the SPS Observer

Volume LIII, Issue 1

SPRING 2019

BIG LABS:

Impacting the World in Big Ways

+ Breaking Boundaries in Breakout Sessions
+ SEES: An Opportunity for Students to See Themselves as Physicists
+ Not-So-Difficult Transitions

SPS Chapter Report

Submission Deadline: June 15

Why Chapter Reports are Important:

- Maintain chapter health, success, and growth by reflecting on the year's events
- Provide guiding template for your chapter's future SPS members
- Determine chapter's strengths and weaknesses
- Share your chapter's best practices with other SPS chapters
- Gain national recognition for your hard work through an Outstanding Chapter Award

What to Include in Chapter Reports:

- Contact information and statistical data for your chapter
- Chapter's participation in SPS National Office programs and use of National Office resources (scholarships, internships, chapter and individual awards, Careers Toolbox, GSS, demo and outreach tools)
- Attendance at zone, regional, and national meetings
- Interactions within your chapter
- Examples of activities include: bad physics movie nights, liquid nitrogen ice cream socials, alumni career panels, colloquia
- Interactions with other SPS chapters, campus clubs/ societies, or your local community
- Examples of events include: "Pi a Professor" day, Harry Potter Family Fun Nights with your Library and Chem Club, outreach events at local museums
- Your chapter's Sigma Pi Sigma inductions and activity
- Blake Lilly Prize applications
- Pictures, news clippings, links to the chapter's social media accounts

For Information regarding chapter reports visit **spsnational.org/chapter-reports**.

Start your data collection now to make completing your report a breeze!

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AIP American Institute of Physics

the SPS Observer

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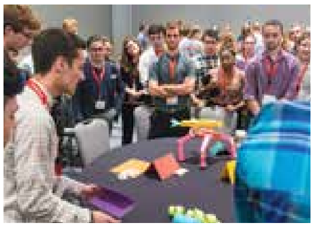
Inside ALICE detector's empty skeleton at CERN. Photo by Julien Ordan/CERN.



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Job or Grad School?

iOS or Android?

Edison or Tesla?

Coffee or Soda?

CAREERS TOOLBOX

www.spsnational.org/careerstoolbox

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.

GradSchoolShopper.com

www.gradschoolshopper.com

GradSchoolShopper offers the most complete set of data on graduate programs in the physical sciences to help you find programs that fit you best.

Mikayla, SPS Intern 2018, Gettysburg College

SPS DOESN'T HAVE ALL THE ANSWERS, BUT WE CAN HELP YOU WITH WHAT HAPPENS AFTER GRADUATION.

SPS

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SPS and the Physics of Connection

by Megan Anderson, SPS Member, William Jewell College

Physicists live in a world of relationships… at least mathematically speaking. From beginning studies of Newtonian mechanics to ongoing research for a theory of everything, people connected to the field of physics seek to better understand reality through the interconnectedness of physical phenomena. This work of learning and discovery can be exhilarating, and mathematical relationships are crucial to its development.

Human relationships aren't nearly as fundamental to the study of physics, and there is nothing very "scientific" about them. However, these relationships are fundamental to our development as scientists.

Like many students, I began my physics degree without really knowing what it would entail. Equipped with far more enthusiasm than ability, I joined the email list for my school's SPS chapter and decided to attend an event. I hoped I would meet some nice people along the way, but I expected it to end there. Little did I know that this physics community offers far more than familiar faces—it cultivates friendships.

As SPS members, we can experience the physics community through multiple avenues: our local chapters, affiliate zones, and, every so often, through coming together as an entire organization for PhysCon. This last form of connection is by far the rarest, which is why I'm really excited about *Making Waves and Breaking Boundaries* this November. The 2019 Physics Congress will give us the opportunity to learn from incredible physicists, tour state-of-the-art research facilities, and present our own research. Perhaps more valuable, however, is the way it will grow our physics community, promoting the kind of atmosphere where a famous scientist is just as approachable as a fellow student.

HERE ARE EIGHT WAYS YOU CAN PREPARE FOR CONNECTION AT PHYSCON:

1. Go over the spherical cow metaphor
Be ready to smile knowingly when you see it floating around on SPS merchandise. Plus, use it as a friendly reminder of the ways our assumptions sometimes limit us.

2. Read about the plenary speakers
The speakers are remarkable people! You never know who you may run into at a workshop or lunch table. Having background knowledge on the speakers will help you appreciate their talks even more, and it can give you talking points in case you find yourself sitting next to one of them. One great thing about PhysCon is that you can make connections with anyone, even notable physicists and Nobel laureates.

3. Get your contact information ready
Is email your go-to? Have you been meaning to create a LinkedIn account? Do you have business cards? You'll want to have some form of contact information available so you can stay connected with new friends and professional contacts after PhysCon.

4. Make a research poster for the student poster presentations
Are you doing research or do you plan to this summer? A research poster is a chance to show off your research and discuss your work with other physicists, both aspiring and experienced. Don't worry—there's a template on the SPS website you can use to help format your findings. Once you make your poster, ask a friend to listen to you talk about it. This will help you know what needs further explanation, and you'll feel much more comfortable once you're presenting during the actual poster session.

ABOVE: Megan Anderson. Photo courtesy of SPS National Office.

5. Apply for an SPS Travel or Reporter Award
If you're planning to present research at PhysCon, you may qualify for $200 that can go toward the cost of your trip. If you're more interested in writing than in research, try applying for the Reporter Award instead. It provides funding for students to document their time at PhysCon, interview leading physicists at the congress, and write about it. Your piece may even be featured in a SPS publication such as the *SPS Observer* or *Radiations*!

6. Learn more about Providence, Rhode Island
You may want to look up restaurants or local attractions to visit during the off-hours of the congress. You'll be in the capital city of Rhode Island, home to a lot of history as well as fun. Exploring the city with fellow PhysCon attendees is another great way to bond with each other.

7. Design a T-shirt your chapter can wear with pride
This will give you the chance to share the uniqueness of your chapter and enter the T-shirt design contest at PhysCon. Make sure your chapter brings enough shirts to participate in the exchange session where you'll be able to see what other chapters are doing across the country and swap extra shirts. (Plus, who doesn't like a good tee?)

8. Think about what is and isn't working for your SPS chapter
You're about to attend an event with literally HUNDREDS of other people going through a similar experience. It's a perfect time to learn from one another.

From once-in-a-lifetime conversations to ongoing friendships, we physicists gain a great deal of insight and inspiration when we connect. I hope you're able to join us for this powerful event! //

Want to know more about PhysCon 2019? Go to sigmapisigma.org/congress/2019.

For more information on SPS Travel and Reporter Awards, visit spsnational.org/awards.

LEFT: Josh Carroll. Photo courtesy of Josh Carroll.

Josh Carroll

BS, Physics, Radford University

Earning a physics degree is challenging under the best circumstances. Josh Carroll's roundabout path included three deployments, a dirty library, a security van, community college, two years of nothing but math and physics classes, and countless YouTube videos.

How he got to physics:

When asked to "draw yourself in the future," a much younger Carroll drew himself in a lab coat with beakers and a telescope. That passion for academics and science stayed with him until the terrorist attacks of 9/11. Then a ninth-grade student, Carroll's priorities shifted, and schoolwork took a back burner. Eventually he left high school with a GED and joined the army to "go overseas and fight."

After returning from his first deployment, to Iraq, Carroll took a job as a school janitor. He would browse books as he cleaned the library at the end of the day. "I found a book, *A Brief History of Time* by Dr. Stephen Hawking, and I started reading it. It retriggered my desire to know more about the universe and to understand how things worked."

After reenlisting and being deployed twice more, Carroll went back to school. He wanted to study physics, but with only a geometry-level math education, he was far behind. The summer before his last semester of community college, Carroll took an uneventful job as a night security guard during which he taught himself calculus via YouTube videos. After that semester ended, he spent three and a half weeks learning trigonometry, again from YouTube videos, before jumping into the physics program at Radford University.

After an intense two years at Radford, Carroll graduated just shy of the top of his class. His roundabout path to a physics degree isn't one he would recommend, but his persistence paid off. "I knew I wanted to be a physicist, and I knew there was no going back," he says.

What he does now:

After graduating, Carroll spent six months with ComServe Wireless as a data analyst and inventory specialist before a recruiter from Booz Allen Hamilton noticed his résumé and reached out. Carroll is now a scientist and systems/electronics engineer for the consulting firm.

Booz Allen Hamilton is a global firm that works with civil government, private-sector, and military clients to solve problems in defense, energy management, health care, and other sectors. Carroll's primary role is to ensure that computer systems and network servers interface with one another as intended. This involves troubleshooting, researching technical components, and traveling to different project sites within the United States.

"I was very much in the theoretical realm of physics, so landing an engineering gig was a bit different than what I had been exposed to through school," Carroll explains. In physics you work with ideal situations, broad generalities, and theoretical frameworks, but in engineering you can't do that, he says.

LEFT: Landis on a Lunar and Planetary Laboratory field trip in Death Valley. Photo by Maria Steinrueck.

Margaret E. Landis

BS, Physics and Astronomy, Northern Arizona University, & PhD, Planetary Sciences, University of Arizona

What she does:

Landis is a postdoctoral research scientist at the Planetary Science Institute (PSI), the largest nongovernmental employer of planetary scientists. She creates numerical models that help interpret data collected by Dawn, a NASA spacecraft that visited the protoplanet Vesta and dwarf planet Ceres to learn about the evolution of the solar system.

How she got there:

"I was always interested in space (probably from watching a lot of *Star Trek* as a kid)," says Landis. "What really got me into space science and physics was watching the Jet Propulsion Laboratory control room during the *Spirit* and *Opportunity* rover landings and seeing the first images come back. I wanted to see new landscapes on other planets for the first time."

With this goal in mind, Landis pursued a bachelor's degree in physics and astronomy and a PhD in planetary sciences. As a graduate student, Landis got a taste of what it's like to be a researcher in academia and, through an internship at the United States Geological Survey Astrogeology Science Center, in a federal agency. Part of the appeal of PSI was the opportunity to work at a nonprofit research institute. She explains, "Like any good scientist, I wanted a little more data before I made a decision about where I wanted to spend the rest of my research career."

Best part of her job:

"I really enjoy looking at the data sets, whether they're new or archival, and working with them to better understand the geologic or climatological history of a region. As much as I love making sure my code runs and my numerical models are realistic, I really enjoy being able to use those models to interpret what we're seeing in the data."

Most challenging part of her job:

"I'm particularly feeling the pressure and challenge of writing proposals at this point in my career.

"Things aren't ideal anymore." Instead of working out the orbits of black holes at a chalkboard, he's now researching how to make sure one server connects to another server given specific constraints. "It all comes down to problem-solving in the end, but it's a different lens."

Looking forward:

Booz Allen is Carroll's first "big job" outside of his time spent in the army, and he's grateful for the opportunity to expand his skill set and explore a career path outside of academia. He enjoys the responsibility and freedom of contract work, travels frequently, and has access to a lot of resources. But even with the perks, physics still calls. Carroll envisions returning to research eventually—maybe earning a graduate degree and working in cosmology or with solar energy.

What motivates him? "My desire to know more tomorrow, or today, than I did yesterday," he says. "It's the drive of being curious and wanting to contribute something to humanity that will live past me. Whether that's helping minorly on a research project that will help keep people safe, figuring out a way to make solar energy more accessible, or putting together a thesis that reshapes how people look at the universe." //

For more of Carroll's story, check out the YouTube Spotlight documentary *Joshua Carroll: Reaching for the Stars* at youtube.com/watch?v=z1zxj-axCEo.

Wanting to direct your own research program in planetary science pretty much means writing proposals (usually to NASA) frequently until you can build up funded projects to support yourself and your lab. I've been incredibly fortunate to have professional mentors who have been good at this. Developing skills both as a leader and collaborator on proposals is definitely a tough but essential skill."

A message for physics students:

Emerging research suggests that the mental health of graduate students is significantly worse than that of their nongraduate student peers—that's worth noting, says Landis. "While there's not yet a documented causal relationship, I think it's worth talking more and sooner about factors other than what is perceived as 'raw talent' that keep talented scientists either out of graduate school or out of the field," she says. Landis is also passionate about bringing to light the stories of women scientists and their often unrecognized contributions. //

To read about Landis's award-winning book collection on women scientists, check out the Spring 2019 *Radiations* article "From the Shadows to the Shelf" at https://www.sigmapisigma.org/sigmapisigma/radiations.

SEES: An Opportunity for Students to See Themselves as Physicists

by Amanda Williams, SPS Alumna, Weber State University

Meetings of the American Association of Physics Teachers (AAPT) are filled with talks, posters, and workshops aimed at physics teachers. But one event at its annual winter meeting is just for students—Students Exploring Engineering and Science (SEES).

SEES is an outreach collaboration between the AAPT and SPS. Dozens of students from local schools are bused to the conference hotel for a morning of fun, hands-on physics led by SPS volunteers. The goal is to directly impact the community while improving outreach efforts across the United States. This past January, 50 sixth-grade students from Christa McAuliffe Middle School in Houston, Texas, participated in SEES at the 2019 AAPT Winter Meeting, and volunteers from 11 SPS chapters were there to greet them.

The sixth graders walked into the hotel ballroom, not quite sure what to expect. Earl Blodgett, a physics professor and SPS advisor at the University of Wisconsin–River Falls, invited them to sit down in the middle of the room. As he walked up to the students, Dr. Blodgett started talking but then interrupted himself to admire the echo in the room. He used that as a segue to note that science is just observing the world around you.

Brad Conrad, the director of SPS, then asked the students, "What is science? What do scientists do?" With answers such as "make new energy sources" and "build structures and develop technology," the students showed an impressive amount of breadth and openness in their answers. Their energy informed us that it was going to be a fun morning!

For most of the morning, the students were guided by volunteers through four different stations. Each station emphasized a different physics concept. The students explored circuits, the diffraction of light, collisions and momentum, and simple motors. They also received "rainbow glasses" (diffraction glasses) to take home, along with some other goodies.

Over a shared pizza lunch, I asked the students about their experiences. I found that each activity was equally cited as a favorite, consistent with the excitement and lighthearted inquisitiveness I saw on the students' faces at each station.

What sets SEES apart from other outreach events is the diverse set of volunteers. Each SPS volunteer had a unique story and reason for volunteering. Some were there for the opportunity to teach, some to learn new demos, and some to solidify their physics knowledge. Our reasons for pursuing physics ranged from "I loved tinkering when I was a kid" to "I want to help the next generation fuse both art and physics." The volunteers reflect the fact that you don't have to fit in a particular box to get into science; you just have to enjoy it and dedicate yourself to it. I was glad we had the chance to share our stories with the sixth graders.

As Michelle Obama put it during her speech at the 2012 Democratic National Convention, "When you've worked hard, and done well, and walked through that doorway of opportunity, you do not slam it shut behind you. You reach back (…)" And that is what SEES is all about: the physics community coming together to inspire the next generation to see themselves in science, too. //

TOP: SEES participants get a new perspective on things with the help of diffraction glasses. Photo courtesy of Brad Conrad.

MIDDLE: The students gave SEES a resounding thumbs up! Photo courtesy of AAPT.

BOTTOM: SPS Outstanding Chapter Advisor for 2018, Dr. Roberto Ramos, receives his plaque from SPS president Dr. Alina Gearba-Sell at the AAPT Winter Meeting. Photo courtesy of AAPT.

For SPS outreach resources, head over to the SPS website at spsnational.org/programs/outreach/demonstrations. There you'll see a growing list of demonstration ideas with comprehensive guides.

SPS also still has a few free Science Outreach Catalyst Kits for the 2018–19 school year. Learn more and request a FREE kit at spsnational.org/programs/outreach/science-outreach-catalyst-kits!.

Not-So-Difficult Transitions

HOW STUDYING PHYSICS HAS HELPED ME TO STEP OUT OF THE BOX AND INTO NEW LIFE EXPERIENCES

by Katherine Zaunbrecher, SPS & Sigma Pi Sigma Executive Committee At-Large Member

ABOVE: Katherine Zaunbrecher. Photo by S. Ferrieri.

No one said it would be easy. In fact, that is why I chose to major in physics. People kept telling me that getting a physics degree would be very difficult. I wanted to prove to them—and to myself—that I could succeed in my studies. So I did.

Even now I am not quite sure what my future endeavors are. Since graduating with my bachelor's in science, I have moved across the United States, completed graduate school, worked at a national laboratory, and given talks around the country and the world. Now I'm teaching physics, mathematics, and so much more to middle and high school students who make my oftentimes challenging work very rewarding. And that's just the career-related side. I know that whatever is in store for me, I am well equipped to handle any challenge, thanks to my education.

Studying physics provides much more than the opportunity to obtain a wide variety of jobs or a higher degree. It allows you to develop tools that will be useful throughout life, both in your career and otherwise. These tools are not merely intellectual and academic. Thanks to the late nights spent working on problem sets and trying to understand a concept that may one day seem simple, I was taught perseverance, the ability to effectively communicate and work with others, and how to be comfortable with not always knowing the answer. Going through a rigorous academic program which emphasized strengthening one's critical thinking skills gave me the ability to readily face challenges. It also developed my intellect and confidence to tackle difficult problems.

Another important and not-so-obvious tool that comes with a degree in physics is the ability to manage transitions well. Even though the future often felt very uncertain for me as I began looking into graduate schools and jobs, studying physics helped prepare me for many of the major and not-so-major life changes that followed. Although I knew that I was not at the top of my class and would most likely not be producing groundbreaking research in my field, I had the confidence to believe that I could succeed at anything I wanted to pursue. That meant being able to handle the stress of graduate school on my own, admitting when I could not handle it, and asking for help when I needed it. It also meant embracing the uncertainty I felt after completing my PhD while transitioning into a research position. Additionally, it helped ease my mind when, almost three years into research I decided that a long-term career in academia or research was not for me. The time I had between research and a new teaching job gave me room to reflect and mentally prepare myself for what I knew would probably be the biggest transition I had yet to make.

Teaching physics and mathematics has been a joy. It is also stressful and difficult at times, but the challenges are different from research. Yet, I was more than prepared. Being solid in my content, which is more than many other high school physics and math teachers can say, has meant that I can focus more time and energy on developing other skills that are useful to managing a classroom, building curricula, and motivating and engaging students. While I still struggle with the occasional onset of imposter syndrome—even the best of us do—I have been well equipped with the tools necessary to succeed. I owe many of my successes, as well as my desire and willingness to try different things, to my education and training as a physicist. I hope that you are also able to recognize the many wonderful opportunities that being a physicist gives you. //

Fall 2018
Chapter Awards

Congratulations to the following winners of the Fall 2018 Chapter Awards. These awards are made possible in part by generous contributions from Sigma Pi Sigma alumni. For examples of past award-winning projects, visit www.spsnational.org/awards/chapter-awards.

FUTURE FACES OF PHYSICS

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

Adelphi University
Labs for Kids
Julianna Yee (Leader)
Matthew Wright (Advisor)

California State University–San Marcos
CSUSM for Diversity in Physics
Carina Maciel (Leader)
Justin Perron (Advisor)

Colorado School of Mines
Future Faces of Physics with CSM SPS
Dylan Honors (Leader)
Chuck Stone (Advisor)

Ithaca College
Minority Groups in STEM
Stavrini Tsangari (Leader)
Michael “Bodhi” Rogers (Advisor)

Juniata College
Diversity and Inclusion in Physics at Juniata
Camden Kasik (Leader)
Jim Borgardt (Advisor)

Rhodes College
Uplifting Students with Hovercrafts: A Smooth Introduction to Physics
David Raymond (Leader)
Brent Hoffmeister (Advisor)

The George Washington University
“I Can Science”
Jason Starita (Leader)
Gary White (Advisor)

University of the Sciences
Shining Light on the World of Optics
Despina Nakos (Leader)
Roberto Ramos (Advisor)

William Jewell College
After-School Activity Series
Megan Anderson (Leader)
Blane Baker (Advisor)

SPS CHAPTER RESEARCH

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

Coe College
Ionic Conductivity of the Lithium Clustering Effect
Anne Ruckman (Leader)
Caio Bragatto (Advisor)

Suffolk University
Neutron Radiation
Molly McDonough (Leader)
Walter Johnson (Advisor)

Universidad Autonoma de Ciudad Juarez
Foucault Pendulum
Julio Lopez Ibarra (Leader)
Sergio Flores (Advisor)

University of Central Arkansas
Small Parallel Supercomputer at UCA
John Singel (Leader)
William Slaton (Advisor)

University of Kentucky
Data Analysis and Accuracy: Small Supercomputer Versus a Dell Dinosaur
Dany Waller (Leader)
Max Brown (Advisor)

University of Tennessee, Knoxville
HARAMOC
Peter Tarle (Leader)
Maxim Lavrentovich (Advisor)

MARSH W. WHITE

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

Augustana College
Spring into Physics!
Emmalee Pentek (Leader)
Cecelia Vogel (Advisor)

Cleveland State University
Fun with Fluids Outreach
James Ellis (Leader)
Kiril Streletzky (Advisor)

Drew University
Local High School Physics Engagement
Matthew Gronert (Leader)
Bjorg Larson (Advisor)

Henderson State University
Science Olympics
Rebecca Voss (Leader)
Shannon Clardy (Advisor)

Juniata College
Juniata's Physics Outreach: Demo Upgrades
Evan Ulrich (Leader)
Jim Borgardt (Advisor)

Rhodes College
SPS Super Sound Science Show
David Raymond (Leader)
Brent Hoffmeister (Advisor)

Southwestern Oklahoma State University
Dobtometry: Helping Western Oklahoma See the Stars
Emily Trail (Leader)
Wayne Trail (Advisor)

Towson University
Science Friday
Bailey Conrad (Leader)
Jeff Simpson (Advisor)

University of Dayton
TechFest 2019: Electro-Physics Exhibit
Dalles DeBruin (Leader)
Jay Mathews (Advisor)

University of Florida
Crash Course in Fundamental Force
Foster Sabatino (Leader)
James Hamlin (Advisor)

University of Maryland
Quantum Kids: You Got This!
Tyler McDonnell (Leader)
Donna Hammer (Advisor)

University of Southern Mississippi
Physics for All
Swapnil Bhatta (Leader)
Michael Vera (Advisor)

University of Texas at Dallas
Physics Escape Room
Andrew Marder (Leader)
Jason Slinker (Advisor)

University of the Sciences
Throwing You for a Loop
Gopal Goberdhan (Leader)
Roberto Ramos (Advisor)

SIGMA PI SIGMA CHAPTER PROJECT

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

Abilene Christian University
Sigma Pi Sigma Induction
Roy Salinas (Leader)
Larry Isenhower (Advisor)

California State University–Fresno
Dining with the Director: An Induction Ceremony with Alumni
Summer Al-Hamdani (Leader)
Douglas Singleton (Advisor)

Lamar University
2019 Sigma Pi Sigma Induction and Dinner
Alek Hutson (Leader)
Cristian Bahrim (Advisor)

Missouri Southern State University
An Emphasis on Physicists
Toby Pederson (Leader)
Jency Sundararajan (Advisor)

St. John's University
Brooklyn Bridge
Russell Lochrie (Leader)
Charles Fortmann (Advisor)

United States Air Force Academy
Building Bridges: Connecting Colorado Springs Students through SPS and Sigma Pi Sigma
Lucy Zimmerman (Leader)
Alina Gearba-Sell (Advisor)

University of Central Florida
The Central Florida Sigma Pi Sigma Induction Ceremony
Kevin Fernando (Leader)
Costas Efthimiou (Advisor)

Everything Is Better with S'mores

by Elyse Rood and Michael Pierce, School of Physics and Astronomy, Rochester Institute of Technology, and Brad Conrad, Director, SPS & Sigma Pi Sigma

Whether it's outside in the woods or in the comfort of their own living room, most people have had the experience of sitting near a warm fire, wanting something warm to eat. It is our opinion that those moments are best accompanied by indulging in a gooey, delicious snack—a s'more. And if you are anything like us, why waste a perfectly good opportunity to geek out? Just maybe we can make s'mores more awesome through science!

EXPERIMENTAL SETUP

A s'more is simply a sandwich of marshmallow and chocolate, as seen in Fig. 1, with the marshmallow heated so that it partially melts the chocolate when they come in contact. For this puzzler we will not assume a spherical tasty treat, but we do need to define some of the components of this ideal physics s'more. Let's assume a few constants:

Standard marshmallow

A standard marshmallow consists of mostly air by volume, with aerated sugar ($C_{12}H_{22}O_{11}$), gelatin (long chains of amino acids), and water. *Note: While at the time of printing there is not a NIST reference marshmallow, there is a NIST standard baking chocolate.*[1]

Diameter: 0.025 m uncooked
Length: 0.038 m
Density: ~0.35 g/cm^3
Melting point (sucrose): 186 °C
Specific heat[2]**:** 2.0 kJ/kg °C
Caramelization temperature: 160 °C

Graham cracker

Side: 0.064 m
Thickness: 0.0063 m

Chocolate

Assumption: Assume six chocolate pieces per s'more (of an average 12-piece chocolate bar—because…reasons)
Length of full bar: 0.136 m
Width of full bar: 0.054 m
Thickness: 0.006 m
Density: ~1300 kg/m^3
Melting point ~30 °C (varies with type of chocolate)
Specific heat[2, 3]**:** ~1.8 kJ/kg °C
Thermal conductivity: 0.5 W m^{-1} K^{-1}

Campfire

Average temperature: ~600 °C at the hottest point
Diameter: 0.5 m
Ambient temperature: 23 °C

Figure 1. An ideal, nonspherical s'more with a toasted marshmallow and a piece of chocolate sandwiched between two pieces of graham cracker.

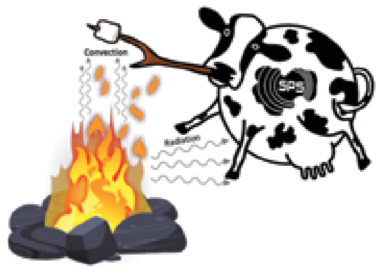

Figure 2. A spherical cow roasting a nonspherical marshmallow over an ideal campfire (not to scale). Note that hot air and radiation are emitted from the campfire.

METHODOLOGY

The first (and some say the most important) step for a s'more is roasting the marshmallow. The marshmallow can make or break a s'more, with the finer points having been debated at great length since a marshmallow was first roasted. The goal is to warm the marshmallow without it melting off the stick or burning it too much. To get it just right, you have to pay attention to where the marshmallow is held in relation to the fire, as seen in Fig. 2, and regulate the rate of heat transfer.

How much energy are we talking about? To calculate how much energy it would take to melt a marshmallow, we apply

$$Q = cm\Delta t \qquad \text{(Eq. 1)}$$

where Q is the heat needed, c is the specific heat, m is the mass of the marshmallow, and Δt is the change in temperature to melt the marshmallow. Applying our constants from page 12, we can see that it takes about 2.1 kJ, which is not a lot!

Whether it is preference or a complete accident, everyone has burned a marshmallow. Burnt marshmallow is simply a marshmallow that has been extremely toasted! There are two main processes that heat a marshmallow: absorption of campfire radiation (photons) and contact with very hot air rising off the fire (convection). If we place the marshmallow directly above the fire, we get both. This *quickly* heats the outside of the marshmallow, which causes the sugars in the marshmallow to break down and react. Some heat is absorbed inside the marshmallow, but it's a slow process, as marshmallow is a good insulator.

Instead, let us consider trying to toast the marshmallow without completely burning it. The tricky part of this process is getting the perfect golden-brown exterior before the inside of the marshmallow melts completely and the whole thing falls off the stick into the fire in a blaze of glory. To achieve the perfect golden brown, it should be cooked slowly and indirectly, allowing the sugars to caramelize, making heavy use of the campfire's infrared radiation while mostly avoiding the convection heat. As the outside of the marshmallow gets hot, the sugars/proteins begin to break down and then burn, which produces new flavors and smells, which gives s'mores their characteristic flavor[4, 5] (and is also why everyone likes their marshmallow done a different way). It also forms a crust that helps the marshmallow keep its form. What makes the process a challenge is that caramelization of sucrose occurs near 160°C but the melting temperature of sucrose is 186°C, meaning you must keep your marshmallow within a rather narrow temperature range.

Once the ideal (melted and toasted) marshmallow is achieved, the next challenge is getting the chocolate to the perfect melted consistency in the sweet sandwich.

Compared to the marshmallow, chocolate has a much lower melting temperature, around 30°C. When you place the marshmallow in between the chocolate and graham crackers—without them it would be a mess—the marshmallow's thermal energy is conducted into the chocolate. Assuming the marshmallow isn't given time to cool after being heated, it should still have a temperature near its melting point of 186°C. We can use the heat transfer relationship for the total energy transferred Q through the chocolate:

$$Q = kA\Delta Tt/L \qquad \text{(Eq. 2)}$$

where k is the thermal conductivity, A is the surface area, ΔT is the change in temperature, t is the time of the heat transfer, and L is the thickness.

Assuming that the chocolate starts at room temperature, to reach the melting temperature it will need to have a temperature change of ~7°C. We can also assume that we're fairly impatient waiting for the s'more and only let it sit to melt for one minute. Using this information and the dimensions of the chocolate, the chocolate gains ~130 J, which is much less than the energy in the marshmallow! This means that the marshmallow can give off this much energy to the chocolate. But does the whole piece of chocolate melt?

The final part of the s'more is the graham cracker. Unlike the other components in the s'more, the graham cracker doesn't go through any physical or chemical changes. Instead, it acts as an insulator for the sandwich, containing the heat to melt the treat within. It also doesn't hurt that it keeps you from getting marshmallow all over your hands. //

PUZZLERS

1) Prove to yourself that the chocolate needs about 130 J to melt using Eq. (2). How impatient could you be and still have it work? This assumes what about the temperature of the marshmallow?
2) Challenge: Now, ignore heat transfer rates and focus on just the total energy gains by the campfire. Assuming the graham crackers are perfect insulators and have a very small specific heat, what will the final temperature of the marshmallow and the chocolate ultimately be? //

Check yourself online![6]

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Dolomites for Thermochemical Energy Storage and Carbon Capture

by Dominic Dodson, Mc Ben Joe Charles, and Wyatt Liptak, SPS Members
Sesha Srinivasan, SPS Chapter Advisor
Scott L. Wallen and Gary Albarelli, Florida Polytechnic University

Florida supplies four million tons of phosphate, used primarily in fertilizer, every year—three-fourths of the phosphate used in the United States. In Polk and Hillsborough counties primarily, long dragline excavators scoop up phosphate-containing minerals mixed with clay and sand, then separate out the phosphate.[1] The most uneconomical ingredient in the phosphate mineral matrix is the calcium-magnesium carbonates, $CaMg(CO_3)_2$, also known as dolomites. The mining industry routinely terminates the mining process when it encounters dolomites, or dolostones, which are a major source of magnesium and are not favorable for phosphate fertilizer processing. The dolomites are not only difficult to remove from the clay matrix but also pose "sustainability issues due to their deposition in clay settling ponds around these counties." The magnitude of this problem will be multifold if future mining expands to other Florida counties such as Manatee, Hardee, and DeSoto.[2, 3]

Dolomites contain magnesium, which is a major hindrance in the manufacturing of phosphoric acid for diammonium phosphate (DAP) fertilizer production. High magnesium content increases the sulfuric acid consumption and causes a lower yield of phosphoric acid.[2, 3]

High-temperature thermochemical energy storage utilizes reversible reactions that store energy in the chemical potential of the system. This type of energy storage process is thought to be critical for on-demand energy production and penetration of concentrated solar power into the grid. Current storage systems rely on molten salts, which have an operating temperature limit of 550°C, but concentrated solar power systems operate above 600°C.

A very recent publication by Kakosimos et al. studied the characterization of surface carbonates obtained from various regions of the Qatar peninsula that have shown promising potential for applications in CO_2 capture and thermochemical energy storage.[4] According to this report, dolomites have higher performance in terms of CO_2 sorption and storage capacity when compared to calcite, $CaCO_3$. In a long-term cyclic stability study, up to 27% thermal energy storage was demonstrated by Perlinger et al. in a groundwater aquifer, which was plausibly due to the presence of minerals (dolomites).[5] Based on the aforementioned reports, the authors are conducting feasibility studies of high-dolomite phosphatic pebbles obtained from the Florida Industrial and Phosphate Research Institute for use in two sustainable and green technological applications: (i) for thermochemical energy storage in concentrated solar power plants, and (ii) related to carbon dioxide capture and sequestration at fossil-fuel-based power plants.

Our team is examining the thermodynamic and kinetic parameters important to the chemical reactions involved in these two applications, as shown in Scheme 1 below:

$CaMg(CO_3)_2 \rightleftharpoons CaCO_3 + MgO + CO_2$	above 588.6 K	(i)
$CaMg(CO_3)_2 \rightleftharpoons MgCO_3 + CaCO_3$	at 605.0 K	(ii)
$CaMg(CO_3)_2 \rightleftharpoons MgO + CaO + 2CO_2$	above 811.3 K	(iii)
$CaCO_3 \rightleftharpoons CaO + CO_2$	above 1118.8 K	(iv)

Scheme 1. Chemical reactions investigated in the thermochemical energy storage and CO_2 sequestration studies.[6]

Thermogravimetric analysis (TGA) accurately measures changes in mass as a function of some perturbation such as temperature, chemical reaction, or even adsorption. The dolomite-containing samples are subjected to temperatures that enable the endothermic calcination [Scheme 1(iii)] and then subsequent exposure to a CO_2 atmosphere, readsorbing CO_2 to undergo the reverse exothermic carbonation reaction, giving off energy. These reversible reactions are then performed over and over to determine the cyclic stability of the dolomite-containing systems. Following the mass changes allows us to examine what portion of the original sample is able to react in a continuous cycle, which is important information in developing a process for the thermochemical energy storage (TCES) and CO_2 sequestration using dolomite mineral resources. At various stages in the process, the dolomite phosphatic rock was analyzed for its constituent minerals using energy-dispersive x-ray spectroscopy (EDS), x-ray fluorescence (XRF), and x-ray diffraction (XRD), as well as examination of the development and closing of pores important for CO_2 diffusion and necessary for the reactions using scanning electron microscopy (SEM).

The first and foremost challenge we overcame during this research was figuring out how to execute the calcination-carbonation looping cycles. We have figured this out by optimizing our TGA methods and procedures. Our next setback was successful operation of calcination and carbonation processes in high-pressure and high-temperature setups, in which we used a hydrothermal Parr reactor and tube furnace attached with a CO_2 gas line. To make sure the experimental environment stayed consistent for each of the calcination and carbonation runs, we had to be very careful and attentive in TGA measurements to not cause any disturbance.

The students who worked on this research project received hands-on training for each of the tools and analytical instruments. Literature searches, given as assignments, improved their skill at finding articles on Science Direct and other electronic sources. By the end of the project, each student had learned and understood the underlying physics, chemistry, and engineering applications of dolomites for thermochemical energy storage and carbon capture.

We are continuing to tune our optimization processes and hope that the addition of other impurities such as a few mole concentrations of alkali halides (for example, NaBr or LiBr) will improve the calcination-carbonation loop cycle performance in terms of rate kinetics and thermodynamics, our next step toward discovering a solution to our world's clean energy storage and carbon sequestration dilemma.

This project was funded via the SPS Chapter Research Award and Florida Industrial and Phosphate Research (FIPR) Institute. Faculty and staff advisors Dr. Sesha Srinivasan, Dr. Scott L. Wallen, and Mr. Gary Albarelli oversaw this research.

Florida Polytechnic University's provost Dr. Terry Parker, as well as professors Dr. Nicoleta Hickman, Dr. Robert Green, Dr. Mary Vollaro, and Dr. Richard Matyi, are gratefully acknowledged for their support in terms of instrumentation accessibility and other infrastructural support. We would also like to acknowledge the comments and suggestions of Dr. Jaspreet Dhau from Molekule, Inc. //

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DIG DEEPER

Read all about the Florida Polytechnic University team's project at spsnational.org/awards/sps-chapter-research-award/2018/florida-polytechnic-university.

INTERESTED IN STARTING A RESEARCH PROJECT OF YOUR OWN?

Learn more about the SPS Chapter Research Awards and how to apply at spsnational.org/awards/chapter-research.

LEFT: Florida Polytechnic University Research Team. Front Row: Shirley Garcia, Mc Ben Joe Charles; Middle Row: Ecieno Carmona, Dominic Dodson; Back Row: Michael Nelson, Jared Nurse, SPS FL Poly chapter faculty advisor Dr. Sesha Srinivasan, Mr. Scott Reinhart, Dr. Scott Wallen, and SPS FL Poly chapter secretary Wyatt Liptak. Photo courtesy of Dr. Sesha Srinivasan.

TOP: Undergraduate research students Wyatt Liptak, Shirley Garcia, and Dominic Dodson preparing dolomite samples for characterization and cycle life testing using the TGA analyzer. Photo courtesy of Dr. Sesha Srinivasan.

ABOVE: Undergraduate research students Mc Ben Joe Charles and Jared Nurse working on the thermogravimetric analysis of dolomite samples. Photo courtesy of Dr. Sesha Srinivasan.

NATIONAL LABS: *Impacting the Physical Sciences*

FEATURE

by Brad Conrad, Director, SPS & Sigma Pi Sigma

The concept of bringing together great minds around issues or topics has a long history, with one of the more recent forms being national laboratories. Starting around the 1600s, scientific inquiry was done within private groups, often focused around well-known scholars. Academies of science and higher learning were early examples, with centers founded in London and France. Scientific institutes of research were fostered in the West beginning as far back as 1724 in St. Petersburg, with the goal of advancing newly developing fields of science, featuring scientists like Euler and Bernoulli.[1]

Within America, scientific inquiry before World War II was often done by individuals or through the support of philanthropists (e.g., the Carnegie Institutes and the Rockefeller Institute).[2] As a result of the war, the US government started funding centers of scientific discovery to aid in the rapid advancement of technology for the war effort. The centers were formed in different ways with different goals: secret government labs working on projects such as the atomic bomb, university partnerships focused on energy, military laboratories, government agencies working on commerce, and everything in between.[3] These national (or international) laboratory partnerships have become and remain focal points for collaboration within the scientific community because they have allowed for the rapid development of science and technology. Each national laboratory is unique but often has cutting-edge equipment, permanent staff scientists, collaborations with university researchers, and visiting scientists. Many of these facilities host thousands of researchers on a daily basis. The majority of people at these laboratories are not physicists, but we play a vital role in advancing solutions to our societal problems and proposing new innovations.

This issue's features focus on different roles physicists can play at these large centers. Physicists—from undergraduates to world-renowned luminaries—can be found at these labs and others: CERN, the operator of the largest experimental particle laboratory in the world; NIST, which helped give us the scanning tunneling microscope[4] and measured the distance from the earth to the moon within a few centimeters;[5] Woods Hole Oceanographic Institution, which discovered the wreck of the *Titanic*, and whose staff were among the first scientists to provide advice after the BP Deepwater Horizon oil spill. Here and at other labs, physics students and scientists with a background in physics are working on cutting-edge projects involving many fields. These features help to shine a light on how you as a student of physics can impact not just physics but scientific innovations spurred by societal need, common goals, and interdisciplinary collaboration. Read on to explore how modern centers of science—national laboratories, research institutes, and academies of science—are impacting the world around us and the role they might play in your future. //

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DIGGING INTO THE DATA:

FEATURE

The Role of a Physicist at the National Institutes of Health

by Tim Stasevich, Assistant Professor & Boettcher Investigator, Colorado State University
as told to Rachel Kaufman, Editor

I was a grad student at the University of Maryland studying condensed matter physics when I attended a talk by Dr. Jim McNally of the Center for Cancer Research at the National Cancer Institute. He described the math they needed to solve the problem they were working on at the time—it was the same thing I was studying. After the talk, I went up to him and asked if he had any jobs for physicists, and that's how I got a postdoc at the largest medical research agency in the United States, the National Institutes of Health (NIH).

We were studying gene expression, trying to understand what makes a cell suddenly turn cancerous. If it has the same set of genes as a healthy cell, why does a cancer cell become a cancer cell? Maybe there's a mutation, or maybe the wrong gene is turned on, or the right gene is turned off.... We were trying to understand how genes were turned on or off at the single-cell level. As you can imagine, that research generated a lot of data, and working with data sets that large was, at the time, pretty challenging for most biologists. My job, and that of the other physicists in the lab, was to help parse the data and generate models that fit what we were seeing.

Working at a big lab was very different from academia. Everyone there had a PhD, and some had both a PhD and an MD, so everyone was very smart and focused on a common goal. The culture was also incredibly interdisciplinary. We were part of a larger group called the Laboratory of Receptor Biology and Gene Expression, with four principal investigators, and every Monday we'd have a group meeting with all four labs, about 60 people total. One lab would give a research talk and get feedback from the whole group. Now, as an academic physicist, I have my own lab meetings, but it's just our lab—there's less communication with other groups.

NIH would also have famous scientists give talks every week. You could feel the energy across the campus as so many people who were really intelligent, with mixed interdisciplinary backgrounds, all gathered in one place.

Today I use fluorescence microscopy to study how genes are turned on and off in living cells—essentially continuing my work at NIH but in my own lab at Colorado State University. I'm glad I went out of my comfort zone and worked in the biophysics lab at NIH. Having an outsider's perspective when I went back into academia benefited me and helped me get a faculty position.

We're going to need more interdisciplinary scientists to solve the problems of the future, and big labs like NIH are great places to get experience. //

Learn more about internships, postbacs, and other training opportunities at NIH at training.nih.gov.

TOP LEFT: SPS and Sigma Pi Sigma director Brad Conrad sporting the spherical cow costume. Photo courtesy of Susan White.

TOP: The NIH campus, looking south. Photo courtesy of NIH.

ABOVE: The Mark O. Hatfield Clinical Research Center (Building 10), NIH campus, Bethesda, MD. Photo courtesy of NIH.

FEATURE

MORE THAN AN INTERN:

The NIST Experience

by Luis Alejandro Royo Romero, 2017 SPS Intern & MS Student at Bowling Green State University

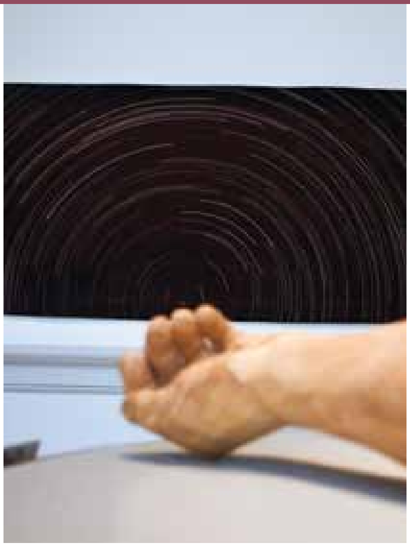
The National Institute of Standards and Technology (NIST) is one of the nation's oldest physical science laboratories. From the name, you might assume that NIST is just a measurement agency, but it is so much more than that name implies. Much of the research carried out at NIST impacts people's lives on a daily basis, from fare standards for rideshare services to reducing the impact of wildfires, to online security and cancer therapy. As a federal agency, NIST's mission is to advance innovation and improve quality of life.

I spent the summer of 2017 as an SPS intern conducting research at NIST under Dr. Angela Hight Walker in the Physical Measurement Laboratory. I quickly learned that I would get out of my internship as much as I put in. I got hands-on experience with instruments I had only seen in textbooks, public-speaking practice in group meetings and colloquia, and mentorship from top scientists. Altogether, there were plenty of learning opportunities at NIST—all I had to do was be attentive and willing to learn.

Yet my time at NIST also came with personal challenges. I was addressed as a colleague, not an intern, which felt amazing! However, I began to doubt myself when I didn't know everything right away, often forgetting that I was there to learn. Additionally, I had to learn how to manage my time when using instruments. At a large facility like NIST, respecting the clock is a top priority because the equipment is often shared. It took a couple of weeks for me to realize I had to stop taking data with enough time to pack up and leave the room before the next person arrived. This was tough since I was eager to continue my research.

Ultimately, what made the most impact on me from my time at NIST was an understanding that science is not necessarily a 9-to-5 job. If you have a supportive research group and are passionate about your research—which I have always been—eight hours a day isn't enough time. To this day, I wish I had been given extra time at NIST because the ten weeks just flew by.

My experience at NIST not only shaped me to become a better scientist but also


LEFT: Outreach Event: Astronomy on the Mall, Washington Monument.

TOP LEFT: Farewell Lunch with Research Group |Left to right: Guangjun Cheng, Angela Hight Walker, Adam Biacchi, Luis Royo Romero, Rebecca Moore, Vanessa Espinoza, Amber McCreary, and Heather Hill.

TOP MIDDLE: Photography in National Museums around DC, Renwick Gallery.

TOP RIGHT: Raman Spectrometer in Hight Walker Lab at NIST.

BOTTOM LEFT: NIST Tour with intern cohort. NIST Center for Neutron Research.

BOTTOM RIGHT: June 1st, first day at NIST, Building 101.

All photos courtesy of Luis Alejandro Royo Romero.

revealed possibilities for my career path. I want to conduct high-impact research, mentor STEM students (especially underrepresented minorities), and give back to the community. I had thought that meant a career in academia. To my joyful surprise, however, I realized that my advisor, Dr. Walker, does all that at NIST. So now I know firsthand that I can pursue these things outside of academia with great mentors to help me along the way.

As I finish my master's and apply to PhD programs, I no longer feel uncomfortable when someone outside STEM asks, "What are you going to do with that?" since my job possibilities are broad. I would never have known all my options if I had not explored options outside academia.

I would encourage all physics students to consider interning at NIST or another federal agency or national lab. The experience will challenge you to be the best version of yourself and grow as a scientist in your field. But keep in mind that the outcome of your time there depends on you. You will be working alongside the best of the best, so be open to new experiences, show initiative, and hold yourself to your highest standard. You may be just an intern now, but one day you could be a colleague. //

FEATURE

WELCOME TO *J-PARC*

by Kristin Dona, SPS Vice President, University of Michigan,
and Noah McNeal, SPS President, University of Michigan

It's a warm evening and the sun is setting low on the horizon. Mountains off in the distance. Freshly plowed sweet potato fields. Cicadas buzzing in the trees around us. After a long day working underground with the detector, we've just biked past the entrance gates to J-PARC, bowing at the security guards and rolling past the big lettering: 日本原子力研究所. Behind us, the Japan Atomic Energy Research Institute is a sprawl of gray research complexes with accelerators weaved-in together with the trees. The light is still red as we watch the cars pass in front of our favorite *conbini*, 7-Eleven, home to a world's supply of *sushi*, *onigiri*, and *anpan*.

"東海村とJ-PARCへようこそ," or "Welcome to the village of Tokai and to J-PARC."

We spent the summer of 2018 living and working in Japan on the KOTO experiment at the Japanese Proton Accelerator Complex (J-PARC). KOTO is a high energy particle physics experiment that hopes to probe the Standard Model by measuring the branching ratio of the ultrarare decay of the $K_L^0 \rightarrow \pi^0 \nu\bar{\nu}$, which, according to Standard Model predictions, is expected to occur once in every 30 billion decays. The motivation behind observing this decay is to measure CP violation, which can help us understand the matter/antimatter asymmetry in the universe. CP violation can be understood by the idea that the laws of physics should stay the same if we switch matter with antimatter (charge symmetry, or C-symmetry) and if we "look into a mirror," swapping right with left (parity symmetry, or P-symmetry). Put C-symmetry and P-symmetry together and you get CP-symmetry (or CP violation). CP violation occurs in the decay at the heart of the KOTO.

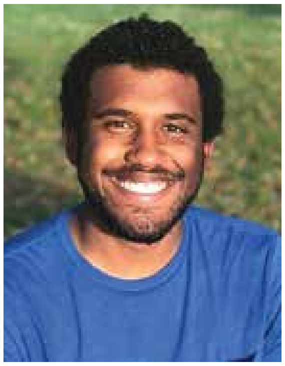
Having worked with the Michigan branch of the KOTO Collaboration (led by Professor Myron Campbell) for several years prior to our time in Japan, we delighted in the opportunity to live and work at the experiment site as undergraduate research assistants. Our overarching task throughout the summer was to disassemble our experiment's detector to prepare it for hardware upgrades that will help the KOTO experiment reach its preliminary goal of observing one single decay. This was a large undertaking that required carefully detaching and documenting hundreds of cables, moving hundreds of pounds of hardware, and enduring the heat of the 100-degree Japanese summer. To handle this enormous task, we worked in a large team consisting of two other Michigan undergraduates and an assortment of Japanese graduate students, research scientists, and professors.

We enjoyed getting to work in person with the collaborators from Japanese institutions, whom we had met only over video calls prior to this. By working under the guidance of our Japanese collaborators, we were able to intimately experience the reality that international

science is broadly based on the concept of the same goals but different methods. Work hours, ways of communicating, and day-to-day accomplishments were all different than we were used to back in Michigan but were just as effective. Each morning, daily meetings were held to discuss our work for the day. At these meetings we would often be told that our anticipated work day would last until 7 p.m. or that our work was not necessary for the day, so our schedule would change depending on the status of the experiment during its disassembly. In addition to limited communication about our work in advance, communication methods with our colleagues were also less direct than we were used to. When asking questions, collaborators would prefer not to say no but rather give begrudging yeses that we learned actually meant no. Another trend that we found surprising was that interpersonal relationships were different from those in Michigan. As Japan has a different work culture than the United States, our Japanese colleagues had a more noticeable work hierarchy as well as a stricter work–life separation when compared with the States. At the same time, we were all able to enjoy ourselves as a team when the group went out to dinner to celebrate big occasions like the end of data taking.

Being part of a large international collaboration is a unique experience. These collaborations allow for the production of ideas from people with different backgrounds. Each person's individual way of thinking and variation in how they were taught results in a great variety of thought. This permits scientific accomplishments that would be unfathomable by a team from a single institution.

Overall, our time in Japan allowed us to personally experience the inner workings of an international scientific collaboration while also learning in the local community and engaging in great science. //



LEFT: Kristin Dona at J-PARC. Photo courtesy of Kristin Dona.

ABOVE LEFT: Kristin Dona. Photo courtesy of Kristin Dona.

ABOVE RIGHT: Noah McNeal. Photo courtesy of Noah McNeal.

RIGHT: Lowering of the YE+2 end-cap for CMS at CERN. Photo courtesy of CERN.

CERN FEATURE

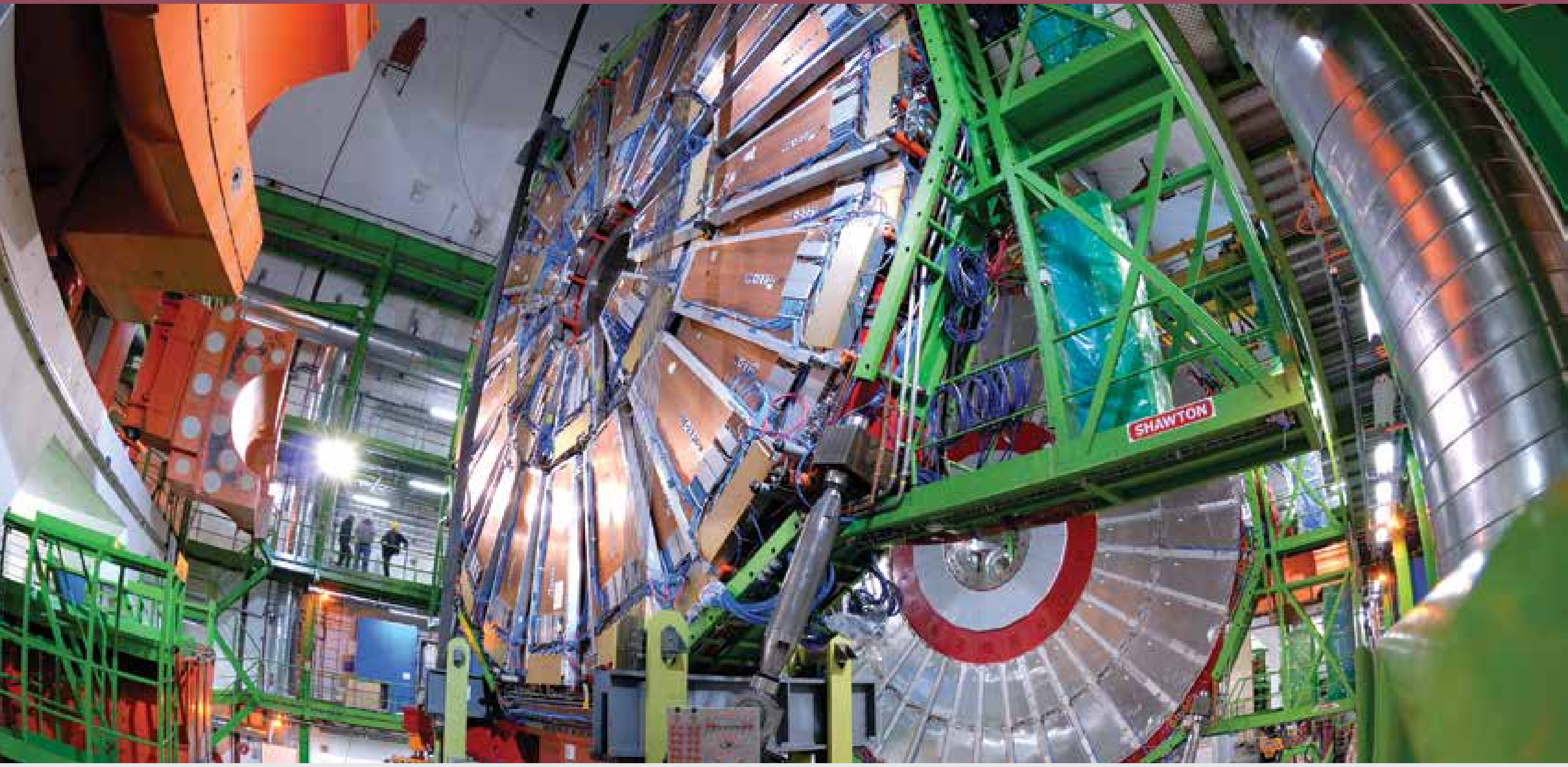
CERN The Place to Be

by Diyaselis M. Delgado Lopez, SPS Member, University of Puerto Rico–Mayaguez

When it comes to particle physics, the European Organization for Nuclear Research (known as CERN) is the place to be. I went into physics because I am curious about the universe and why we are here. To study the minuscule fundamental particles that make up the universe, we need to build large-scale, complex scientific instruments. The tools of high energy physics (HEP) research—complex accelerators, sensitive detectors, high-volume data storage and analysis—are required to answer the essential questions about how the universe was created. The Large Hadron Collider, located in CERN's accelerator complex, is the largest machine in the world—and one of the most expensive—but it gives us the ability to study the building blocks of the universe.

I am a member of the Compact Muon Solenoid (CMS) experiment on the Large Hadron Collider. The CMS detector is built around a huge solenoid magnet. This takes the form of a cylindrical superconducting coil that generates a magnetic field of 4 tesla. The field is confined by a steel bulk that is extremely heavy and dense for its compacted size, hence the name.

I have been intrigued by high energy physics from the very beginning, even when I barely knew what it meant. Before joining the CMS team, I had done research on astrophysics, which involves studying some of the universe's largest objects, and now I was captivated by its tiniest components: subatomic particles. I approached my professor with the curiosity to know more and



to ask for a spot on the particle research group at my school, the University of Puerto Rico–Mayaguez. I was accepted and became a CMS nondoctoral student working on testing physics analyses focused on supersymmetry and dark matter studies for long-term preservation and reproducibility.

After a year of research, I had the opportunity to join CERN on-site for six months as the representative from Puerto Rico to participate in the Non-Member State Summer Program at CERN and later on as part of the University of Michigan Research Semester Abroad program. Both programs aim to provide undergraduates with research experiences at CERN.

I was assigned to the data preservation and open access division at CERN. The staff members who reviewed my application thought this department was a good fit for my computing abilities and general theoretical knowledge of high energy physics. My project was to help the open data division better store its information so that it can be preserved for future use by both the CERN community and any physics enthusiast. To do this, I developed and tested simplified examples of research to see how to best structure the data for long-term preservation and reproducibility. I created workflows so that raw data can be run on-demand, even after years have passed from the original experiment. This means that no matter how much computer technology changes, physicists of the future will be able to access the data from experiments conducted at CERN.

After this unique experience abroad, I've continued my on-campus research on supersymmetry under the same CMS experiment as I prepare for my graduate education centered on particle physics. I did not expect to fall in love with the field of particle physics, but I have found my niche, and for that I am grateful to my professor who helped me find my career path—and to CERN for making it possible. //

TOP: Lowering of the YE+2 end-cap for CMS at CERN. Photo courtesy of CERN.

MIDDLE: Photo of Diyaselis M. Delgado Lopez at CERN. Photo courtesy of Diyaselis M. Delgado Lopez.

BOTTOM: Workers at CERN. Photo courtesy of CERN.

FEATURE

GREATER TOGETHER:

A Visit with the Director of Los Alamos National Laboratory

by Nicholas Huntoon, Zone 16 AZC & SPS Member, University of New Mexico

Driving north out of Albuquerque, New Mexico, I wasn't surprised to feel anxious. I was on my way to meet the new director of Los Alamos National Laboratory (LANL), Dr. Thomas Mason. As an undergraduate physics major I had never interviewed anyone before, but I was looking forward to finding out about the lab and its plans for the future.

LANL was founded during World War II as part of the Manhattan Project, bringing together many famed scientists to work on the design of nuclear weapons. Since then, "Los Alamos has changed the world many times," Dr. Mason told me.

After the Manhattan Project, because of the lab's work on how radiation affects humans, its expertise in cell biology and genetics was key to developing the technologies for the Human Genome Project—a project that initially faced skepticism because DNA sequencing technologies were slow and costly.

Today, LANL focuses on national security challenges, including nuclear weapons stewardship, energy security, and other threats. The capacity to work on projects that require "big science," like the Manhattan Project, the Human Genome Project, and cybersecurity, is unique to multidisciplinary environments. "To do this science we need scientists across a range of disciplines," the director shared.

Though he became director of LANL just last year, Dr. Mason spent 10 years as the director of Oak Ridge National Laboratory and was most recently senior vice president for Battelle, a nonprofit company that helps manage national labs. He drew on these experiences to create an agenda for LANL over the coming decade.

One of the lab's major challenges is to certify the safety and security of the nuclear stockpile while combating nuclear proliferation. The United States has participated in a nuclear testing moratorium since 1992. This allows tests occurring in other places to be more easily detected but complicates the process of predicting the behavior of the existing stockpile. As components age, changes in the stockpile accelerate. Los Alamos has to develop the tools that are necessary to assess the stockpile and predict complications in the future.

National labs like LANL are organized by projects, not disciplines, a structure that invites staff to try different things and engage with colleagues from different backgrounds. Dr. Mason described it as a process of learning in which you fully immerse yourself in a project until you're tired of it, switch to something else, and then dive back in to the original work. "I find it most energizing to be on a steep learning curve," he told me.

Dr. Mason also reflected on his early experiences with physics, his father's career as a geophysicist, and how it always seemed natural that he would be a physicist as well. We went on to discuss his time as an undergraduate and the exhilaration of finally getting meaningful data from a difficult experiment. Dr. Mason also described the role of graduate school in his success. "You don't learn how to be a nuclear weapons designer in grad school, and that's a good thing," he laughed. Rather, the most important skill he looks for in potential employees is the capacity to learn.

As I drove away from Los Alamos, I tried to collect my thoughts. The history of the lab, with its impressive resume of technological and scientific accomplishments, the scale of the scientific endeavor taking place right here in my own state, and the impressive career and leadership of Dr. Mason all left me in awe. He had convinced me that LANL offers prestige to those who join its ranks but that the true benefit of the lab is bringing together so many different researchers inspired to create something greater together. //

TOP: Nicholas Huntoon (left) interviews LANL director Thomas Mason. Photo courtesy of Los Alamos National Laboratory.

FEATURE

UNDERSTANDING

by Alexis Mulski, SPS Member, University of Michigan

In early February of 2018, I sat alone in a cold warehouse, hunched over a desk covered in a tangle of cables and wires. Adjacent to this warehouse was a building which once housed the experiment responsible for producing the first unambiguous signals of the W boson. I was testing electronics for the upgrade effort of the ATLAS experiment at the Large Hadron Collider (LHC) in Geneva, Switzerland. It was the beginning of my work on a project that entailed six months abroad and continues to this day.

The experience and privilege of working at CERN can only be properly parsed in hindsight. After all, it's not every day that you can walk over and gaze into the 50-meter-deep cavern in which a Nobel prize–winning discovery was made. The elation of figuring things out—that feeling of finally truly understanding something—is unrivaled. But after a while, even exciting, important research took on the drudgery of any other daily task. The inevitable obstructions mounted, and frustration built. As the last vestiges of excitement about my new adventure began to fade, the appeal of working alone ("blazing your own trail," as it's often romanticized) went with it. Even though I knew I was doing important work, it felt like something was missing.

Then came spring, breathing new life into that cold facility. I attribute this less to the warming weather and more to the emerging presence of people—undergraduates, research scientists, postgraduates, and technicians, who were all returning to CERN after the cold Swiss winter. It didn't matter that we all did not share the same language. We communicated problems and solutions through gestures, drawings, and facial expressions. Even those who I did not work with directly, extended their expertise and services without hesitation. My personal success became inextricably tied to theirs. We had a problem to solve, no matter the constraints.

In this way, scientists working on multinational collaborations are like athletes on a sports team. Even the most talented athlete can't succeed alone. One must be trained and mentored, growing under the coaching of an advisor. Research collaborations of all sizes exist because we believe that being a scientist is a transferable skill that can be taught. Mentees learn from their advisors, and the cycle repeats. Besides, no one person could build a machine that probes matter at distance scales of 10^{-19} meters. In order to

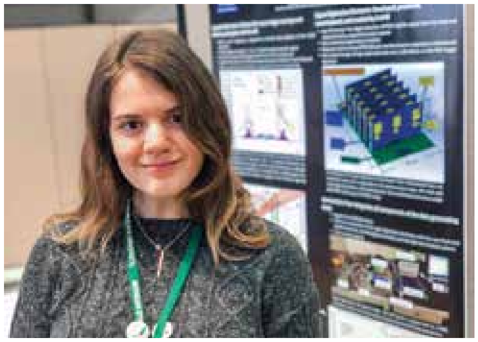
Together

advance the field of high energy physics, we no longer have a choice. Together we can go farther than we ever could alone—and there is no going back.

The investigation of the "big" questions—regardless of whether or not it yields discoveries or develops technologies directly applicable in society—is an honorable human pursuit. Even if the LHC makes no headline-worthy discovery in the next 20 years of anticipated operation, it will not have failed. The LHC is the culmination of decades of work at CERN. At its inception in the 1950s, CERN united the physics community in the uncertain climate of the early postwar era. People from many nations, very recently out of conflict, were working together constructively to achieve a common goal rather than aiding in each other's destruction. The experiments conducted at CERN have always been equal parts social and physical in nature.

The recently announced conceptual design report for the Future Circular Collider (FCC) at CERN reflects the achievements of LHC as the first worldwide science initiative. However, in order to build a machine of even greater energy and intensity, we will require an even larger team.

The late Carl Sagan once said, "The brain is like a muscle. When we use it we feel very good. Understanding is joyous." But perhaps the Sagan quote misses the essence of what it means to work on a machine like the LHC: Rather than understanding things alone, understanding them together brings the most joy. //



TOP LEFT & RIGHT: Inside ALICE detector's empty skeleton at CERN. Photo courtesy of CERN.

ABOVE: Alexis Mulski with her research poster about the work she did at CERN. Photo courtesy of Alexis Mulski.

FEATURE

BE THE (CLIMATE) CHANGE
You Wish to See

by Eeshan Bhatt, Graduate Student, Massachusetts Institute of Technology & Woods Hole Oceanographic Institution

As a PhD candidate in oceanography at the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution (WHOI), I am often asked how I found myself here. While the long answer is cochlear, gravitating around chance opportunities and excellent mentors, the short answer is quite simple: climate change.

When I was finishing up my undergraduate studies (in mechanical engineering and materials research), I wanted to put all my accrued technical knowledge into solving a problem that could directly help people, not just be academically interesting. For me, that meant tackling some part of the climate crisis.

My current research focuses on how collaborative networks of different types of autonomous underwater vehicles can leverage acoustic transmissions to be more efficient data gatherers than traditional profiling platforms, which usually collect point measurements as they drift wherever the ocean current takes them.

As you may know, sound travels much faster underwater than in air, and the path it takes changes based on the temperature and salinity of the medium. By inverting the acoustic transmissions between a source and receivers on various vehicles, we can estimate what large spans of ocean volumes look like much faster than we could before. Furthermore, by having these vehicles assimilate the information they receive with pre-run models, they can communicate with each other to reposition themselves to take the most useful data.

Having better data lets us run climate models with a more accurate driving input and monitor how quickly a specific region, such as the Arctic, is changing. My research is just one small contribution to the various technologies, experiments, and theories in the broader field of ocean and climate research, and depending on the day, you might think I was an acoustics physicist, robotics engineer, or data scientist.

One of the great things about the research done at WHOI—and ocean and climate research in general—is that it's interdisciplinary.

Researchers come from various backgrounds such as physics, mathematics, chemistry, biology, geology, and engineering. Many projects necessitate researchers to work across these disciplines to make the best use of ship time and fully understand the scope of the science. If you so choose, fieldwork can take you on six-month-long cruises, training as a scientific diver or setting up remote stations for continuous monitoring. That empirical data collection is balanced out by modeling, data analysis, or instrument development. All these methodologies are necessary to paint a complete picture of a system as complex as the earth, especially when we are experiencing dramatic variability.

At this point in human history we are at unprecedented crossroads for the relationship we have with our natural environment and its resources. When we hear stories about global warming and reducing greenhouse gas emissions, it's easy to forget that the ocean is our greatest heat and carbon sink. Understanding how the ocean is changing is vital to understanding how our own lives will change.

In October 2018, the Intergovernmental Panel on Climate Change issued a report calling for "rapid and far-reaching" change to limit global warming to 1.5 degrees Celsius (lowering the bar from 2 degrees Celsius as previously established by the Paris Climate Agreement of 2015). This limit is derived from minimizing significant impacts on ecosystems and human health and would go hand in hand with ensuring a more sustainable and equitable society. There is a lot of work to be done to reach that goal—so let's get to it. //

ABOVE: Bhatt diving to prepare an experiment. Photo courtesy of Eeshan Bhatt.

BOTTOM LEFT: Bhatt testing an autonomous underwater vehicle at Ashumet Pond in East Falmouth, Massachusetts. Photo by Tom Kleindinst. © Woods Hole Oceanographic Institution.

BELOW: Bhatt onboard the research vessel *Neil Armstrong*. Photo courtesy of Eeshan Bhatt.

SPECIAL FEATURE

Breaking Boundaries in Breakout Sessions

by Toni Sauncy, PhysCon 2019 Planning Committee Member

Planning for PhysCon 2019 is vastly different than planning for the typical technical conference. There are similarities, of course: plenaries, poster sessions, an expo hall, and a banquet are big events that come to mind. But making this a once-in-a-lifetime event for the anticipated 1,500+ enthusiastic undergraduate students means that the traditional mold must be broken in other ways. At PhysCon, the main way this will happen is with our parallel sessions. Most conferences have these sessions, sometimes referred to as breakouts, where multiple sessions occur simultaneously. They are typically set up like lectures, with speakers talking to a room full of passive onlookers and listeners. PhysCon is anything but passive.

There will be parallel sessions, but don't expect to just sit back and listen—you are needed to make these sessions a success! Planners have worked for the past three years to design breakouts that are informative and inspiring but, most importantly, interactive. That's right: audience participation required.

When you register for PhysCon 2019, you will have the opportunity to select options from three sets of breakout sessions that will invite you to stretch your creativity, acquire new skills and knowledge, and expand your professional network as you interact with super-cool presenters and get to know other students. The PhysCon2019 breakouts really do break the boundaries, pushing physics students to think and explore everything from career planning to how physics will have a global impact in solving some of the big problems facing humanity.

Will the breakouts take you out of your comfort zone? Hopefully. That is what the planning committee had in mind as we pored over feedback from previous PhysCons to figure out what physics students really want and need as they navigate the undergraduate physics experience. For PhysCon 2019, the breakouts include workshops and panel sessions where students will engage in a range of topics, which include spanning the maker movement, the role of scientists in science policy and funding, and even the connections between astrophysics and jazz. That's right. Jazz. And physics. Interested? Take a look at the list of options on the PhysCon website. The only problem with a list of mind-bending breakouts is that you only get to pick three. We can't wait for you to experience the boundary-breaking breakouts of PhysCon 2019. //

A Few Boundary-Breaking Breakouts:

PHYSICS FOR HUMANS

This is a maker/thinker/problem-solver workshop where you will learn and experience how physicists are at the forefront of solving problems that profoundly affect human life. An expert will challenge participants to create their own hands-on solutions.

THE PHYSICS OF CLIMATE CHANGE—PUTTING NUMBERS TO THE ISSUE

What are the facts? What is the role of an individual, a community, a region, a nation, or the whole human population of the planet in climate change? If you have ever wondered how to get to the heart of what really matters and how physics will be at the forefront of solving these problems, this is the workshop for you!

A DAY IN THE LIFE OF A GRAD STUDENT

What is the real deal with graduate school? Want to know the scoop on the realities of quality of life and how you might fit in an advanced degree program? Come learn from the experts—current grad students in a wide range of graduate programs—uncensored.

SCIENCE POLICY FOR SCIENTISTS

If you are interested in how science policy influences science and how scientists can be influential in science policy, this is your chance to interact with a combo team of a science policy expert and a Nobel laureate working on a large, government-funded project. Participants will engage in the process of real decision-making that impacts science and scientists.

See sigmapisigma.org/congress/2019 for the complete list of PhysCon breakouts.

PHOTOS ABOVE: PhysCon 2016 attendees partook in a wide array of breakouts. Photos courtesy of AIP.

Register for Breaking Boundaries at sigmapisigma.org/sigmapisigma/congress/2019/breaking-boundaries-event.

Champion Your Chapter at PhysCon 2019

by Brittney Hauke, PhysCon 2019 Planning Committee Member

This year at PhysCon 2019 we are featuring a brand-new event—Breaking Boundaries. During this event, there will be a graduate school and jobs fair, a T-shirt exchange and contest, Blackout Bingo, and most importantly, the Chapter Showcase. Our goal with this event is to give your SPS chapter a way to show what makes you unique and provide an opportunity for you to learn from and network with other chapters from across the country to see what they do well. Maybe your own chapter struggles with fundraising or getting people to attend events. We hope that you will be able to take ideas from other chapters to make your own chapter stronger.

If you're attending PhysCon 2019, we hope you'll participate in this event by running a table at the showcase. We're encouraging chapters to bring demos and posters, awards and plaques, scrapbooks and photos, as well as things visitors can take away with them, like outreach manuals or fundraising guides, pins, stickers, or other swag. Bring your best tips for outreach, chapter engagement, and creating inclusive spaces, because other chapters will definitely want to learn from you. Our Blackout Bingo will be designed to get people interacting, so the more varied and creative your display is, the more people will stop by and chat!

TOP: Brittney Hauke. Photo courtesy Brittney Hauke.

BOTTOM: Students from the University of San Diego showing off their SPS chapter. Photo courtesy of SPS National.

Don't forget to bring T-shirts in a few different sizes so you can enter the T-shirt contest and exchange witty tees with other chapters.

If people enjoy the event, we hope that this will be replicated at future PhysCons and at zone meetings. My committee has been working hard to iron out the details and make the Breaking Boundaries event as fun as possible. We're excited for all of you to experience it in November! //

Teach For America: Tips to Apply

by Kayla Stephens, Programs Manager, Society of Physics Students & Teach For America Alum

Nelson Mandela once said, "Education is the most powerful weapon which you can use to change the world." Although it has been over 60 years since *Brown v. Board of Education*, the United States still struggles with the concept of integrated and equal schooling. The potential of each student across the country is equal; however, access to opportunities remains disproportional.

This is especially true in physics, where students in many parts of the country don't have access to advanced math and science classes. Often this is because there are not enough teachers. In the United States, studies show a need for qualified high school physics teachers. Compared to other core subjects, physics has the second-lowest percentage of teachers with a degree in their content area—less than 50 percent. With a rising number of students enrolling in physics, it is important to meet that demand and ensure academic achievement.[1]

Since 1990, Teach For America (TFA) has recruited almost 60,000 college graduates with the mission to close the opportunity gap for all children. Selected corps members commit to at least two years of teaching in under-resourced communities. Recruits are placed based on academic background, interest, the specific needs of their preferred geographic regions, and where they will have the biggest impact on student outcomes. Since physics majors have strong backgrounds in mathematics and physics, they are most likely to teach those or similar disciplines. There is a high demand for STEM teachers, especially in under-resourced areas, and TFA is consistently working to increase the supply of qualified teachers in these subject areas.[2]

Teach For America's hope for their corps members is that they stay in education or use their career to continue to advocate for educational equity. The TFA program is selective and holds a high bar for admission, with an acceptance rate averaging between 11 and 15 percent. This is not meant to be intimidating but to show that preparation is key. If TFA is a potential next step for you after graduation, use the following tips to help you stand out as a top candidate.

FIND OUT IF TEACH FOR AMERICA IS FOR YOU

The application and interview process for TFA is quite rigorous and can take a significant amount of time and preparation. Before beginning the process, assess whether their mission and values align with your own.

- **Meet with a recruiter:** If a campus recruiter has not reached out to you yet, you can look on TFA's website (teachforamerica.org) to find a recruiter near you. Recruiters are most likely alumni themselves and can be a major resource, providing support for you throughout the application process. Speaking with a recruiter can help you understand the mission of TFA and what role you can play.
- **Reach out to current corps members or alumni:** This is another great way to receive tips and support during the application process. You can gain a genuine perspective on experiences in the classroom and what kind of training corps members experience. This is also an opportunity to gain insight into the rewarding aspects of teaching with TFA, as well as the challenges you may face. If you personally do not have any contacts, your recruiter may be able to connect you with some.
- **Visit a nearby TFA school:** Your recruiter may be able to help you organize a visit to a nearby school that employs TFA corps members. A corps member may even be able to host you during your trip. This will give you more of a hands-on view of life as a TFA teacher.

THE APPLICATION—RESUME AND WRITTEN RESPONSES

There are certain characteristics that Teach For America is looking for in their applicants, such as leadership experience, academic achievement, perseverance, interpersonal skills, respect for diverse groups, and importantly, your passion for making sure that all children have equal opportunity to succeed. The experiences in your resume and written response should highlight these qualities. This application is TFA's first impression of you and a determining factor for whether you will be invited to an in-person interview.

- **Be concise and to the point:** Teach For America can receive almost 60,000 applications in a year. It is important that your achievements are clearly seen in your resume and written responses. The website (teachforamerica.org) has tips on what they are looking for and provides articles written by other corps members on the skills you want to hone and share. Also, refer to the Winter 2018 issue of the *SPS Observer* Professional Development section for more tips on how to effectively build your resume.
- **Review and edit:** Before you apply, have your resume and your written responses reviewed and/or edited by multiple sources. This can ensure that the important information is easy to find and that your documents are clear of spelling, grammar, and formatting errors.
- **Apply early:** Teach For America provides five application windows and you can apply in any one of them. However, once you're accepted to TFA, there are still additional steps you must take to ensure that you are eligible to be placed in a school. For example, to qualify to teach, each state has their own state exam that you will have to pass before you're allowed in the classroom. It can take time to retrieve your results, so it is best to do this early in case you have to retake a test. Plus, applying in an earlier time window will help you solidify your plans after graduation.

PREPARE FOR THE INTERVIEW

This is the fun part of the application process! During the in-person interview, you will participate in a group activity with other applicants, teach a five-minute lesson of your choice in front of the group, and finally, have your one-on-one interview. This may sound intimidating, but if you prepare ahead of time and be yourself, it can be enjoyable.

- **Practice your lesson:** It is important not to overcomplicate your lesson. Keep the topic as simple and engaging as possible. Remember, you only have five minutes—you want to pick a topic that will be easy to grasp. Consider using one of the demos from the SPS Library! (See spsnational.org/programs/outreach/demonstrations.) Involve your audience in the lesson as well. Practice with your friends and get their input prior to your interview.
- ***Be yourself!*** This is the chance for the interviewers to get to know who you really are and to get a grasp of your interpersonal skills. They want to see that you can be a leader as well as a team player. And remember, they are human just like you! //

Visit teachforamerica.org to get more information on the work they do, who they are looking for, and how you can apply. Also, take the time to read articles written by TFA alum, such as "Rocket Scientist to STEM Teacher: Why I Chose to Teach For America" by Natalia Chabebe.

For more information on resumes and professional development resources, visit spsnational.org/careers.

OTHER POPULAR ALTERNATIVE TEACHING PROGRAMS:

American Board (americanboard.org)
The New Teacher Project (tntp.org)

FAR LEFT: Students conducting a structured study session. Photo courtesy of Kayla Stephens.

LEFT: Students testing fibers during a science lab. Photo courtesy of Kayla Stephens.

TOP: Physical science students testing their rockets. Photo courtesy of Kayla Stephens.

BOTTOM: Kayla Stephens in her classroom dressed up for Pajama Day during spirit week. Photo courtesy of Kayla Stephens.

References

1. "U.S. Physics Teacher Shortage and the Need for PhysTEC." Physics Teacher Education Coalition – Improving the Education of Future Physics Teachers, 2019. http://www.phystec.org/webdocs/shortage.cfm.
2. Teach for America. 2012–2013 Teach for America Annual Letter. Durham, NC, 2013. https://www.teachforamerica.org/sites/default/files/teach_for_america_fy12–13_annual_letter.pdf.

2018 AAS Division for Planetary Science:

Bringing Planetary Science down to Earth

by Dany Waller, SPS Chapter President, University of Kentucky

My research advisor called me late one afternoon to ask if I knew how to get to Tennessee. Being a native Kentuckian, I laughed and said I practically lived next door. Then he insisted I look at the email he had sent only moments ago. The American Astronomical Society's Division for Planetary Science (DPS) was meeting in Knoxville and the registration deadline was a week away. I knew I had to find a way to get there.

DPS is dedicated to research within our solar system, specifically planetology and solar system exploration. As a senior who is researching lunar and martian geophysics, attending this conference was a dream come true. Hosted by the University of Tennessee at Knoxville, the meeting offered academic mentoring workshops, informational sessions on publishing and advancing your career, and over two dozen talks on innovative planetary research.

When I arrived, I was met with a bright room filled with posters, bustling booths, and large touch screens featuring even more posters! After picking up our badges and adorning them with "First Time Attendee" stickers, fellow student attendee Kris Andrew and I took our time exploring the main hall. There was a planetary-science-inspired art exhibit, booths from half a dozen universities with tempting offers of graduate school, a booth selling miniature stuffed planets, and two space-themed virtual reality demonstrations! I gleefully spent my first half hour of the conference launching digital stars into a black hole.

As an avid science outreach volunteer and NASA solar system ambassador, I took pages of notes for future workshop ideas and demonstration designs based on what I saw in the hall. I then wandered over to the large touch screens that hosted an electronic poster gallery. Several people stopped by and read along with me, and I made small talk with physicists from far-flung places like California's Jet Propulsion Laboratory and the Atacama Large Millimeter/submillimeter Array in Chile.

Another highlight of my first day was the Women in Planetary Science Discussion Hour. It was affirming to speak with other women who experience imposter syndrome and exchange tips on how to manage that anxiety. I also learned about some of the problems that women of color face in the planetary sciences, an issue that I was incredibly undereducated on. I am so grateful for the opportunity to listen to the perspectives of other women.

The second day was another fun-filled adventure, exploring outreach activities and attending contributed and plenary talks. That evening, I attended the DPS banquet at the Knoxville Museum of Art. It was my first time at a professional banquet, and I was nervous about knowing only one other person. However, I ended up sitting at a table of fantastic scientists whom I can now call friends. For the evening's pumpkin-decorating contest, we brought together our variety of research fields—cloud systems on gas planets, magnetic anomalies on the moon, core-collapse supernovae simulations, extrasolar planets, and protoplanetary disks—to create a beautiful "planet."

After dinner, Kris and I attended a telescope observing session that turned out to be the best event that we attended. We spent two hours on the roof of the physics building, connecting with students, learning a lot about ground-based telescopes, and viewing objects in the solar system through various telescopes. My favorite thing to see (unsurprisingly, given my research focus) was the moon!

There was an incredible amount of content at DPS, which was a little overwhelming, and often talks ran long due to questions, but the environment was one of pure curiosity. From the talks I attended, the most memorable quote was by research scientist Dr. Shannon Curry: "All models are wrong; some are useful." The most frustrating part of my undergraduate research has been encountering models that explain some parts of a problem but not all. It was strangely comforting to see professionals grappling with the same situation.

This was my first professional conference, and it has set the bar astronomically high! The wealth of resources that I brought back is invaluable, as well as the generosity of so many physicists in their mentorship and kindness to first-time attendees. I cannot wait to attend again next year! //

ABOVE: Dany Waller. Photo Credit: Dany Waller.

TOP RIGHT: The moon through a telescope at the nighttime observation event. Photo Credit: Dany Waller.

MIDDLE RIGHT: An optical physics art exhibit. Photo Credit: Dany Waller.

BOTTOM RIGHT: Dany Waller experiencing virtual reality for the first time. Photo Credit: Kris Andrew.

Highlights of the Michigan State University CUWiP

by Gabrielle Feeny, Zone 7 AZC & SPS Member, Kettering University

As a senior physics major, this was my last chance to attend one of the annual Conferences for Undergraduate Women in Physics (CUWiP). I was excited to go so I could speak with other women in physics and learn about graduate schools and potential career paths. I was hoping this might help me figure out what I would like to do after I graduate.

Sprinkled throughout the conference were a number of workshops and panel discussions about just what I wanted to learn—preparing for the future. They included topics such as what you can do with a physics degree, how to apply to graduate school, how to write a resume, and so on. For me, the most impactful workshops were "Improving Mental Health and Wellbeing" and "Impostor Syndrome." In the former, participants acknowledged that academia can be a high-stress environment and discussed ways of coping and approaching overwhelming tasks. I have already put some of these strategies to use. In the latter, we played a game that helped me realize just how much I'd been affected by imposter syndrome, and we learned strategies to minimize feelings of inadequacy.

Another highlight of the conference was the plenary talk by Dr. Erica Snider. She shared her story of personal growth from a physics student into a project lead at Fermi National Accelerator Laboratory (Fermilab). Toward the end of her talk, she shared with us her passion for diversity and equity, particularly concerning women and LGBTQ+ individuals. As a member of the LGBTQ+ community, it was encouraging and awe-inspiring to hear the success story of someone like me and to learn that there are people within the physics community advocating for our inclusion and acceptance.

The conference included many other fantastic activities, such as tours of the National Superconducting Cyclotron Laboratory, a poster session, a serenade by the university's all-physics student choir, and a "physics slam," during which a handful of professors gave 10-minute talks and attendees voted on the best presentation. Overall, I had a wonderful time. I couldn't have felt more included, and I gained a lot of insight into the career opportunities out there for physics undergraduates. //

TOP: Gabrielle Feeny. Photo credit: SPS National.

ABOVE: More than 150 women attended the Midwest regional session of the national Conferences for Undergraduate Women in Physics on Jan. 18–20. Photo credit: Harley J. Seeley, University of Michigan.

2017–18 Outstanding Undergraduate Research Award Winners

by Rachel Kaufman, Editor

The SPS Award for Outstanding Undergraduate Research is presented each year to SPS students who demonstrate exceptional research achievements in a physics-related field. Awardees receive a $500 honorarium for themselves, $500 for their SPS chapters, and funding to present their research at a professional physics meeting. SPS is pleased to introduce the most recent winners, Luciano Manfredi Console and Sophia Sánchez-Maes.

For more details on the award and recipients, visit the SPS website at www.spsnational.org/awards.

MEET LUCIANO MANFREDI CONSOLE, LOYOLA MARYMOUNT UNIVERSITY

Right now there are gravitational waves passing through us from black holes that merged way back in the past, in the early universe. We can't feel them, but we can detect them with a sensitive instrument (like the newly upgraded LIGO). These waves could help us understand how the universe works.

As an undergraduate, I fell in love with general relativity. There are some problems with general relativity the way Einstein proposed it. One big problem is dark matter and dark energy, which must be introduced to account for observational data like galaxy rotation curves and accelerating expansion of the universe, which Einstein's theory alone cannot fully explain. But of course we've never seen or detected either, even though general relativity says it should make up 95 percent of the universe. We've tried many ways to detect it, so people are starting to think that it doesn't exist. I started working on a theory called modified gravity (MOG) that doesn't require dark matter or dark energy to account for what we see in observations.

My research focused on how to test this theory—to find a measurement that would be different if MOG was true rather than if general relativity was true. It turns out that merging black holes may hold the key. When two black holes merge, they collide and form a bigger black hole. The collision causes a perturbation, and just like if you hit a bell, it will vibrate. Likewise, just as the bell gets quieter and quieter and eventually stops vibrating, so do black holes. How they do that—what we call the quasinormal mode—is uniquely determined by the theory you use to describe space-time. By finding the quasinormal mode of a black-hole merger, we can compare it to what Einstein's theory would predict and what we'd expect to see under MOG. Through my work in calculating the quasinormal modes for MOG, we found that they're very different from general relativity. If we can detect more gravitational waves, we might be able to discover which theory of gravity is more correct.

I'm now pursuing a master's at Cambridge, going into more heavy math, taking courses in geometry and topology. Research has showed me that I'm passionate about dealing with problems that we don't know the answers to. I want to stay in academia and give back to society by disseminating knowledge as a professor. I believe that's something I'll be good at. //

MEET SOPHIA SÁNCHEZ-MAES, YALE UNIVERSITY

My path has varied a lot. It looks like I bounced from tectonics to biofuels to geology to astronomy to physics, but all of these things, to me, feel like a natural progression.

I grew up in Las Cruces, New Mexico, on the US–Mexico border. Many tech companies funded summer classes to teach Latinas like me how to code. Those classes got me jobs in my high school years—my first job was actually in a physics lab. I was 15, and the job was in Albuquerque, three hours away. I moved in with an aunt for the summer. It was lonely but definitely worth it in the end. That lab taking a chance on a 15-year-old girl meant that at 17 I was working at NASA.

We were looking at exoplanets, and I grew frustrated thinking of these cool worlds that we weren't thinking of as full, complete worlds. They were just points on a mass-radius plot. That curiosity about what each world was like led me to geology, trying to figure out the fundamental physics of plate tectonics.

Earth is the only planet in the entire universe that we know has plate tectonics. It's important for the carbon cycle. We know of planets that have volcanoes; they emit gases, but without plate tectonics bringing carbon back into the mantle, the cycle isn't completed.

There are two hypotheses for how plate tectonics work, basically reducing friction so these giant plates can move. One involves a thermal-cracking process that requires water, and the other involves reducing the size of tiny grains found at plate boundaries. If you want to know which of these processes are necessary for plate tectonics, you follow the energy. The work I did was to prove that plate tectonics requires the thermal-cracking mechanism, which requires water—so now we know that an earth-sized terrestrial exoplanet can't have tectonics without water as well, and we know that a planet with an active tectonic system must have water. This is important because to a distant observer, Mars, Earth, and Venus all look like they're in the habitable zone. However, they are not equally habitable. We'll need to understand how to tell them apart from light-years away.

Now in my senior year, I have switched up my interests yet again. I'm currently conducting research on the quark-gluon plasma in the early universe. It existed in the earliest instants after the big bang and has implications for everything that followed, but we can actually create it experimentally. It's everything I love—complex systems, fluids, physics, and astronomy. //

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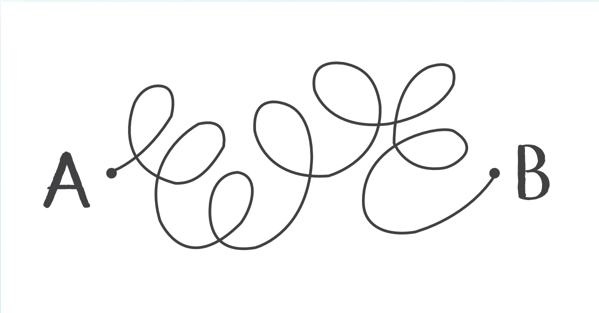

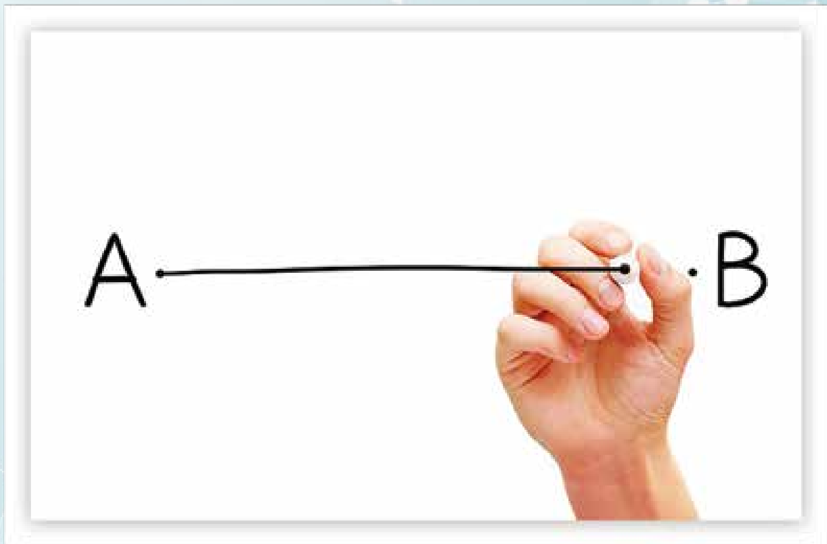

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