduate Women in Physics– <https://www.aps.org/programs/women/workshops/cuwip.cfm>
- National Society of Black Physicists– <https://nsbp.org>
- National Society of Hispanic Physicists– www.hispanicphysicists.org
- LGBT+ physicists and astronomers– <https://lgbtphysicists.org/>
- Society for the Advancement of Chicanos and Native Americans in Science– www.sacnas.org

LEFT TOP: Elon Price graduated last spring from North Carolina State University and is now a graduate student in the Fisk-Vanderbilt Bridge Program. Photo courtesy of Elon Price.

RIGHT TOP: Joshua Burrow is a graduate student at the University of Dayton and the student representative to the NSBP board. Photo courtesy of Joshua Burrow.

LEFT BOTTOM: Joshua Burrow explains processes conducted in the Nano-Fab Lab at the University of Dayton during a workshop for high school students attending a women in engineering camp. Photo by Ankita Khanolkar.

RIGHT BOTTOM: Physics students, alums, and faculty from Morehouse and Spelman Colleges at the 2018 NSBP national conference. Photo by Kyron Keelen.

Support

SPS and ΣΠΣ by Hiring with SPS Jobs

spsnational.org/jobs

- **Post** your REU, internship, or bachelor-level position absolutely FREE!
- **Access** a community of 70,000+ Society of Physics Students (SPS) and Sigma Pi Sigma (ΣΠΣ) student members worldwide!
- **Find** THE best candidates seeking positions in physics, astronomy, engineering, and other STEM fields!



Find us @SPSNational on:



Physics Instruments Now & Then

by Kendra Redmond, Editor

”

New instruments
open doors and trigger creativity.

—Dick Peterson

“

As physicists push the boundaries of understanding, the citations in their research papers reveal the mountain of knowledge on which new work is built. What may be less considered is the role of instrumentation in the discovery process. Yet digging deeper, looking further, and seeing in greater resolution than ever before requires equipment that's up to the challenge. In this section, two experts share some of the changes they've observed on the job. Their responses to questions from *Radiations* have been edited slightly for length and clarity.

Dick Peterson: Reflections on the Evolution of Optical Tools

Peterson is a physics professor emeritus at Bethel University, long-time worker in applied optics, and a passionate builder of apparatus for teaching physics. He was a leader in the formation of the Advanced Laboratory Physics Association (ALPhA), past president of the AAPT, and winner of the APS award for research with undergraduates. In 2017 he received the APS Jonathan F. Reichert and Barbara Wolff-Reichert Award for Excellence in Advanced Laboratory Instruction.

1. When you consider the field of optics, what strikes you most about how key instruments have evolved over time?

Since I was introduced to the challenges of optical measurements in my student days of the 1960s, I can't help but first reflect on the impact of gas and solid-state lasers. For example, while doing "pre-laser" optics we championed the coherence length of a low-pressure Hg-198 lamp source for doing interferometry. Physical optics metrology has been totally revolutionized if one compares the mercury lamp coherence length (a few centimeters) to that of the now common stabilized, single-mode He-Ne lasers found in many undergraduate labs (hundreds of meters, or even more). Of course, modern LIGO-level research systems can extend that coherence and stability by additional factors of thousands.



2. Do any other tools stand out as interesting examples of this evolution?

The acousto-optic modulator (AOM). It has always been possible to shift the frequency of light waves as they interact with matter (e.g., Doppler shifts). I recall building a cumbersome moving mirror system to shift light frequencies for heterodyne interferometry around 1970. However, the AOM became a low-cost and easily implemented way to change the frequency, intensity, and phase of light waves. Now optics tables around the world have multiple AOMs for varying applications—including laser cooling systems. I think few of us anticipated how widespread AOM applications would be. Their simplicity and modest cost make them a powerful tool in undergraduate advanced lab projects.

It is most appropriate that there should be in America a separate journal devoted exclusively to scientific instruments. For, the history of science is in large part a history of scientific instruments. Zeeman discovered the Zeeman effect, where Faraday had failed forty years before, simply because Zeeman had a more powerful magnet and a spectroscope of greater resolving power. Instruments of high precision and sensitivity turn the difficult tasks in the laboratory of a generation ago into mere routine of today. New instruments make new methods of research and investigation, and hence new discoveries, possible. Just as the investigator in any branch of pure or applied science follows carefully the progress of his science, so he should keep abreast of developments in new instruments and methods of research, to make his investigations more effective. And just as the results of scientific investigations are published for the benefit of one's colleagues, so also a new instrument or method of research should be described.

TOP: Antique test meter from an instrument collection at MIT, acquired by the school in the 1940s. The top center instrument is a miniature Weston voltmeter whose scale ranges from 0 to 120. The shape of the voltmeter is reflected in Sigma Pi Sigma's insignia. Photo credit: Elmer Cat.

LEFT: This excerpt is from the editorial which appears in the volume 1, issue 1, January 1930 edition of *Review of Scientific Instruments*. Photo credit: AIP Publishing.

3. How do you view the relationship between research, instruments, and the researcher?

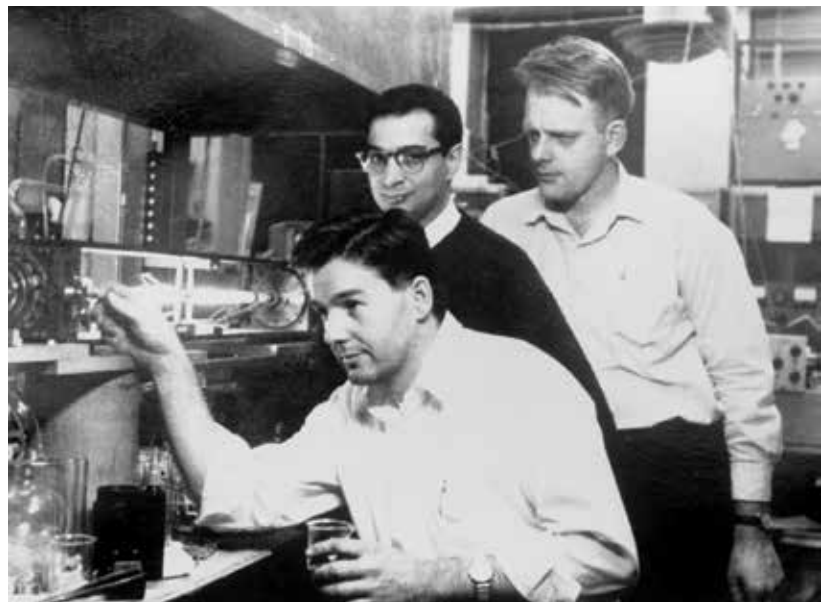
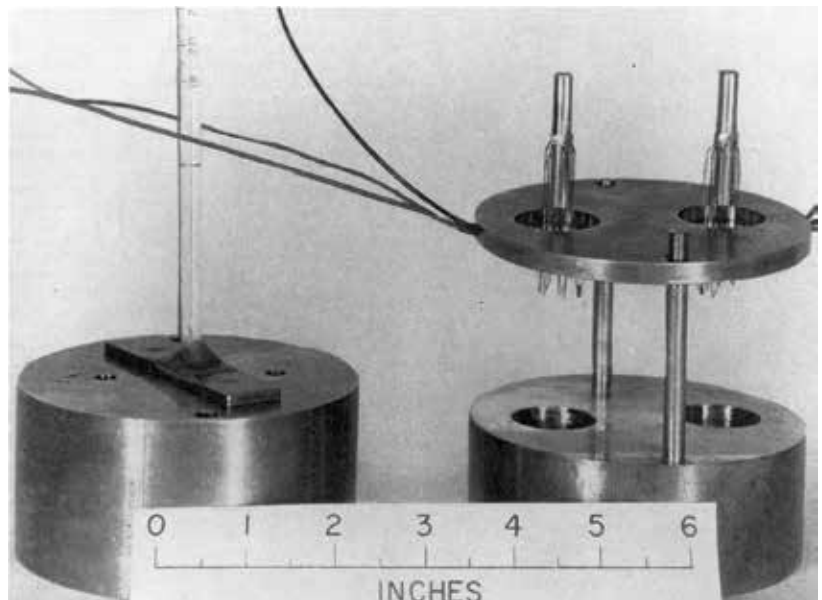
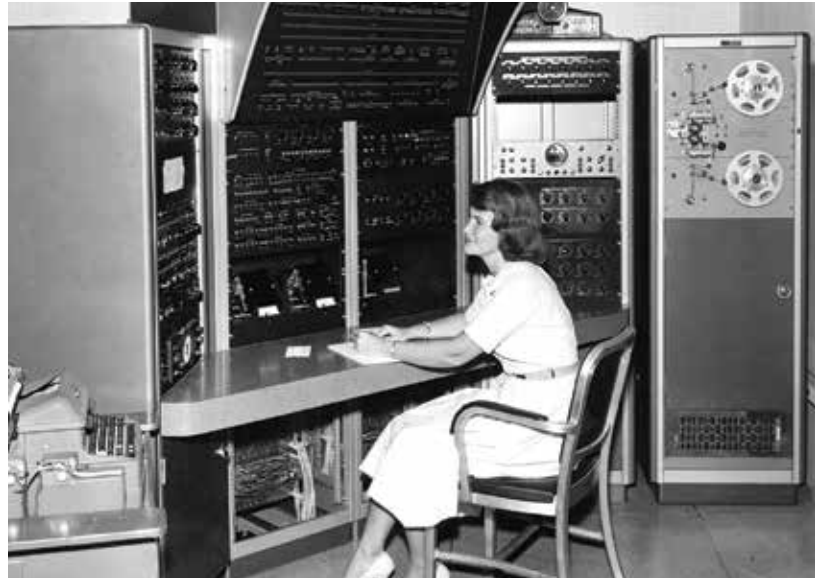
New instruments open doors, trigger creativity, and add to the fun. An experimentalist typically opens a fresh issue of a journal like *Review of Scientific Instruments* anxious to see if some new tool may broaden the perspectives of their work or (equally important) simply do it better and faster. Decades ago, I had a wonderful postdoc mentor at Los Alamos, Franz Jahoda, who was known for jumping on any new idea or optical gadget from a journal or conference and cleverly employing it the next week in his plasma diagnostics labs. I can still feel his intense (and competitive) experimental focus following such stimulation!

Bert Coursey: Reflections on the Evolution of Nuclear Radiation Equipment

Coursey is a guest researcher in the Standards Coordination Office at the National Institute for Standards and Technology (NIST) and a former editor in chief of the journal Applied Radiation and Isotopes. He is an expert in radioactivity and radiation measurements and has spent 47 years at NIST, nine of them on detail as the director of standards of the Department of Homeland Security.

1. When you consider the history of work in nuclear radiation, what strikes you most about how key instruments have evolved over time?

Modern nuclear instrumentation systems were developed in the mid-20th century for three different applications: diagnostic detection systems for nuclear weapons programs, measurement and control systems for commercial nuclear power stations, and data acquisition systems for high-energy particle accelerators. The central components of these systems are radiation detection instrumentation—ranging from Geiger-Muller counters to solid-state detectors—and analog and digital electronics systems for recording and processing signals from radiation detectors.



TOP: National Bureau of Standards (NBS) staff member sitting at the PILOT computer in 1961. Designed by NBS in 1958, this computer contained three independently programmed systems that could communicate and work together concurrently on a common problem. The PILOT has been called one of the earliest examples of multiprocessor computer architecture. Photo credit: National Institute of Standards and Technology Digital Archives, Gaithersburg, MD.

MIDDLE: Microcalorimeter for radioactivity standards at the National Bureau of Standards. Photo circa 1954. Photo credit: AIP Emilio Segrè Visual Archives, gift of Bert M. Coursey.

BOTTOM: Donald Herriott, Ali Javan, and William Bennett with the first helium-neon laser. It produced a steady infrared beam and was the world's first nonpulsed laser. Photo credit: AIP Emilio Segrè Visual Archives, Hecht Collection.

It clearly made much sense to develop standard detectors, electronics, and data acquisition protocols such that manufacturers could provide nuclear instrumentation components as reliable, off-the-shelf products that met the purposes of these three communities. The IEEE American National Standards Institute (ANSI) Nuclear Instrumentation Committee N42, under the leadership of Louis Costrell at NIST, stepped up to this challenge in the United States. They also provided the leadership in the IEC (International Electrotechnical Commission) Technical Committee TC 45 on nuclear instrumentation.

Radiation detection instruments have benefitted from major advances in physics: first the introduction of inorganic scintillation detectors in the 1960s and then the advent of solid-state detectors (germanium, cesium iodide, etc.) in the 1970s to 1990s. Since 2001 there have been major advances in neutron detectors driven by the needs in homeland security.

2. Are there any tools in the field that you find especially interesting in light of this topic?

Major changes in instrumentation came with the IEEE leadership in standard instrumentation modules. The Nuclear Instrument Module (NIM) bins provide a platform with a power supply that accepts standard components, including preamplifiers, amplifiers, and analog-to-digital converters. USB and other newer interfaces have aided the transition away from custom-built electronics. With advances in computational power, the radiation pulse data acquired is rapidly processed and presented as a gamma-ray radiation spectrum. With an onboard library of gamma-ray spectra, the instrument displays diagnostic information about the source.

3. How do you view the relationship between research, instrumentation and equipment, and the researcher in the field of radiation measurements?

Researchers in these fields use nuclear instrumentation as a tool to interpret radiation interactions with matter. It is not cost effective or productive for them to design the basic instrumentation modules, interfaces, and display systems that they need for their jobs. This gap is filled by fundamental research in radiation physics that leads to new radiation sensors and by the dedicated professional engineers of the IEEE and IEC committees that agree on standard packages and protocols to meet universal needs. ●



TOP: Photographs of a system that was developed for the Atomic Energy Commission designed to monitor radioactive fallout and used during the 1955 atomic bomb tests in Nevada. Left: Control station that includes a radiation monitoring switchboard (bottom), time-gates frequency counter (middle), and digital scanner (top) that supplies printing signals to the printer (right, next to switchboard). Upper right: Typical radiation monitoring station installation. Photo credit: National Institute of Standards and Technology, Gaithersburg, MD.

BELOW: An unidentified member of the National Bureau of Standards Mass Spectrometry Division in 1948 using a mass spectrometer. The mass spectrometer ionized gas at extremely low pressure and measured the mass of the resulting ions. Molecules were identified by their molecular weight and by the molecular weights of their dissociation products. Photo credit: National Institute of Standards and Technology Digital Archives, Gaithersburg, MD.

Send us a note with your thoughts on how physics instrumentation has changed over time at sps@aip.org.



FYI

SCIENCE POLICY NEWS FROM AIP

Science policy affects you— stay informed with FYI



With a 25-year history of consistent, nonpartisan reporting, FYI helps scientists like you know what's happening on the Hill. You can rely on FYI for authoritative information about federal science funding, legislation, key appointees, the administration's priorities, and more.

Sign up for this free email service at aip.org/FYI

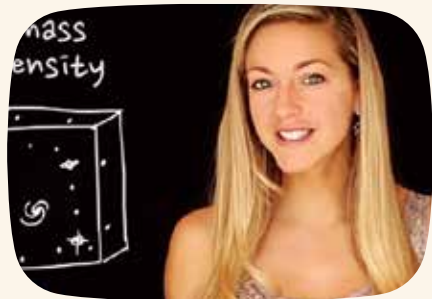
AIP
American Institute
of Physics

Sigma Pi Sigma Favorites: YouTube Science



by Jana Washington, SPS Education Intern

Here are the top results:



Physics Girl, also known as Dianna Cowern, uses her channel to comment on and explain cool physics concepts. She aims to make science more accessible to everyone, including women and girls. Her super-successful videos earned her a place in the Forbes 30 Under 30 education category and won the top video prize from the Alan Alda Center for Communicating Science at Stony Brook University.



Veritasium, a YouTube channel run by science communicator and filmmaker Derek Muller, shares videos that he says are “simply based on truth”. Focusing on scientific misconceptions, great songs, and fun experiments to test viewers’ scientific logic and reason, Muller’s channel has accumulated over six million subscribers!



Kurzgesagt – In a Nutshell focuses on explaining concepts about the universe through science, with infographics. From the concepts of loneliness and optimistic nihilism, to string theory and what would happen if we brought the Sun to Earth, the channel is ideal for the wandering mind, or for someone who just wants to look at awesome infographics.



MinutePhysics, created by Henry Reich (one of the 2016 PhysCon workshop leaders), explains physical science concepts and theories in terms that everyone can understand in five minutes or less. The clear narration and quirky cartoon drawings of MinutePhysics have acquired quite a large following and led to collaborative videos with other science YouTubers too. Check out the channel to learn about the physics of caramel and the shape of space!

In today's world, where technology is the main source of information sharing, people snap videos and upload them without thinking all the time; it's almost second nature to many millennials and Generation Z. From cute videos of kittens to product reviews, YouTube is a wildly popular platform for sharing everything people want to see (and some things people don't want to see!). It's also become a great outlet for sharing science with the next generation.

The SPS National Office asked Sigma Pi Sigma members and SPS students to share their favorite science YouTuber channel. Among them, some have millions of subscribers, some are crash courses for general college classes, and others are focused on specific topics like the science behind beauty products or debunking common misconceptions about the world.

Here are a few other YouTubers that members enjoyed viewing as well:



Vsauce: Created by Michael Stevens and now split into three different channels, Vsauce aims to answer questions about the universe through thinking, finding, and playing.



SmarterEveryDay: This channel is run by Destin Sandlin, who simply wants to get smarter every day and hopes that through his channel, you will too!



Andrew Dotson: Dotson's channel focuses on what it's like to be a physics student. Topics go from applying to graduate schools to explaining complex theories. Ultimately, Dotson's channel offers tips and tricks to survive the undergraduate physics major.



Lab Muffin Beauty Science: Run by Michelle Wong, this channel aims to debunk myths and explain the science behind beauty products.

▶ Don't see your favorite YouTuber listed?
Let us know who it is and why by emailing SPS@aip.org.

Sigma Pi Sigma – A Departmental Legacy of Fellowship

by Brad R. Conrad, Director of SPS and Sigma Pi Sigma and Earl Blodgett, Historian of SPS and Sigma Pi Sigma



What we know today as Sigma Pi Sigma and the Society of Physics Students began back in 1920 at Davidson College, North Carolina, when four students and five physics department faculty members formed an organization to

*... reward high scholarship and promote interest in the advanced study of Physics, to stimulate individual research, to enable its members to keep pace with the progress of the science, and to encourage a spirit of co-operation and friendship among those who have displayed marked ability in this study.*¹

In 1920, the field of physics was still being defined, but it was clear to the founders that something was needed to facilitate student cooperation, friendship, and intradepartment collaboration.

A formal decision to create such a fraternity was finalized on December 21, 1921, but it was immediately apparent to the founding members that they were different than a “social fraternity of the conventional kind.”¹ The organization immediately became a vehicle for change within the department, gave opportunities for individual student and faculty expression, and let its members “talk shop” informally and freely through seminars and friendly gatherings outside the department. While there was a social component to the fraternity, as was customary at the time, the primary focus was on forming a physics-related professional community through shared meals, scholarship, and development of the department.

Discussion topics ranged from social to science—from physics, to astronomy, to what would become several different physical sciences as we know them today. The group aimed to be “an active factor in the life” of its members.¹

While it may seem that physics departments, and indeed, physics students, must be vastly different today than they were in 1921, an article from the December 1931 issue of *The Radiations of Sigma Pi Sigma* suggests otherwise.² That issue highlighted the 10th anniversary of the organization and gave an intimate view into the first meetings of the first Sigma Pi Sigma chapter, or the alpha chapter. L. M. Curie, a founding member, tells *Radiations* readers,

From such a modest beginning, the present organization of Sigma Pi Sigma has grown. From this beginning, however, interest in physics at Davidson has shown a steady increase. The most serious subject for consideration at the first business meeting after organization was a discussion by Price, Brice, and Dew (founding members) as to how much voltage could be

applied to “Wooly” Grey (a member of the first group initiated into the chapter in 1922) without doing him any permanent injury. A moderate voltage was decided upon and applied at a later date.

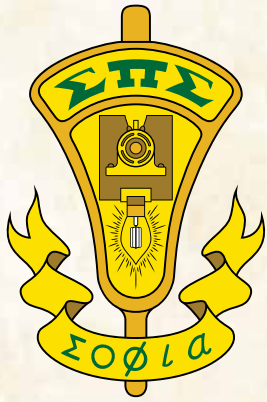
I don’t know if your classmates were anything like mine, but this would have fit right in with discussions we had at my chapter at the Rochester Institute of Technology almost 80 years later. In fact, the last time I hosted an induction at Appalachian State University, we made a pun in this vein about giving “the charge” to new Sigma Pi Sigma members.

Curie goes on to write,

It seems somewhat the irony of fate that among my first efforts for the good of the cause should have been a paper which I presented to the group sometime during the first year. This paper dealt with dry cells and primary batteries in general. As a punishment for that effort, I have spent the last six years finding out that two-thirds of what I said in my first paper was not true—and I have as yet been unable to find out the reason for the truth of the 33-1/3 percent.

More than any words I could write, this quote gets at the heart of what Sigma Pi Sigma is—not just to individual students and faculty but

TOP: Sigma Pi Sigma leadership from 1928. Picture from M. White personal records.



The first public symbol of the organization, a pledge badge, was a horseshoe magnet and was adopted² on February 22, 1922. Excellence in physics was stressed from the beginning, as members of the first class to be inducted into Sigma Pi Sigma “were expected to prepare some paper on a physics topic.”

to a department's sense of identity. Each chapter is a reflection of that department and who they strive to be. The Davidson College members began something that was distinctly its own, something that supported its members and promoted excellence but also could be shared with the broader community of physicists. They saw Sigma Pi Sigma as an agent of change.

It was decided that Sigma Pi Sigma should become a national organization, and on April 12, 1925, a modest expansion program began. A second chapter of Sigma Pi Sigma was chartered at Duke University that spring and a third chapter at the Pennsylvania State University the following academic year. The first national convention of the society was held in 1928, with all six chapters participating. During this period of

time, questions of governance, the constitution, and requirements were adjusted to more closely resemble what we know today. Of great debate was the requirements for chapter activity. Ultimately, it was decided that while no formal requirement for regular meetings or activities needed to be specified, chapters should be ingrained within the department culture, faculty and students alike. Early discussions stressed that membership within the society was regarded as an honor to strive for, yet it was well understood that the chapter should benefit the entire department, so much so that it was decided by the 1928 convention to actively promote the concept and vision of Sigma Pi Sigma to colleagues and other institutions. This resulted in rapid expansion, and by June 2, 1930, there were 19 chapters, with 9 of the chapters being installed in 19 days!

Over the following decades, Sigma Pi Sigma continued to grow and respond to the needs of new generations of physical scientists. Through the early support of Marsh White and several other societies, including the American Association for the Advancement of Science, the American Association of Physics Teachers, and the American Institute of Physics, Sigma Pi Sigma has grown to represent hundreds of departments and continues to serve the needs of students, faculty, and the broader community. ●

1. “Nine Years of Lusty Growth: Visions of Founders of Local Honorary at Davidson College far Surpassed by Substantial Development of Recent Years — A Story of Achievement,” *The Radiations of Sigma Pi Sigma*, October 1930.

2. L. M. Curie, “Letter from Our Founders,” reprinted from the December 1931 issue of *The Radiations of Sigma Pi Sigma*, p. 1.



The Careers Toolbox offers:

job search tips, resume and cover letter guides, skills assessments and more to help you land the right career for you.

Explore your options and find opportunities as a physicist at
www.spsnational.org/sites/all/careertoolbox

The Theologian

Rachel Erin Stuart

PhD student, Hebrew Bible, Emory University Graduate Division of Religion,
Sigma Pi Sigma, University of Rochester, 2012



Photo courtesy of Mary Stuart.

“

Even if you land in the humanities or in the church or somewhere else that people tend to perceive as completely disconnected from science, you’ll find that having that training can help shape the kinds of questions you ask, how you analyze data, and what kinds of patterns you look for.

”

I’m really just a polymath at heart. I started my undergrad studies wanting to go into theoretical physics or possibly music theory, but by the end of my junior year, one too many people had asked me why I wasn’t applying to seminary. Now I’m in the ordination process in the United Methodist Church (UMC), studying for my PhD in Hebrew Bible at Emory University and learning about digital scholarship. In my free time (what little exists), I sew much of my wardrobe, write hymns, and do armored combat and scribal work in the Society for Creative Anachronism, among other things.

I’ve never not wanted a PhD, so I’m thrilled to finally be at this stage of my academic career. I absolutely adore learning languages, and studying the Hebrew Bible is a delightful excuse to learn Middle Egyptian, Ugaritic, Akkadian, and Sumerian, in addition to all the modern languages I’m learning on Duolingo now that I’ve passed my German and French exams.

I also TA regularly—especially at the Candler School of Theology—and am a graduate intern at the Emory Center for Digital Scholarship, working primarily on the Sounding Spirit project. The project is creating digital and print editions of five major books of American sacred music from the late 1800s to the early 1900s.

As part of the ordination process, I’m a provisional elder, both to Emory and to the local church I attend, North Decatur UMC. As the theologian-in-residence I’m responsible for various pastoral tasks that include preaching, leading congregational classes (usually on books of

the Bible), and writing portions of the updated liturgy for our traditional service. I’ve always been a total church nerd and love high church liturgy (the “smells and bells” type of worship service), so the fact that I get to be part of the team that’s making our service a little more liturgical is wonderful.

I already believed the liberal arts approach to education was a good idea when I was young, but it’s been borne out in my career so far—having some training in pretty diverse fields has been indispensable to just about everything I’ve done up to now, and I only want it to become more so as time goes on.

To aspiring physicists, I say stick with it if you really want to be in the field (that goes for anything, especially in academia), but don’t be afraid to let your interests change if they need to—and take physics with you if they do. Even if you land in the humanities or in the church or somewhere else that people tend to perceive as completely disconnected from science, you’ll find that having that training can help shape the kinds of questions you ask, how you analyze data, and what kinds of patterns you look for. If you work with colleagues who are primarily trained in the field you choose, a physics background can bring some added creativity and innovation to your work.

The same goes for those who follow a STEM path: Get as much training in the humanities as you can, because it will change the kinds of questions you ask and the way you approach both your theoretical work and the practical implications of what you do. ●

The Environmental Engineer and “Physics Drifter”

Tracy Williams

Environmental Regulatory Compliance Engineer at GlobalFoundries



Photo courtesy of Tracy Williams.

“After trying to major in mechanical engineering, electrical engineering, and even English literature, I finally learned that there was life beyond academia and research with a physics degree—options like medicine, law, and architecture.”

I like to think of myself as a physics drifter, letting this wonderful degree take me from one mission and objective in my career to the next. I’m currently an environmental regulatory compliance engineer, but I doubt my journey will stop here. My career path has never been steady or straightforward, and believe it or not, that aspect has been great.

At an early age, I found myself very excited by machines with speed: jet planes, race cars, space shuttles, you name it. I didn’t know exactly what I wanted to do—I just knew I wanted to go fast, “shake ‘n bake” like Ricky Bobby. In high school I started to realize that some of my ambitions to “just go fast” wouldn’t pan out. When I landed in a great high school physics class, I began to learn the why and how behind going fast, and my love for the science of the physical grew, propelling me into everything science.

Still, I had no interest in pursuing a physics degree in college. No way was I going to be stuck in a lab coat, fiddling around in a makeshift lab, sporting bad hair while searching for plutonium to power my DeLorean. After trying to major in mechanical engineering, electrical engineering, and even English literature, I finally learned that there was life beyond academia and research with a physics degree—options like medicine, law, and architecture. I was sold, ultimately obtaining my degree in physics and an MS in materials science. During this time I was able to work with the Department of Energy on several projects, including fuel cell work, vapor deposition for nanoscale technologies, and analytical microscopy.

This sort of quirky educational background landed me in IBM’s Microelectronics Division, where I worked as a semiconductor process engineer. Given my background in physics and materials science, I became one of the outlier thinkers in most of the engineering groups I worked with. I could adapt to almost any role because my somewhat complex educational background came down to something fairly simple—I’m a critical thinker who solves problems. I then successfully transitioned to an industrial engineering role, then an environmental operations engineering role, and now I’m an environmental regulatory compliance engineer with GlobalFoundries.

In this role, I’ve been able to use my physics research skills to implement changes in hazardous and nonhazardous waste operations, ensuring little to no harm comes to our environment through the process of microchip manufacturing. Implementing innovative ideas that help to both satisfy the microchip process and maintain a healthy environment is tough at times, but necessary.

On that same pattern of thought—making innovative creations that are environmentally friendly—I recently started a small business to create and build environmentally safe products for everyday life. This is the newest part of my physics drift, and one that I’m looking forward to making great contributions toward.

If I had known, at the beginning of my collegiate career, all the places a degree in physics could and would take me, I would have never doubted pursuing this degree. I’m still not certain where I’ll end up in my career and have never really had a definitive outlook on the end—but that’s what makes this journey all the more exciting. ●

Empowerment and Eärendil's Star

Dwight E. Neuenschwander, Southern Nazarene University



“Empowering the Next Generation” forms the theme of this issue of *Radiations*. I was invited to reflect on changes I’ve seen over generations of physicists and offer thoughts on how I think today’s students will impact the field.

On the changes I’ve seen among generations of physicists, I’ll make a personal observation. The first physics conference I attended brought together over a thousand participants. As a young rookie I was a bit intimidated, unsure of the protocols and etiquette of professional physics meetings. I met a few people and managed a few conversations. For facilitating those catalyzing moments, I especially thank a professor from my undergraduate days, Sallie Watkins, who introduced me to her colleagues. Sallie helped me tunnel through some kind of barrier, so I kept going to meetings. At our next meeting, could we be Sallie Watkins to those standing on the fringes?¹

One can be a first-timer only once, so I cannot say with certainty how social interactions go for first-timers attending large physics conferences today. But I have observation-based reasons to suppose the physics community makes more deliberate efforts nowadays to help first-timers feel part of the club. There are receptions explicitly for first-timers and events that encourage socializing at no extra charge—for a splendid example, the American Physical Society cosponsors the now-expected dance party at Sigma Pi Sigma congresses. When walking around physics meetings today the atmosphere seems more relaxed, with more welcoming openness and diversity than I saw 40 years ago—a work in progress, but encouraging progress.

Regarding future impacts of today’s students, I remember how wise Lady Galadriel in J. R. R. Tolkien’s masterpiece *The Lord of the Rings*

eloquenty expressed the futility of foretelling: “I do not foretell, for all foretelling is now vain: on the side of darkness is hope.”² Nevertheless, Galadriel offered what gifts she could to assist Frodo’s company in their forbidding mission. To Frodo she gave “the light of Eärendil’s star ... [that] will shine brighter when night is about you.” Every generation has faced a future of darkness and hope. Perhaps I can pass along a modest Eärendil’s star consisting of what little wisdom I have gleaned (mostly from others), along with key questions that have helped me in my journey.

If I am expected to say something that will empower the newest generation of physicists, I must confess to having words no more profound than any other physicist my age.³ But I will suggest this to the next generation of physicists: *you are empowered already*.

You know how to ask questions. You know how to use quantitative, evidence-based reasoning. You know how to be open to new ideas

2. J. R. R. Tolkien, *The Fellowship of the Ring*, 50th Anniversary One-Volume Edition (Houghton-Mifflin, Boston, 2004), p. 376.

3. Wise or not, a sample of the author’s previous thoughts on the impacts of SPS and Sigma Pi Sigma on the physics profession and society include “Cutting Across the Lines,” *Radiations* (Spring 1995), pp. 1–7; “Scientific Citizenship: Connecting Physics and Society,” *Radiations* (Spring 2008), pp. 13–14; “Physicists and Dissent: The Obligation of Scientific Citizenship,” *Radiations* (Fall 2008), pp. 19–21; “Applied Physics, Grand Boulevards, and the Social Dimension,” *Radiations* (Spring 2018), pp. 22–25, and other articles in *Radiations* and *SPS Newsletter/Observer*.

LEFT: One way to empower the next generation is through science outreach. That was the goal with this volunteer-made viscosity demonstration, shown here at a Society of Rheology annual meeting outreach event.

RIGHT: Children play with a fluid demonstration during the same event. Photos courtesy of Brad Conrad.

1. Mary Kay Hemenway and D. E. Neuenschwander, “Sallie Ann Watkins,” obituary in *Physics Today*, October 2012, p. 72.

while looking them over with a critical eye, saying, “Is that so, eh? How interesting—but what’s the evidence?” Having earned your degree, you are near the place where Freeman Dyson said of his own journey, “I was now ready to start thinking.”⁴

At this point a steep mountain looms before you. A career must be established, a niche found, respect and reputation earned. It is right for us to climb this mountain, to build on the opportunities we were given. Along the way, sometimes we must do what is expedient—there are school loans to repay, rents to make, mouths to feed. But it’s not only *what* you climb but *how* you climb that makes all the difference. It’s more about the journey than the destination.

In *Zen and the Art of Motorcycle Maintenance*, Robert Pirsig describes hiking in the mountains near Bozeman, Montana, with his young son Chris. Chris starts out full of beginner’s enthusiasm, rushing to be the first to top the next rise. But he soon gets tired and frustrated. His walking becomes clumsy and his attitude degenerates to sullen detachment. Pirsig muses, “When you try to climb a mountain to prove how big you are, you almost always never make it. And even if you do it’s a hollow victory. In order to sustain the victory you have to prove yourself again and again ... haunted by the fear that the image is not true and someone will find out.” He contrasts such ego-climbing to another climb he attempted years earlier in India, accompanying a group of pilgrims ascending a holy mountain. He dropped out, exhausted, even though many pilgrims who made it were less physically fit than he was. They were driven not by their egos but by their sense of the mountain’s sacredness.⁵ The climb was not about themselves.

So instead of asking how we can empower the next generation, I would like to turn the question around and ask the next generation, *Who do you wish to empower?*

As we ascend our career mountain, we catch glimpses of a valley beyond.⁶ It may emerge in the form of the reflective question *Why am I doing what I am doing?*, as doubts grow about what one’s talents are enabling,⁷ as when ...

—You help your company develop an impressive new technology intended to make life easier. But you begin to notice that every technology seems to quickly become weaponized—or produces collateral damage, such as eliminating jobs through automation, invading privacy, diminishing manual skills, undermining human agency, or increasing the scandalous gap between rich and poor.

—You begin to realize that your children don’t care how many papers you publish or how many awards you’ve won. What they *do* care about is whether you *were there* for them. One cannot attend a conference and a child’s piano recital at the same time—that’s a dilemma. Or you wonder why you knock yourself out on a project that maybe only half a dozen people in the world care about. But then, you never know where even the most esoteric research will lead. That’s another dilemma.

The rude but searching question “Why am I doing what I am doing?” begs a deeper question that must be answered first: *What principles guide*

4. Freeman Dyson, *Disturbing the Universe* (Harper and Row, New York, 1979), p. 49.

5. Robert Pirsig, *Zen and the Art of Motorcycle Maintenance: An Inquiry into Values* (Morrow Quill, New York, 1974), pp. 210–211.

6. These metaphors are borrowed from David Brooks, *The Second Mountain: The Quest for a Moral Life* (Random House, New York, 2019), Ch. 1.

7. Tyler Durden, “Google Employees Revolt, Refuse to Work on Clandestine AI Project for the Pentagon” (<https://www.zerohedge.com/news/2018-05-14/google-employees-revolt-refuse-work-clandestine-ai-drone-project-pentagon>), May 14, 2018.

my decisions? In my times of crossroad decisions, this question has been an Eärendil’s star to me, offering a ray of clarity amid confusing darkness. Answering this question precedes effective responses to the “Why am I doing what I am doing?” and “Who do I wish to empower?” questions.

Physics has no lack of problems, and the world has no lack of needs. But my awareness of a particular problem or need does not necessarily mean it becomes my responsibility to remedy. For me to engage the need with joyful effectiveness, there must be impedance matching between that need and who I am. And while little of significance will ever be done if one always waits for the timing to be perfect, timing is important. Before engaging the task I may first have to take care of family obligations, personal issues, or adequate experience. That’s part of the journey. I must listen to my life.⁸ When we know who we are and the time is close enough to being right, when we care deeply for a cause and join with like-minded others in shared commitment, great things happen. Consider a few examples:

—In July 2019, to celebrate the 50th anniversary of the first moon landing, NASA finished restoring the Mission Control room and equipment that guided Apollo 11 in July 1969. In a radio interview, 85-year-old Eugene Kranz, who was the Apollo 11 flight director, recalled,

*... a group of people united in pursuit of a cause, and basically the result was greater than the sum of the parts... There’s an awful lot of future out there, and what you got to do, is you go out and grab it, wrestle it to the ground... You’ve got the skills. You’ve got the knowledge. You’ve got the love, and you’re capable of moving forward.*⁹

—The Cosmic Background Explorer satellite was launched on November 18, 1989, carrying three instruments to measure the cosmic microwave background radiation to unprecedented precision. John Mather, who headed part of COBE’s mission, recalled,

*The three instruments exceeded all expectations. Few people, including scientists, may realize, however, that by the time COBE scientists began making their series of announcements, many team members had been working full-time on the project for nearly two decades, some devoting their entire working lives to it and staking their careers on its success or failure.*¹⁰

—In his recent book, *The Second Mountain*, David Brooks tells of Fred Swaniker, who grew up in four African countries. He won a scholarship to Macalester College in Minnesota, and his degree there was followed by corporate work experience and another degree from Stanford. These experiences were Swaniker’s first mountain. But he “was haunted by the fact that he had been given these opportunities while hundreds of millions of young Africans just like him never would be.” He envisioned a system of African universities that would educate promising students from across the continent. This was his second mountain. As of 2019, Swaniker’s

8. Parker J. Palmer, *Let Your Life Speak: Listening for the Voice of Vocation* (Jossey-Bass, San Francisco, 2000), p. 4.

9. Interview with Eugene Kranz, National Public Radio’s “Morning Edition,” July 1, 2019; see Shannon van Sant, “Former NASA Flight Director Gene Kranz Restores Mission Control in Houston” (<https://www.npr.org/2019/06/30/737327895/former-nasa-flight-director-gene-kranz-restores-mission-control-in-houston>), June 30, 2019.

10. John Mather and John Boslough, *The Very First Light: The True Inside Story of the Scientific Journey Back to the Dawn of the Universe* (Basic Books, New York, 2008), p. xix.

organization has opened the third college of his African Leadership University network. Brooks shares the criteria for commitment—the Eärendil's star—that guides Swaniker:

The world is full of problems, but very few are the problems you are meant to address. When you feel the tug of such a moment, Swaniker advises, ask yourself three big questions:

First, 'Is it big enough?' Those who have been fortunate to receive a good education, who are healthy, and have had great work experiences should not be solving small problems...

Second, 'Am I uniquely positioned...to make this happen?' Look back on the experiences you have had. Have they prepared you for this specific mission?

*Third, 'Am I truly passionate?' Does the issue generate obsessive thinking? Does it keep you up at night?'*¹¹

Frederick Buechner's definition of vocation as "the place where your deep gladness meets the world's deep needs"¹² offers a brilliant polar Eärendil's star.

Sigma Pi Sigma members are hidden and explicit physicists found in all walks of life, a leaven of evidence-based reasoning and physics appreciation sprinkled throughout society. Accordingly, the Sigma Pi Sigma mission statement includes the components of fellowship and service.¹³

The fellowship component reminds us that we live and work in community. Whatever the cause may be in the spectrum of honorable endeavors—from preserving historic aircraft to detecting gravitational waves to stopping human trafficking—a cause can be effective only when it is empowered by individuals who *care* and use their talents with like-minded others in purposed community.^{14,15}

The mission statement's service component acknowledges that to whom much is given, much is required. Sigma Pi Sigma members have been blessed with talent, opportunities, and tenacity. Resources were made available to us. Teachers, mentors, friends, and family were there for us. They cared about us. What can we give back, and to whom, to uplift and empower some segment of society?

On this journey, there is wisdom in borrowing the wisdom of others. Let us listen to South African novelist Alan Paton; University of Vienna psychiatry professor and Auschwitz survivor Viktor Frankl; and the Dalai Lama:

—In Paton's moving novel, *Cry, The Beloved Country*, Arthur Jarvis was a distinguished engineer who became a social conscience in South

Africa during the 1940s, as Apartheid was setting up firmly with the 1948 election of the National Party. Nevertheless, Jarvis persisted in his agitation for social justice and the dignity of all human beings. After his tragic murder, his grieving father found Arthur's personal manifesto, "Private Essay on the Evolution of a South African":

*I shall no longer ask myself if this or that is expedient, but only if it is right. I shall do this, not because I am noble or unselfish, but because life slips away and because I need for the rest of my journey a star that will not play false with me, a compass that will not lie.*¹⁶

—In Auschwitz, Frankl observed a pattern among his fellow prisoners: If one could see a meaning for one's life, then one was more likely to survive. He concluded that "the meaning of life" is not some buried treasure that we are to uncover. Rather, life asks us, *What meaning shall we create out of this marvelous gift of our personal existence?* Frankl wrote, "It did not really matter what we expected from life, but rather what life expected from us."¹⁷ Could it be that life asks every new generation of physicists, *Now that you have equipped yourself with powerful tools, what will you do with them?* This is not a scientific question, but an ethical one.

—In *Ethics for the New Millennium* the Dalai Lama observes the empowerment that come through knowledge of the material world: *Clearly, a major reason for modern society's devotion to material progress is the very success of science and technology ... And we are impressed by the results ... Unfortunately, this devotion encourages us to suppose that the keys to happiness are material well-being on the one hand and the power conferred by knowledge on the other ... [But] knowledge alone cannot provide the happiness that springs from internal development, that is not reliant on external factors. Indeed, though our very detailed and specific knowledge of external phenomena is an immense achievement, the urge to ... narrow down in pursuit of it, far from bringing us happiness, can actually be dangerous. It can cause us to lose touch with the wider reality of human experience and, in particular, our dependence on others.*¹⁸

We as physicists have attained a type of empowerment. If we are to be wise and ethical in its use, what are our responsibilities? *Who* will we empower, and *why*? As for the next generation of physicists "impacting the field," we know our community is far more diverse than, for example, agents of the industrial-military complex. Going forward, the choice of missions and the tone of our profession's interactions with society can expand such public perceptions to include an appreciation of the physics community as an international treasure, respected for coupling its understanding of the physical world to human empathy. Life asks each of us, *What principles guide your decisions? What do you choose as your Eärendil's star?* ●

11. David Brooks, ref. 6, p. 119.

12. Frederick Buechner, *Wishful Thinking: A Seeker's ABC* (Harper, San Francisco, 1993), p. 119.

13. "The Mission Statement for Sigma Pi Sigma," *Radiations* (Spring 1996), p. 20.

14. Umair Haque, "The Real Roots of the Crisis," *Harvard Business Review* (http://blogs.hbr.org/haque/2010/02/the_real_roots_of_the_crisis.html), February 24, 2010. "What really caused the [2008 financial] crisis was the fact that we *didn't care*. ... We didn't care because we were chasing stuff. ... In the name of stuff, we sacrificed what mattered: people, community, comity, trust, education, skill, quality, happiness—and tomorrow itself." Or recall Pirsig (ref. 5, p. 35): "...There is no manual that deals with the *real* business of motorcycle maintenance, the most important aspect of all. Caring about what you are doing."

15. D. Neuenschwander, "For the Love of the Game: It's Not About the Prize," *Radiations* (Fall 2010), pp. 2–4.

16. Alan Paton, *Cry, The Beloved Country* (Scribner, New York, 2003), p. 208.

17. Viktor Frankl, *Man's Search for Meaning*, 17th printing (Washington Square Press, New York, 1970), p. 122.

18. His Holiness the Dalai Lama, *Ethics for the New Millennium* (Riverhead Books, New York, 1999), pp. 9–10.

Congratulations

to the newest members of Sigma Pi Sigma

Abilene Christian University

Michael Arrasmith
Marshall Beard
Alyssa Borquez
Benjamin Wesley Edwards
Zachary David Moses
Roy Salinas
Olive Tuyishimire

Adelphi University

Christian Chong
Thomas V. Danza
Carissa Giuliano
Elias Goldman
James Haddad
Hamid Jalili
Ryan David Kennedy
Ken Mathew Kidangali
Brendan McDougal
Charanpreet Singh

Andrews University

Devin German Garcia
Michael John Lee
Justin Wiley

Angelo State University

Parker James Adamson
Michaela Beth Allen
Wyatt Campbell
Christian James Dempsey
Chelsea Lenae Green
Kara Mckenzie Naegeli
Chevy Ray Robertson
Andrew Russell

Appalachian State University

Robert Evan Martin
Barnes
Kaleb Brookshire
Ryan J. Chicosky
Stewart Fasolak
Lucian Philip Murray

Auburn University

Davis Spence Arthur
Pierce Masters Jackson
Logan Ridings
Samantha Rizzuto
Mason Scott Sake
Brady Unzicker
Grant Roger Wilkinson

Augsburg College

Samuel David Bennyhoff
Brent William La Muro
Javier Pérez Lukes
Peace Neza Sinyigaya
Benjamin Michael Stark
Micah Vandersteen

Augustana College

Jacob Connors
John Patrick McDonough
Mark Sharp
Ivan Starenko

Augustana University

Shannon Dancler
Caitlyn Larson
Charles Schwartz
Trey J. Waldrop

Austin College

Gary Casey

Austin Peay State University

Philip Long
Ivy MacDaniel
Trystan Alan Rogers
Andrew Scott Tadsen

Ball State University

Alsaïd Hosain Alaa
Thomas Michael Alexander
Toner Benjamin
Tyler James Crumrin
Spencer Deats
Korah Elaine Gillard
Nicholas Casey Gilliam
Abu Alkhayr Abdulhamid
Ibtisam
Bradley Keith Shrader

Baylor University

Blake Allan
Jack McHatten Causey
Dustin Lee Sanford
Andrew Zazueta

Benedictine College

Abigail Hickin
Kristy Nixon
Daniel Alexander Pankratz

Bethel University

Jonathan D. Anderson
Tyler Allyn Johnson
Evan Scharnick
Jacob Stein
Kyle Steven Wahlberg

Binghamton University, State University of NY

Robert Beblavy
Steven Blum
Douglas Chadwick
Vincent Cuda
Galo Paez Fajardo
Brandon Gallipoli
Corbin Henry
Nancy Huang
Jake Michael Kaufman

John Kern
Matthew Andrew Krebs
Mary Teresa Mahoney
Chad Nelson
Denis Ryan O'Byrne
Randy Allen Owen

Boston College

Roy Thomas Forestano
Maxwell James Lavey
Nicole Menkart
Eva Pontrelli
Joseph Bruno Schulz
Fengdan Shi
Thomas Tartaglia

Bradley University

Matthew Barber
Tresario DelFiaccio

Bridgewater College

Austin Michael Back
Aidan Fennelly
Rachel Zarin

Bucknell University

Christopher Barber
John Henry Buggeln
Kathryn Childers
Michael A. Gerber
Jae Young Lee
Jeanine Shea
Serena Michelle Tramm

Butler University

Ivan R. Fuller
Austin Jacks
Elise Merchak

California Lutheran University

Javier Berjon de la Parra
Collin Michael Faber
Christopher Jelloian
Richard Eric Rasmussen

California Polytechnic State University - San Luis Obispo

Joseph Robert Crowley
Grant Gilbert
Ryan Tetsuo Mizukami
Mara L. Niesyt
Keilan Finn Ramirez
Jahangir Rassouli
Pranav Jayaram
Seetharaman
Savannah Ashley Silva

California State University, Chico

Andy Beronilla
Joseph Michael Levine

Rejean April Cruz Nuestro
Kirk Williams

California State University, Fresno

Summer Al-Hamdani
Kaelyn Dauer
Katherine Elder
Gobind Singh Puniani
Jennifer Brianne Tyler

California State University, Northridge

Justin Bracks
Nicholas Arturo Carrillo
Christopher Sean DeMellier
Tanya Klowden

California State University, Sacramento

Kai Hu
Andrew Pace
Christina Pino
Jeremy Adam Rowe
Rafael Umeda

California State University, San Marcos

Andrew Benjamin Gonzales
Jesus Alberto Perez
Gary Gregory Scott
Lauren Rose Tafla
Thomas Patrick Toole
Trang Tran

Carthage College

Max Becher
Nathan Fiege
Sheila J. Franklin
Jeremiah Munson
Michael Raymond
Raymond Regotti
Nycole Kristine Wenner

Central Connecticut State University

Jalal-ud-din Butt
James Kulowiec
Amir Omidwar
Christopher Oville
Daniel Pereira
William Andrew Tuxbury

Central Michigan University

Joseph Ausmus
Ramesh Bhandan
Thomas Brewster
Chapman
William Fagan

Katukurunde Kasun
Gayasri Gamage
Alexander Irun Johnson
Gabrielle Nowak
Kamal Sharkas
Philip Mark Snoad
Pelagia Tsintan
Kailong Wang
Adam Zettel

Central Washington University

Kourtney Adkisson
Mohamed Nawwar
Griffin Story Running
Brooklyn Wheeler

Centre College

Kaj den Ouden
Grant Giesbrecht
Henry Wright Gunner
Jin Lee
Charlotte Eleanor Mabbs
RileyAnne Sharpe

Chicago State University

Felicia Davenport

Christopher Newport University

Michael Ryan Anstett
Hayden Andrew Cunningham
Tanner M. Hawk
Jeffrey David McKaig
Michael Andrew Patel
Catherine Sueatis Wells
Carly Wever

Cleveland State University

Anthony Daniel Dobrila
Aubrey Lauren Lokey
Jeffrey Richard Mackey
Maxwell Orseno
Daniel Terrano
Ilona Tsuper

Coe College

Andrew Maurice Gunsch
Derek Hammar
Cole E. Hunzeker
Taylor Mehmen
Anne Ruckman
Joshua Seymour
Rebecca Welch

Colby College

Randall K. Chan
Jacob Hagler
Emma Marta Iverson
Merve Kahraman

Ananta Karki
Joshua Zebulon Keith-Hardy
Yin Li
Cole Turissini

Colgate University

Scott William Adler
Katie Chapman
Brianna Holmes
Jin Huh
Patrick Matulka
Jacob Pilawa
William Rosencrans
Alina Sabyr
Robert Sasse
Jonathan A. Schuldt
Allison Shahidi
Michelle Tebolt
Kristina (Nina) Wittler
Saiyang Zhang

College of Charleston

Katherine Bruce
Timothy Grant Farmer
Bridget Anne Ierace
Payden Lenarue Shaw
Patrick Simonson
Wesley Williams

College of the Holy Cross

Liam Finn Campbell
Wilber Alfaro Castro
Colin William McGurk
Alex Lee Murphy
Nhon Ngoc Phan
Sanchi Saitia
Daniel Taylor
Duy Tran
Chantal Umuhoza

Colorado Mesa University

Nick Wright

Colorado School of Mines

Erik Bensen
Mikayla Bradsby
Adria Brown
Joy Cotie
Forrest Nicholas Doherty
Gabriel Iverson
Sarah Jones
Austin Monaghan
Zachary Parrott
Joshua Stackhouse

Concordia College

Brett Gary Erickson
Cameron Jenson

Connecticut College

Tyler Clark
Dishane Chand Luximon
Manuel Adalberto Rosales

Creighton University

Shrey Ansh
Matthew Butschek

Margaret Glick
Kellan Kremer
Anh Tu Mai
Michael Joseph Merrick
Tomilola Obadiya
Colin Reedy
Mason Rhodes
Sam Ruiz
Adam Sova
John Sunderland

Davidson College

James Michael Barnhill
Samuel George Frederick
Margaret Elizabeth Houck
David Sisson
Toler Hayes Webb

Denison University

Varishta Medha
Lallbeeharry
Ang Li
Sirui Liu
Tran Anh Hai Nguyen
Quinn Plaga
Rahul Shrestha
Xubo Wang

Dickinson College

Adam Baldoni
Julia Huddy
Sophie Dallas Kirkman
Hieu Le
Hongyi Li
Housseem Mhiri
Moyi Tian

Drew University

Luis Muncharaz Duran
Rutendo Jakachira
Shanjida Khan
Jesse Murray
Ryan Joseph Underwood
David James Van Dongen

Duke University

Crystal Burgos
Sara Idris
Giavanna Jadick
Isabel Ruffin
Faris Mouti Sbahi
James Allen Shackford
Nikita Alekseyevich
Zemlevskiy

Duquesne University

Joshua David Baktay
Nicholaus Loudon Trotta
Michael Veltre

East Carolina University

Matthew Burgess
Tristan Kendall Gaddis
Gregory Lapicki
Miranda Susan Lee
Kyle Lingelbach
Justin M. Litofsky

East Central University

Kevann Natazia Burrows
Clayton Dee Henry

Tessa Neeley

Eastern Kentucky University

Matthew Sean Collins
Hannah Jayne Miller
Ian Szyjkowski

Eastern Michigan University

Hunter Austin Daymon
Matthew Ronald Floyd
James Herman
Md Sanyat Rabby

Elizabethtown College

Andrew S. Brndjar
Christopher Carr
Brandon J. Huey
Connor Martin
Alberto Miguez Dominguez
Robert Connor Pavlik
Rebecca Voler

Elon University

Michael Harris Dryzer
Isaac Jonathan Sasser
Daniel James Yameen

Embry-Riddle Aeronautical University - Arizona

Alexander Reed Barrett
Calvin Carmichael
Macayla Jean Carroll
Tristan Croizer
Ashley Elliott
Luke Francis
Joshua Freed
Austin Wayne Luttrell
Måns Johannes Mattsson
Ryder Joseph Moreno
Jacob Philip Muth
Pedro Jesus Quiñonez
Colter James Richardson
Nate Treadway
Brittany Wright

Emory University

Olivia Boyd
Dian Ding
Yulin Gong
Tianshu Huang
Mia Chase Morrell
Alan Christopher Willis
Rohrbach
Ainsley Stanczak
Leon Kiptoo Tare
Qiyu Zhang

Fairfield University

Richard Albert Capobianco
Christopher Michael Costabile
Christine Elizabeth Cunniff
Davis Doherty
Joshua Barros Dougherty
Patrick Evans
Michael L. Lynders
Kaitlyn Elizabeth Nelson

Madison Roberts
Bryan Sepkowski
Alexa Nicole Tyner
Daryl J. Vinluan

Florida International University

Kavon Octavis Bastian
David Boswell
Jonathan Cabrera
Ariana Bueno Castro
Ethan Angel de Para
Rachel Baluja Fernandez
Chase Geiger
Alexa Gerts
Dylan Anthony Jeff
Sebastian Lacayo
Antonio Martinez
Margolles
Alexa Mia Morales
Arlenys Serrano
Kelsey Lynne Shannon

Florida State University

Kelly James Anderson
Elise Marianna Chavez
Robert Michael Goff
Kyle Scott Kehrer
Juan Antonio Martinez
Castellanos
Austin Hunter Reaves
Haley Reid
Daryn Alyse Sagel
Douglas Patrick Schoedel
Aodhan Sweeney

Fordham University

Victoria Rose Cirillo
Haley DeWeese
Weton Jiang
Claire Polacheck
Elizabeth Scacifero
Thomas Stoke

Fort Hays State University

Luke Lloyd Longren
Taylor Martin

Franklin & Marshall College

Enrico Calvanese
Donald James Fasce
Conor Larison
Elisa Panciu
Shubh Punj
Ruosi Sun

Frostburg State University

Zachery David Repp

Furman University

Anna Kathryn Alford
Maxwell Hunter Fisher
Philip Ricciardi
Shelby E. Walcott

Georgia College and State University

Matthew Paul Dallas

Cain Gantt

Georgia Institute of Technology

Jacob L. Campbell
Kenneth Jon Higginbotham
Emily Marie Hollingworth
Bryson Graham Kagy
Adam R. Kull
Douglas Byron
Allen Stewart

Georgia Southern University

Morgan LaBalle
Thomas Mulkey
Hannah Tidwell

Georgia State University

Braven Lyall
Leyla Rohani

Gettysburg College

Mikayla Lorraine Cleaver
Aawaz Raj Pokhrel
Daniel Valette

Grove City College

Benjamin James Carlson
Marc Ebiri
Josiah Samuel Gowen
Tim Magargee
Darin Curtis Mumma

Gustavus Adolphus College

Matthew Blomquist
Tyler R. Brau
Nicholas Brazel
Kathryn Hagen
Ethan James Henneman
Dalton Grant Myers
Robert William Nelson
Daniel Nold
Hannah Nolte
Benjamin Andrew Rorem
Karl Satterlund
Xiaoqi Yu

Hartwick College

Jeffrey Antonio Carvalho
Yury Chernyak
Tyler O'Brien Fish
Nicole Greenman
Gavin Smith

Henderson State University

Joseph Dees
Samuel David Dobson
Gillian Rose Garramone
Thomas Hodges
Michael Patton
Alexander Nicholas York

High Point University

Nathan Jefferson Grinalds
Stephen Craig Walser
Michael Thomas Welter

Hillsdale College

Philip Samuel Andrews

David Forman
Joseph Michael Harvey
Melissa Hutcheson
Sashabaw Niedbalski
Caleb Ramette
Judith Schellhammer

Hofstra University
Benjamin Alexander Lichy

Hope College
Michael Dennis
Scott Joffre
Alexander Robert Medema
Cole Persch
John Christopher Peterson

Houston Baptist University
Sydney Briann Carr
Skylar Gay
Bryce Mortimer
Sara Sharif

Howard University
Iman Y. Ahmed
Jyohomson Dawadi
Kevaughn Kevin Johnson
Pradip Kattel
Rishap Lamichhane

Illinois Institute of Technology
Abdulaziz Abogoda
Guy Lucas Adelman
John Rison Callahan
Brinden Carlson
Whitmaur Castiglioni
Onur Gilanliogullari
Julia Kise
Paulina Kulyavtsev
Spencer Micheal Lee
Yurii Shylnov
Zachary James Sierzega

Illinois State University
Nathan James Bennett
Jordan Edward Brandt-Trainer
Reid Gramm
Zachary Mobile
Anne Moore
Amber Rose Sammons
Chloe Schmidt
Zoryana Smozhanyk
Fabiola Pinto Suarez
Jonathan Sullivan-Wood

Indiana University - Purdue University Fort Wayne
Liam Patrick Carolan
Spencer Joseph Kelham
Nicklaus Mahasena
Veronika Marie Meyer
Anna Patterson
Tyler Brennan Sidwell
Samuel Gilbert Wyss

Indiana University South Bend
Stephanie Cassandra Tallman

Nathan James Walkowski

Ithaca College
Preston James
Countryman
Jerome Fung
Valerie Gugliada
Jesse Hsu
Alexander Anthony Massoud
Robert Melikyan
Liana Rodelli
Samantha Todres
Stavrini Tsangari

James Madison University
Matthew Gregory Baka
Sean Michael Gholson
Adam Golfman
Alexandra Goodis
Tyler Austin Hain
Kate Jennison Holwick
Piper Josephine Smith
Nicole Voce

John Carroll University
Kyle Blasinsky
Ian Michael Glass
Avery Gould
Crew Joseph Weunski

Juniata College
Camden Larson Kasik
Robert Kauffman
Abigayle Grace Shank
Caleb Taylor
Evan Norris Ulrich

Kansas State University
Axel Manuel Campos

Kent State University
Jacob Paul Boyd
Steven David Planitzer

Kenyon College
Maxwell Green
Burke Stephen Irwin
Andrew Lesak
Sarah Murphree
Rachel Nguyen
Georgia Stolle-McAllister
Robert Oliver VandenBerg
Madeline Wade

Kettering University
Raymond Cieslinski
Garrett James Dymond
William Ephlin
Derek Matthew Gee
Cale Gray
Ruth Willet

Kutztown University
Morganne Bennett
Michaela Collins
Anna Faretty
Daniel Alexander Johns
Amanda Portoff
Ryan Rauenzahn
Andrew David Venzie
Taylor Worthington
Austin Zimmerman

Lafayette College
Zachary Bartholet
Nia Burrell
Aditi Desai
Jordan Ashlee Gusdorff

Lamar University
Justin Lee Kirk
Luis Romero
Bonnie M. Ruten
Levi Kenneth Snowden
Steven Williford

Lawrence University
Stephen Deeter
Willa Julia Dworschack
Alyson Fritzmann
Richard McCarthy Kubly
Zachary Manning
Mattias McMullin
Gretchen A. Niederriter
Bricker W. Ostler

Lebanon Valley College
Joshua Miller

Lewis University
Edward Wiss

Linfield College
Joseph Tatsuro Murphy
Joseph Simpson

Longwood University
Luke Alexander Androvic
Sydney Backstrom
Cody Clements
Andrew Allen Garnjost
Austin James Hedges
Derek Edwin Holmberg
David M. Robb

Louisiana State University - Baton Rouge
Sage Belle Ducoing
Katherine Victoria Dugas
Bailey Hutzler
Blaine Harris Irlie
Collin C. Kersker
Breona Symone Leonard
Shanice Manning
Hunter Meyer
Bryce Smith
Aaron Trigg
Dzmitry Vaido
Braden Warr

Louisiana Tech University
Lewis Johnson
Connor Hilton Waits

Loyola Marymount University
Matthew T. Guhl
Nicholas Michael Lozano
Heather Rose Mentzer
Mia Calhoun Mummert

Loyola University - New Orleans
Megan Chelsea Adamson
Grace E. Heath
Mark Jaunet

Nicholas Neal
Kennedi Lynette Turner
Victoria Grace Wilson

Luther College
Nicholas Andrew Behrens
Abigail Annmarie Fahrenkamp
Grace Katherine Seiler

Lycoming College
John Paul Balas
Andrew Brandon
Narshini D. Gunputh
Aaron Christopher Haake
Hannah Naomi Marye
Maya Robin Merhi
Kayla Louise Nowak
Paige Rockwell
Kanta Shiromizu
H. Paul Shuch
Thomas Matthew Van Patten
James Wait

Lynchburg College
Nicholas John Savino

Manchester University
Daniel Baker

Manhattan College
Peter Francis Gilmartin
Sarah Reese

Marietta College
Matthew Chih
David Robert Erzen

Marquette University
Mustafa Abu-Mallouh
Holly Fortener
Michael Mastalish
Aaron Moriak
Ian Ritzinger
Amelia Saveria Ruffolo
Jax Sanders
Kathryn Schultz
Jack Smedley

Marshall University
Emma Lockyer
Rae Stanley
Emily Sutherland
Noah Wigton

Mary Baldwin College
Asch Balaji
Anais Esmeralda Gutierrez
Colette Isabelle Levens
Elyse Genevieve Levens
Emma Marie Rhodenizer

Massachusetts Institute of Technology
Faisal As'ad
Shankar Balasubramanian
Arindam Bhattacharya
Zachary Bogorad
Madelyn Grace Cain
Joseph Nicholas Curti
Dylan H. Hendrickson
Molly Elizabeth Kaplan
Lev Haldar Kendrick

Patrick John Ledwith
Radha Rose Mastandrea
Deng Pan
Saranesh Prembabu
Jianqiao Xia
Tony Zhang

McDaniel College
Shannon Marie Bernier
Francisco Marques dos Santos Vieira
Dimitri Alexander Lezcano

McMurry University
Chandi Renee Chandler
Aaron Stephen Jerome Herring
Mason James Mireles
Jonathan Jacob Samudio
Joseph Watson

Mercyhurst University
Simona Carrubba
Rachel Anne Guest
Rachel Melin Noel

Messiah College
Christopher Benner
Nathan Chan
Keller Martin

Miami University
Benjamin Amend
Subhash Bhatt
Ajithamithra Dharmasiri
Jonathan Fee
Abigail Faye Hurley
Kefeng Jiang

Michigan State University
Justin Bensley
Brendan Boyd
Molly Janasik
Alexa Muethel
Aalayah India Spencer
Abe Yeck

Middle Tennessee State University
Matthew Robert Kurilich
Adam Richardson

Millersville University
Destinee Holloman
Alex Kyler
Joseph Wright

Minnesota State University Moorhead
Melissa Foley
Boston Q. Heaford

Missouri Southern State University
Rabindra Bajracharya
Matthew A. Cruzan
Cade M. Hensley
Maxwell Donald Murphy
Cori Marie Jian Smith
Jency Sundararajan

Missouri University of Science & Technology
Joseph Billing

Jonas Gray Buxton
Joshua Dalton
Kenneth Anthony Vinson
Distefano
Michael Thomas Ellis
Zenon Klok
Nathaniel Page
Nicholas Razo
Peter James Schonberg
David Scott
Ravi Sanjay Shastri
Aaron Silvus
Seth Stubblefield

Moravian College

Madison Sinclair
Kaminskyj
Bryan Kelly

Morgan State University

Derick Buckles
Ramesh C. Budhani
Richard Damoah
Jesse Dampare
Atiyya Davis
Amanda Christine Dotson
Michael Boyd Guy
Ezana Negusse
Joshua Samba
Nathaniel Tyree

Mount Holyoke College

Janae Athia Davis
Emma Grotto
Yijin Guo
Gillian Lauren Hagen
Michaela Heilman
Sofia Lis
Barbara Marquez
Nguyen Nguyen
Victoria A. Parrish
Keelin Quirk
Clara Anneliese Richter
Mary Ann Valerio
Linda Zhang
Ye Zhang

Muhlenberg College

Jackson Davis
Ji Ku

Murray State University

Zach Balleau
Kyle Britton
Shelby Huber
Brevin Jeffery Tilmon

Nebraska Wesleyan University

Jackson Louis Maschman
Adrianna Patricia Vinton

New College of Florida

Mallory Lauren Harris
Leo Hei Kiu Law

New Mexico Institute of Mining and Technology

Nicholas Baldonado
Robert Bentley
Keith Robin McElroy
Corey Anne Pearson
Dylan Ward

New Mexico State University

Jorge Alejandro Garcia
Sarah Garner
Wade Kloppenburg
Ryan Lane
Mason Scott Walls

New York University

Alex Thomas Cushen
Paul Martin Erlanger
Pei-Hsuan (Angela) Hsieh
Mitchell A. Lewis
Sung Ching Liu
Matthew Joseph Mirante
Serah Moldovsky
Aditya Pandey
Alexander Shpylko
Joshua Nicholas
John Tong

North Carolina State University

Jason Cuddeback
Tarik M. Dahnoun
Joshua Stephen Miller
William Miltich
Skyeraid Anne Rothwell
Sreeram Venkat
Timothy Chase Willard
Haouxuan Yan

Northern Arizona University

Jonathan Robert Chin
Samuel David Gilinsky
Jacob Michael Heneman
Mitchell Magnuson
Jake Navas
Brian Szutu

Northwest Nazarene University

Daniel Alan Binkley
Jacob Manzi
Andrew W. Silva

Northwestern University

Theodore Baker
Mark Berger
Kristopher Mortensen
Shaam Murthy Nobel
Riley Campbell Wind
Isabelle Ann Zinghini

Occidental College

Michael (Tao Wang) Kwan
Courtney A. Nelson
Sebastian Salazar

Ohio Northern University

Nicole Mary Braunscheidel
Justin Chapman
Claire Louise Griffith
Travis Maenle
Nathaniel McCutcheon

Ohio Wesleyan University

Alec Nicholas Martin
Akul Rishi

Old Dominion University

Nicolas DeStefano
Corey Jacob Sargent

Penn State Erie, The Behrend College

Colton John Barger
Cole Brown

Portland State University

Marie Vallens

Presbyterian College

Briana Louise Cody
Harrison Fisher
Alyssa Leaman
Preston Robinette

Radford University

Cory Ashworth
William Ball
Zachary Sean Gwyn
Percie J. Lyons
James Noel
Joshua Parker
Trevor Quinten Tidwell

Randolph College

Damien Kyle Douglas
Brandon Michael Kaiser
Jackson Samuel Powell
Jude Quintero
Joe Vazquez

Randolph-Macon College

Dea Santi Alqurwani
Duaine Jacob Benson
Haylie Noel Moore
Tommy Salvato
Zach J. Salvato
Anshu G. Sharma

Rensselaer Polytechnic Institute

Samuel Goodwin
Robert Gryncewicz
Conrad Florentin Meyer
Julian Arman Mintz
Moussa N'Gom
Nicholas Michael Pittman
Timothy Nicholas Tierney
Joseph Vidal

Rhodes College

Aubrey Gray
Phillips Hutchison
Savannah King
Bilal Sohail Siddiq
Zachary James Wall

Ripon College

Antony Gradillas
Jared James Zeman

Roanoke College

Austin Bane
Joseph Carman
Cameron Guernsey
Morgan Heckman
David Lloyd
Duncan B. Maclean

Roberts Wesleyan College

Nathan Timothy Cannon
Jared Scott Sittig
Katelyn J. Wagner

Rockhurst University

Madeline Majors
Kaley Marcinski
Victoria Stradella
Samson Truong
Ceara Van Buskirk
Mai To Vu
Stephen L. Wingo

Rollins College

Jack Gabriel
Lauren Michele Neldner

Saint Anselm College

Joseph Letendre
Nathan Letteri
Victoria T. Milner
Andrew Diego Ortiz
David Philbin
Samuel Patrick Poisson
David Scalia

Saint Bonaventure University

James Michael Kernan
Nicholas M. Martel
Kaylee Stanbro

Saint Mary's College

Peter Thomas Orban
Beth Thomas
Rose Young

Saint Mary's College of Maryland

Nicholas Ryan True

Saint Mary's University

Sawyer Rosner
Alec Schillinger

Saint Michael's College

Ian Bennett

Saint Vincent College

Nicholas Jesse Bohn
Nicholas David Bono
Loukas Anthony Feher
David Mignogna
Justin Gene Newrman
Morgan Smith

Salisbury University

Ellen Berry
Zachary Adam Cioccio
Hannah Rachel Hall
Jake Sands
Cal Wilkens

Sam Houston State University

Clayton J. Ellinwood
Jack James
Brandon Ray Sands

Santa Clara University

Wilder Boyden
Connor Timm FitzGerald
Jaehun Matthew Kim

AJ Joseph Boyle Kraus
Matti Masten

Seattle University

Ethan Christopher Hunt
Neipori Pelle

Seton Hall University

Ibukunoluwa Ifeoluwa
Akintola
William Peter Davis
Nnamdi Ene
Michael Gattas
Isaac C. Guevara
Kimberly Krakower
Daniel Thomas Mahoney
Matthew Joseph Melfi
Patrick Milan
Layla Ogletree
Nicholas James Severson
Kalenny Sin

Sewanee: The University of the South

William E. Koopman
Minju Lee
Youjin Sung
Andrew Michael Werner

Shippensburg University

Conner Oldt

Siena College

Nabila Akhter
Daniel Jacob Allspach
Cassandra Billings
Kim Conger
James Angelo Farnan
D'Annibale
Camila D. Davila Gutierrez
Vanessa Havens
Catherine Hill
Aurelien Hong
Kristen Anna McAndrew
Kent Mohlar
Christian Montero
Samuel Austin Morrison
Lauren R. Pecora
Abril Isabella Pejuan
Martinez
Zainab Raza
Andreas Rosnes
Brandon Smith
Thi My Phung Thai
Daniel Whinnery
Abbi Wright

Simpson College

Jacob Austin
Ian Dean
Nathan Daniel Magalhaes
Kade Allen Tatkenhorst

Skidmore College

Samuel Thomas
Blumenstiel
Lucas Graham
Veronica Mierzejewski
Tiantong Qi
Jeremy Gregoret Wilson

Slippery Rock University

Zane Bayer

Jesse Hansel
Samuel Edward Stanford
Jonathan Trimpey
Panyapit Uareksit

South Dakota School of Mines & Technology

Jonathan Hulscher
Thomas Kadlecek
Abigail Otten

South Dakota State University

Micah Mather

Southeast Missouri State University

Dylan Hill
Siena Senatore
Taylor Shivelbine

Southeastern Louisiana University

Mahitha Koduri

Southern Nazarene University

Rebecca Janka

Southwestern Oklahoma State University

Brock Byron Mason

St. John's University

Yahya Muhammad Azam
InWai Cheong
Reyna Gontaruk
Sedariest Hammond
Alexander Ng
Leanne Kathleen
Doctolero Palisoc
Ryan Lim Pangilinan
Anthony Joseph
Santagata
Christopher Valdes
Linkun Wang

St. Lawrence University

David Bain
Dhimiter Cobani
Benjamin Kelty

St. Olaf College

Kayla Gephart
Isaac John Griffin-Wiesner
Beatrice Gulner
Jakob Andrew Hofstad
Marianne Peterson
David R. Stone
Aaron Harper Swanson
Skylar Whitcomb
Karina Holmes Zikan

Stephen F. Austin State University

Lee Walter Henslee
James Holt
Corina Huether
Abigail Rickards

Stetson University

David Bergstrom
Anna David
Cynthia Lu
Riley E. Reynolds

George Elvis Andrew
Ridgeway

Stevens Institute of Technology

Adam Joseph Coscia
Hao Jia
Ryan Weiss

Stockton University

Aaron Paul Casanada
Jonathan Edward Ely
Briena Feltner
Madison Goodman
Tara Jacobsen
Colleen Lindenau
Matthew Miller
Atharva Manan Naik
Steven Runyon
A Sharo
Steven Joseph Todd

Stony Brook University

Shane Andrews
Justin Ao
Justin Zehan Chan
Benjamin Evan Chase
Matthew C. Cimino
Evan Davis
David Diaz
Kiran Eiden
Bassel El Amine
Maziar Farahzad
Evan Flick
Albert Guo
Kristofer Heller
Daniel Humphreys
Prabhjot Kaur
Cormac Killeen
Ray Kiser
Nikhil Kumar
Luke Kyle Legnosky
Jinzheng Li
Peiran Li
Andrea Londono
Gregory Alexander
Matousek
Jeffrey Michel
Nicholas Miklave
Blair Hanna Ness
Eunji Oh
Edena Samoylovich
Garrett SansSouci
Stoddard
Nasratullah Sultany
Naziul Talukder
Emma Van Nieuwenhuizen
Daniel Welborn
Bowen Yang
Ishmam Yousuf

SUNY Buffalo

Scott Michael Abbot
Nicholas A. Bartelo
Samuel Bednar French
Julia Quebral
Hannah Seppala
Logan Walters
Cameron James Watt

SUNY Fredonia

Michael Joseph
Przybycien

SUNY Geneseo

Alexander Paul Belchou
Jessica Frances Block
Anthony Cooper
Lucas Timmermann Finn
Rebecca Glaser
Trevor John Greco
Luke Holtzman
Sean Patrick King
Matthew Gerard Klein
Laura Kowalski
Sarah Loprieno
Ethan James Nagasing
Katarina Alice Nichols
Jonathan Field Sparling
Barak Forest Oskar
Fischer Stockler
Alenna Marguerite Streeter
John Wilson
Jacob Stephen Wood

SUNY Oneonta

Andrew Baker
Alexander James Idzinski
Mahmmod Jodeh
Melissa Marry
Abigail Anne White

SUNY Plattsburgh State University

James Michael Blaise
Franquiz Arturo Caraballo
Alba
Jace Lenon Lenon
Fuji Maneesai

Susquehanna University

Hannah Cooper
Julia Therese Hutsko
Anne Eileen Loeliger

Tarleton State University

Charles Amsden
Victor Badlwin
Kenneth Evans
Eric Scott Hall
Christopher Brian Marble
Matthew Lawrence Ussery

Texas A&M University - Commerce

Joseph William Barnett
Shandi Marie Groezinger
Frank Hall
Macon Andrew Magno
Michael Xavier Ross
Micalyn D. Rowe
Alexander Noble
Westbrooks

Texas Lutheran University

Andrew Hunter Hamilton

Texas State University

Md Hanif Ibne Ali
Ian McCoy Anderson
Augustus Arbogast
Mary Bowling

Charles Condos
Mitchell Timothy Ford
Selena Rose Najar
Xandria Raemyn
Quichocho
Keith Richard Rodriguez
Erin Schipull
Samuel Federico Zamora

Texas Tech University

Hawra Alghasham
Madeline Brown
David Do
Madeline Louise Lockhart
William James Milestone
Karen Esther Navarro
Jake Noltensmeyer
Binod Rajbhandari
Jacob Siau
Giammarco Turriziani
Colonna
Montana Niccole Williams

The Citadel, The Military College of South Carolina

David Allen Clark
Austin Jowers
Landon Ford Madden
James Rea Quimby
Joshua Michael Roides

The College at Brockport, State University at NY

Nolan Joseph Coble
Andrew H. Rowley

The George Washington University

Shannon Babcock
Miya Bernal
Eric Boulter
Bryce Fallon Halter
Zachary He
Morgan Gae Joyce
Bethany Cobb Kung
Kyuchool Lee
Steve Mackwell
Illa Moskowitz
Jane Louise Peabody
Elizabeth Rossi
Jason Taylor Starita
Cameron Swanson
Chen Zeng

The Johns Hopkins University

Hanru Sun
Jason Fan
Andrew King
Travis Leadbetter
Melissa H. Mai
Aidan Joseph Reilly
Sydney Rae Timmerman
Turner Woody
Katherine Molly Xiang

The Ohio State University

Collin Thomas Christy
Ian Martin Dela Cruz

Andrew L. Ehrman
Evan Fitzmaurice
Ari Josephson
Cameron Klos
Jessica Kulp
Nathan Lachner
Luca Lavezzo
Kevin Lee
Brandon Manley
Joey Masters
Davis McClellan
Brandon Raymond

The University of Scranton

Benedicto Arbizo
Sergey Gnilyopat
Samantha Lynn Kyle
Camille Mikolas
Victoria Norman

The University of Toledo

Christina Poduska

Thomas More College

Matthew Joseph Shaw

Towson University

Nicholas Boecker
Jonathon Michael Cartelli
Joseph Cartelli
Mack Adrian Dela Cruz
Kelsey Samantha Glazer
Colin David Hamill
Miriam Hiebert
Hristo Ivanov
Maegan Jennings
Timothy William Koeth
Benjamin Lukk
Meaghan McDonald
Daniel Wangunwa Pimbi
Caiin Reamy

Trinity College

Aashwin Basnet
Alexander David Bellas
Parker William Brown
Donovan Ross Palmer
Hadley Santana Quieroz
Fumihiro William Tamada

Trinity University

Zachary Jones Carter
Madelaine Griesel
Frances Stone
Yian Xu

Truman State University

Kevin Alexander Barrow
Brent R. Koogler
Angelina Partenheimer
Hannah B. Sechaga
Jordan Elizabeth Shroyer

Tufts University

Natalie Bohm
Elias Jerry Marcopoulos
Courtland Stevens Priest
Michael Rosenbaum
Kristen Lynne Schretter
David Quan Tu
Joao Marcos Vensi Basso
Susan Zec

Union University

Daryl Lane Crouch
Davina Amaris Norris
Jonathan Graham Van Neste

United States Air Force Academy

Lachlan T. Belcher
Marcus Brinker
Kayla Brown
Zachary Condon
Francesco Jozac Echeverria
Patrick Gresham
Joseph Haefner
Cameron Harris
Michael Jacoby
Casey Kowalski
Cory Lane
Jacob Malloy
Gabrielle McClelland
Daniel James McIlhenny
James Scoville
Jefferson Braxton Sesler

United States Military Academy at West Point

William Addy
Jarrod Austin Broussard
Alexander Steven Chung
Jared Matthew Cochrane
AnnaMaria Bonilla Dear
Anthony John DiNallo
Timothy Donnellon
Eric Dragland
Isaac Ferrell
Brendan Guenther
Christopher L'Amoureux
Dylan Lapore
Madeline Leahy
Josephine Marie Marsh
Anthony Martin
Meaghan McGovern
Scott James Nieboer
Benjamin Petrella
Taggart Joseph Solomon
Seth Michael Thompson
John Everett Von Kleeck

United States Naval Academy

Andrius Vytautas Bernotas
Charlie Kim

University of Arkansas

Lucas Harrington
Justin James Ryan
Logan Siems

University of California, Irvine

Kyle Jerry Callahan
Tejas Jagiesh Dethé
Gregory Ryan Krueper
Yiwen Xiao

University of Central Florida

Hunter N. Cannan
Geoffrey Garrido

Matthew Alexander
Reinhard

Andrew Silverman
Spencer Tamagni

University of Cincinnati

Korash Dorien Assani
Sarah Elizabeth Carl
Rajpreet Kaur
Roberto Carlos Mandujano
Joseph Clayton Peacock
Nathaniel Quinton Willis

University of Connecticut

Brian Barrette
Robert William Bickley
Amelia Michele Anne Boutier
Henkel
Cong Hu
Josh Anthony Machado
Matteo McDonnell
Edward F. McManus
Giovanni Ninivaggi
Zachariah Rankin
Paul William Simmerling

University of Dayton

Rachel Adams
Logan Cordonnier
Kyle Thomas Hagan
Danielle Smith

University of Houston

Galen Lytle
Jimishkumar Patel
Daniel Maddox Scott
Hilary Utaegbulam

University of Kansas

Andres Abreu
Zachary Flowers
Allison Kirkpatrick
Brendon Cory Madison
Duncan Cavanaugh
McGraw
Quinn Meier
John Joseph Pace
Hartwin Peelaers
Grayson Petter
Christophe Royon
Jordan Scharnhorst

University of Louisville

Meghan Carrico
Bryson Clifford
Anjali Kanwar
Wade Brenner Roemer
Thomas Edward Rosbottom

University of Maine

Kyle Patrick Blum
Justin Brown
Christopher Butler
Kendall Jon Butler
Arianna Giguere
Aidan Greenlee
Jacob Marchio
Aidan Lee Peacock
Nicholas Soucy

Benjamin Thompson

University of Maryland - Baltimore County

Peter Braunschweig
Adurshsiva Iyer
Phoebe Sandhaus

University of Maryland - College Park

Vivan Carvajal
Benjamin Scott Flagg
Anna Grafov
Ruhi Perez-Gokhale
Orlando M. Romeo
Timothy Joseph Taylor

University of Massachusetts - Lowell

Alyre Jean Blazon-Brown

University of Minnesota

Jonathan Michael Brashear
Amanda Gatto Lamas
Tanner Stephen Leighton
William Hobart Pannell
Tien Vo

University of Mississippi

John Phillips

University of Missouri

Carly Brown
Benjamin Gabriel Krewson
Anthony Joseph Puleo
Matthew Snyder
Matthew Soehngen

University of Nevada, Las Vegas

Keoni Castellano
Dylan Edward Durkee

University of New Hampshire

Evan H. Jones
Nicholas Raymond Larose
Jordan Loll
Thomas A. Manion
Asher Staunton Merrill
Ryan Williams

University of North Carolina Asheville

Shannon Bonomi
Makennah Bristow
Tiffany Shreves

University of North Carolina Charlotte

Christopher Scott Avery

University of North Carolina Greensboro

Mason Glenn Casey
Seth Chaffin
Ian David Gallagher
Jackson Tyler Hales
Lindsay R. House
Jackson Leonard

University of North Carolina Wilmington

William Thomas Jarratt

Christian M. Koertje
Conner Lester
Amber Link

University of North Georgia

Seth Shirley
Michael Steven Testagrossa
Ella Camille Wasiluk

University of Northern Iowa

Mitchell James Anderson
Dylan Tylor Blattner
Taylor Ann Harris
Zachary Heinzman

University of Notre Dame

Nicolas DeBickero
Matthew Douglas Kevin Drnevlch
Umesh Garg
Cameron Gorsak
Taylor Michelle Hernandez
Zachary Huber
Patrick Link
Walter McLallen
Patrick James Millican
Maciej Wojciech Olszewski
Erik Robert Peterson
Anne Katherine Stratman
Judah Emmanuel Van Zandt

University of Pittsburgh

Andrew Aukerman
Grace E. Chu
Meghan Cilento
Alex Haidet
Emily Ann Harris
Mairead E. Heiger
Peter Hu
Joseph Nelson
Mariya Alisa Savinov
Connor Wallis

University of Puget Sound

Tom Daligault
Julian Long
Aidan Lee Roeser
Schumann
Patrick Zimmerman

University of Richmond

Omar Alonso Aguilar
Matthew Heyrich
Xiaodi Hu
Lillian Hughes
Jackson Leviness
Connor Addison Painter
Michael Wyatt
Mason Zadan

University of Rochester

Natalie Allen
David Anuta
Jeremy Leonard Atkins
Carter Ball

Leesa Brown
Kurt Callaghan Cylke
Wei Fan
Aaron Goldin
Yunze Li
Tyler Jay Mason
Ethan Walter Otto
Yufan Qie
Adina Ripin
Ethan Henry Savitch
Tasha Schapiro
John Siu
Chengyuan Wang
Yue Wang
Nathan Wies
Fatima Zaidouni
Alexander Zavriyev
Ruiyu Zhou

University of San Diego

Hans Broders
Luke Thomas

University of San Francisco

Alexis Isabel Casas
Nicholas Eremita
Trysten Hess
Nada Khogeer
Andrew Pilon
Chris Storfer

University of South Florida

Chandler Jordan
Armstrong
Nicolas Pichette
Alexander Walker

University of Tennessee, Chattanooga

Sara Bey
Jordan Madrigal
Benjamin R. Smith

University of Tennessee, Knoxville

Noah A. Crum
Ashley Holt
Hannah E. Miller
Catherine E. Sylvester

University of Texas at Austin

Jesus Alberto Botello-Esquivel
Alice Michelle Burington
Joseph Alexander Guidry
Zachary Kuklinski
Andrew Kenneth Manchester
Peter Smith

University of Texas at Dallas

Jacob Eric Davis
Bojana Ivanic
Guillermo Suarez

University of the Cumberland

Dustin Hensley

Joshua Barry Isenhoff
Lydney Short

University of Vermont

Elizabeth Andrew
Abby Postlewaite
Joseph Robert Turner
Jiangyong Yu

University of Virginia

Joey Nicholas Clement
Colin Carncrose Crovella
Benjamin Devico
Kyle Fielman
Katherine Ann Maddock
Daniel Mills
Eric Rohr
Lingnan Shen
Ryan McLean Taylor
Jillian Ticatch
Adam Turflinger
Alison Joy Verster
Jasmin Elizabeth
Washington
Andrew Wilkers
Alex Xia
Yara Yousef

University of Washington

Landon Bevier
Ana Isabel Duarte
Kasey French
Noah Hoppis
Maxim Amon Karrenbach
Siu Cheung Lam
Kuan-Wei Lee
Timothy Mathew
James Francis Ragan
Danila Sergeevich
Sokratov
Yingtao Song
James Walker Steere
Matthew Stortini
Zining Zhu

University of Washington - Bothell

John McBride Bayley
James Bensen
Paola Rodriguez Hidalgo
Mitchell William Mote
Mikayla Musser
Elyssa Brianna Roeder
John Waldroup

University of West Florida

Leah Gross
Korinna Welch

University of Wisconsin - Eau Claire

Kyle Christopher Glaeser
Jidong Gu
Whitney Mottishaw
Cameron Michael Severin

University of Wisconsin - La Crosse

Peyton Aplin
Danielle M. Barmore
Leah Clark
Harold Robert Hart
Martin Balzer Meier
Jacob Pfund
Zarif Mubassir Rahman
Trenten Andrew Smith
Hanna Zanchó

University of Wisconsin - Parkside

Chloe Teal Calderon
Michael J. Connolly
Sean Franklin
Lukeus Wayne Perez

University of Wisconsin - River Falls

Dalton Andrew Anderson
Bilal Asif
Madison Dudek
Nicholas Hovel
Maxwell John Kiernan
John David Lowery
Jonathon Maples
Lindsey Murry
Hanna Richards
Rachel Schnell
Austin Smith
Emily Swanson
Amy Zingsheim

University of Wyoming

Jacob Center
Aman Kar
Rachel Parziale
William R. Scougale
Ethan James Taylor
Jesse Bryant Winner

Ursinus College

Jason Bennett
Veronica Fried
Bianca Rose Gualtieri
Benjamin Raymond Klybor
Brittani Schnable
Lisa Skiles

Utah State University

Noah Braeger
Kripa Nidhan Chauhan
Neal R. Criddle
Zachary Gibson
Brock Halling
Trevor Harshman
Matthew Thomas Hogan
Christian Michael Lange
Han Kyu Lee
Madison Mortensen
Alexandra Hughlett Nelson
Cade Pankey
Trevor Vincent Taylor
Kerstin Ell Tingey
Mubarak Sulaiman
Ukashat

Vanderbilt University

Dylan Folsom
Cameron Elaina Norton
Erich Stephen Remiker
Keefer James Rowan
Joshua Seabaugh
Thomas Patrick Skacel
Cheng Tao
Hansen Wu
Timothy M. Zaklama

Virginia Military Institute

Vincenzo J. Ferrari
Lane Kieler
Li-Hsing Lai
Jonathan Rockford Murray
Ethan Zane Severns

Virginia Polytech Institute and State University

Orien Joseph Altman
William Philip Banner
Patrick Robert Crandall
Kevin J. Diaz
Diego Guerra
Nicholas Treptor Hurtado
Anri Karanovich
Tommy Lam
Bikun Li
Varun Mathur
Darius Mattson
Olti Myrtaj
Vivek Sharma
Ho Lun Tang
Eli M. Welch
Hong Yao

Wake Forest University

Elmira Alipour
Richard Dudley
Austin French
Chris McAvoy
Daniel Nealon
Fernando Jose Rigal
Jacqueline Zhu

Wartburg College

Darby Marie Kramer
Codey Olson
Justin Schoppe

Washington & Jefferson College

Brianna Rose Billingsley
Abigail Dodson
Sean Dugan
Kiera MacWhinnie
Christopher S. Madia
James Anthony Mastran
Megan Laurel Perry
Andrew David Rockovich
Krista Jo Sudar
Sami K. Zimmo

Washington and Lee University

Elise Baker
Laura Bruce
Daniel Clark
Kathryn Blair Fagan
Sho Michael Gibbs
Fady Gouda
Lauire Jones
Anthony P. Lorson
Will Medick
Griffin Noe
Perry Siehien
Matthew Withers

Washington University in St. Louis

Blake Bordelon
Ryan Juien Chang
Patrick Gardner
Benjamin Grobstein
Jordan Pack
Frederic Cecile Reu
Jeremy Nathan Shapiro
Ryan Wahidi

Wayne State University

Ibrahim Chahrour
Khalil El Dairi
Christopher James Issa
Efren Munoz
Joseph Pakizer
Alan Michael Stoelton
Shreya Sutariya

West Chester University

Joseph Backowski
Sean Cadden
Garrett Compton
Alexander Lowry

West Virginia University

Arwa Alyahya
Billy J. Cole
Kenneth Sible
Anna Katharine Turner

West Virginia Wesleyan College

Richard Calo
Virginia Lyn Martin
Anna Puigvert i Juan
Baylee Senator
Joshua Yancosek

Western Kentucky University

Alexander Banaszak
Andrew Davis
Jacob Dobler
Alex Edmond Henson
Will Marsh
William Poteet
Taylor Robinson

Westminster College

George Paul Huncik
Jacob Staub

Whittier College

Evan C. Arns
Nicholas Orlando Clarizio
Dallas DeHart
Nicholas Haarlammert
Derek James Janoski
Aaron Alexander Mendoza
Naya Sarab Sawah
Cassady Smith

Widener University

Christopher Bryce Martin
William Jewell College
Kyle James Bartz
Graham Chambers-Wall
Catherine Dema

Wittenberg University

Anna Beggs
Jake Bertemes
Joshua Darang
William Taylor
Victoria Ruth Toetz
Hannah Weaver

Worcester Polytechnic Institute

Sathwik Bharadwaj
Jacob Nicholas Bouchard
Alexis Taylor Buzzell
Dominic Othneil Chang
Atanu Chatterjee
Benjamin H. Child
Patrick Devin Fitzgerald
Kateryna Kushnir
Friedman
Darien Gaudet
James Leonard Kingsley
Matthew Lund
Shaun Alan Marshall
James Patrick McClung
Andrew Mendizabal
Nathaniel Mione
Erin Mae Morissette
Sayed Iman Mousavi
Dung Ngoc Pham
Paula Sarrion Silvestre
Aline Natalie Tomasian
Taylor Trotter
Steven Vandal
Bryannah Voydatch

Xavier University

Lillian Haerr
Joseph A. Lanier

Xavier University of Louisiana

Amani Christopher
Kayla S. Freeman
Carrie Elizabeth Johnson
Chinyere Jones
Tyler Noelle Kelly
Ashley Montgomery
Imari Parham

Radiations

American Institute of Physics
1 Physics Ellipse
College Park, MD 20740

DONATE TODAY!

Sigmapisigma.org/sigmapisigma/giving



Annual donations from Sigma Pi Sigma and SPS members help ensure the future of the physical sciences.

Your donations help us continue to encourage and support undergraduate physics students with scholarships, career resources, and professional development.

Donations help provide travel support for students to attend Sigma Pi Sigma Physics Congresses, research grants, scholarships, and much more!



**LIVE
STREAMING**

Please join us

**phys
con**
2019 Physics Congress

November 16th | 2:45 p.m and 7:45 p.m EST

Livestreaming of two 2019 Physics Congress plenaries:

www.youtube.com/user/SPSnational