the SPS Observer
Volume LII, Issue 3
WINTER 2019

Providence, RI
14–16 Nov 2019

Get ready to make waves at physcon

+ Roberto Ramos: Empowering future scientists
+ Kirtley Watts combines physics and food
+ Build your own hovercraft

FUTURE OF PHYSICS DAYS

Events for Undergrads

Coming to Boston?

Join us for the SPS Undergrad Meet & Greet, the Awards Reception, and more!

Joining us in Denver?

Be sure to check out the Grad School panel and the Awards Brunch!

FPD events include:

- Undergrad research sessions
- Professional development workshops
- Networking and social activities
- Free t-shirt

and more - just for undergrads!

MARCH MEETING 2019

March 4–8, 2019
Boston, MA

APRIL MEETING 2019

quarks Q2C cosmos

April 13-16, 2019
Denver, CO

APS physics

SPS

LEARN MORE: go.aps.org/fpd

Join us in 2019 for Future of Physics Days (FPD) at the March and April meetings!

the SPS Observer

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Mark your calendars for November 14–16, 2019, for PhysCon 2019, the largest gathering of undergraduate physics and astronomy students in the country! Photo credit: GoProvidence.com.

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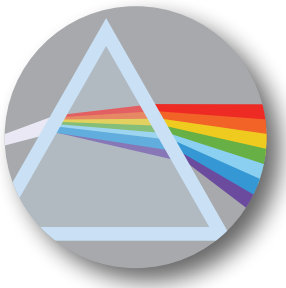

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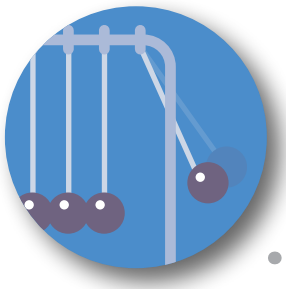

THEORETICAL, EXPERIMENTAL, OR COMPUTATIONAL?

What's important to you in a graduate school?

Got these questions on your mind?

GradSchoolShopper.com has the answers!

Phoebe, SPS Intern 2018, Rhodes College

SPS

AIP American Institute of Physics

One Interaction at a Time

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

I believe that it takes a special kind of person to be up at 3 a.m. working on impossible integrals so that you can prove that the energy levels of the harmonic oscillator are, in fact, quantized. I also believe that solving them provides a special type of satisfaction! If it weren't for the sense of community and fellowship my SPS friends gave me, I'd have never made it past Math Methods, much less E&M I. (And, for the record, I am still not a huge fan of optics… Sorry, Dr. Kotlarchyk.)

However, it wasn't just early morning homework set scrambles that got me through undergrad. It was selling pizza[1] so we could buy a coffeemaker and new soda fridge for the SPS lounge. It was having (more or less) the entire department contact me after my father passed away, and it was knowing that none of us went to bed until we all finished our senior research PowerPoints. We ran tutoring sessions for freshmen and attended graduating seniors' cap and gown ceremonies when their parents couldn't come. While excellence in physics is important, fellowship and service are the hallmarks of some of the best department groups, and that's highlighted when we come together at every ΣΠΣ-supported Physics Congress.

The Physics Congress, or PhysCon, began as a national convention designed to bring together the departments and students who wanted to support each other's successes.[2] We honor that legacy to this day by continuing to host PhysCon. While many things happen at a Physics Congress, one of the most important is the formation or extension of your physics community. Students and faculty from across the United States (and beyond) come together to discuss shared issues, work on societal problems, and learn about the broader community of which they are members. PhysCon strives to help students develop a sense of fellowship through not just a shared experience (awesome talks and breakouts), but by having people learn and work together. This emulates what happens at the department and, more importantly, the student level. While the professional development may be helpful, the connections and memories you make will last a lifetime. PhysCon works to develop your extended physics family and guide the next generation of physical scientists.

In college, I nearly changed my major. I didn't because I found a home and—more importantly—a family in SPS. That was a few years ago now, but when I travel to physics departments, I get to see how SPS is still changing lives, one interaction at a time. I was recently at the University of Tampa to work with them on their newly formed chapter and was pleasantly surprised to see their chapter advertising itself as a "physics family" on fliers. I spent the afternoon with the chapter, working on homework, physics trivia,[3] and finding the nearest open coffee shop… It felt like home. When I was at Gettysburg College[4] this fall, we talked about how to capture the best pictures at the observatory with a cell phone and how we could make sure incoming freshmen felt welcome in the department. While these chapters are about 1000 miles apart, they share common experiences. It's these experiences that connect us, and we often don't even realize it until we come together. This is why PhysCon is so special… It's like meeting long-lost friends you never knew you had and finally having a room full of people who get you.

> It's not easy being a physics student,
> and we need to be there for each other.

One of the lasting impacts of Sigma Pi Sigma (ΣΠΣ) is that, in the United States, most physics and astronomy departments have a club, group, or cohort that students can make all their own (other regions of the world are set up differently).[5,6] While ΣΠΣ, the physics honor society, helped form the Society of Physics Students 50 years ago, the core reasons for ΣΠΣ's existence haven't changed in almost 100 years: It's not easy being a physics student, and we need to be there for each other.

When I tell people about what I do, a response that regularly comes up (mostly from non-physics/astronomy types) is, "Why is SPS special?" If you ever ask me, I'll probably have one of two answers for you. First, it's one big, emergent family. And second, we change lives, one interaction at a time. PhysCon can help you along your career path, and just might change your or someone else's life. //

1 Robertson, Physics and Pizza: Joining a Global Community of Scientists, (2017) https://www.spsnational.org/the-sps-observer/fall/2017/physics-and-pizza-joining-global-community-scientists.

2. P. Dixon, The History of Sigma Pi Sigma, (1996) https://www.sigmapisigma.org/sigmapisigma/about/history.

3. https://www.spsnational.org/programs/outreach/physics-jeopardy.

4. http://www.gettysburg.edu/academics/physics/student-opportunities/society-of-physics-students.dot.

5. A. Landcastle, Get Involved in the International Association of Physics Students, (2015) https://www.spsnational.org/the-sps-observer/fall/2015/get-involved-international-association-physics-students.

6. S. Borer, International Peers and Where to Find Them: My Experiences at 2018 ICPS, (2018) https://www.spsnational.org/the-sps-observer/fall/2018/international-peers-and-where-find-them-my-experiences-2018-icps.

PhysCon Is a Congress—Each Student Has a Voice

by Jim Borgardt, Sigma Pi Sigma President

No matter what your political beliefs are, the 2018 elections again showed the importance of being involved in the democratic process, of participating in your local community, and that each individual vote matters. The same is true in regards to your professional life—it's important to be engaged, connect with others, and have your voice heard. PhysCon 2019, with a theme of *Making Waves & Breaking Boundaries* will be held November 14–16, 2019, in Providence, Rhode Island, and offers a perfect opportunity to do just that. PhysCon 2019 will be the largest known gathering of undergraduate physics students in the United States, with an anticipated 1,500 participants! PhysCon is different because it's not a standard conference. It is a gathering of like-minded students: part conference, part retreat, part congress. PhysCon is for students. Not only does it connect you with other students, the National Office, Nobel Prize recipients, and other luminaries in physics, but it also gives you a unique and powerful chance to have your thoughts and ideas heard and to hear and consider those of others you will meet. PhysCons only occur every few years, so this is something you and your SPS chapter should make every effort to take advantage of!

MAKE YOUR VOICE HEARD AT…

Plenary Talks

With five plenaries from physics VIPs on a diverse array of physics-related subjects, this is a once-in-a-lifetime chance to interact with them and ask questions. Based on student input, we've arranged speakers who reflect the diversity of our community. We have people who've gotten a PhD and who haven't, who work in academia and industry, and who've changed their fields in big ways and small. At PhysCon 2019, we will be seeking your input on who should be invited to the next meeting and what kinds of topics you want to hear about!

Breakout Sessions

After the last PhysCon, some attendees voiced concerns that students had to make hard choices and sometimes missed a workshop they really wanted to attend due to scheduling conflicts. We also solicited student feedback on which sessions you found valuable or wanted more of, which you felt could be left out, and which unrepresented topics you wanted to see included in PhysCon 2019. In short, we heard you! In the upcoming PhysCon, there will be a greater variety of topics, including climate change, entrepreneurship, outreach, data visualization, backyard astronomy, the physics of cooking, graduate school, careers, science policy, career toolbox items, and more!

Some of the sessions that are anticipated to be more popular will be repeated, giving you more flexibility. We'll continue to have a congress-wide interactive session where we explore what we need to work on within the community, as a community. We'll figure out who we are as a group and what we can do to come together more effectively and productively to help reach our collective goals.

Poster Sessions

Based on suggestions from students at the last PhysCon, there will be a stronger footprint here too. PhysCon 2019 will offer not one, but two student poster sessions, with dedicated time for viewing the contributions from an expected 750 poster presenters—about half of all of the students attending! We'll also be continuing the art competition, which helps explore the profound connection between art and physics.

Graduate School and Career Fair

We are committed to having even more graduate schools, companies looking to hire budding physicists, and representatives from our national labs. PhysCon 2019 will not only have opportunities for you to interact with these groups, but will also include a mix of posters and exhibitors, including AIP Member Societies, to provide a well-rounded experience for students looking for internships or pursuing graduate work in a physics-related field. This is an excellent opportunity to share your experiences and interests—don't forget your resume!

Tours

Providence offers an excellent home base for touring nearby state-of-the-art facilities in a wide range of work steeped in physics. There will be an opportunity to tour nearby physics attractions such as Woods Hole Oceanographic Institution, New London Naval Research Base, MIT, Harvard, the Rhode Island Hospital Medical Physics facility, and Optikos, the world's largest manufacturer of equipment for measuring optical image quality.

Breaking Boundaries!

Based on student input, PhysCon 2019 will also feature a new event called "Breaking Boundaries" focused on promoting SPS chapters from across the country. The goal is for students to visit with and learn from one another, while also finding ways to improve their own chapters. Each chapter has its own unique culture, and the aim of this session is to create a space to share ideas and items that other chapters can take home to their own institutions.

This lineup of plenaries, breakout and poster sessions, a career and graduate school fair, tour destinations, and the new Breaking Boundaries event—each envisioned or improved with student representation on the planning committees—promises to "make waves and break boundaries" and make PhysCon 2019 the best to date! With so many opportunities to personally benefit, to enjoy and build our physics community, and to meet and make new connections with about 1,500 physics students from SPS chapters around the country, now is the time to energize your chapter's plans to join us in Providence, Rhode Island, for PhysCon 2019! I look forward to meeting you and hope to hear your voice there. //

Kirtley Watts

BS Applied Physics, Rutgers University–New Brunswick

What she does:

Kirtley Watts is a process specialist at Puratos Corporation, a food ingredient supplier. Puratos Corporation makes ingredients for other bakeries to use in their foods. You may never see a Puratos-branded bread mix on a store shelf, but that doesn't mean that the company's items aren't in many of the packaged baked goods you buy.

As a process specialist, Watts works on scaling up new recipes for ingredients.

"Our R&D will make something delicious in the lab—a fruit filling that you'd see in a pie, for example. At lab scale, they can make 3 pounds at a time. On our production line, we could be making 3,000–6,000 pounds at a time."

Watts's job is to translate a recipe for three pounds of cherry filling into one that works on industrial equipment.

How she got here:

As an undergrad, Watts lured other students to her study groups by promising home-baked goods. After graduating, a friend pushed her toward food science. During her job interview with Puratos, Watts described how she fixed her own gas oven. ("It was pretty frightening—I shoved everyone out of the house.") The impressed interviewer said that's why she was hired.

Best part about her job:

"I get to do a lot of experimentation... As long as things are documented, I can change whatever I want." She's working on developing "clean label" preservative-free versions of existing products. Watts says she also loves going to the store and seeing her products on shelves. "That's my filling on that bar, or that's my glaze. It feels so good to see something you made."

Most frustrating part of her program:

"I want to innovate and make new things... I may want to make 90,000 things, but to run a business, we need to make nine things and make them well."

How she uses physics:h

Watts puts her problem-solving skills—honed by her physics degree—to work by setting up and calibrating new equipment. "There's a lot of physics and engineering involved when you're making food on a mass scale." Beyond that, Watts has brushed up on her organic chemistry, crucial for food science.

Most surprising fact about her:

She still bakes for fun! "Recently I've been baking cookies, for like eight weeks.... I make pie dough for fun." //

Outstanding Chapter Advisor & Outstanding Chapter Awards

2017–18 SPS OUTSTANDING CHAPTER ADVISOR

The SPS Outstanding Chapter Advisor Award is the most prestigious recognition given each year by SPS. The following SPS advisors were nominated by their students, colleagues, and departments in recognition of their dedication to furthering the mission of SPS. The winner receives a total of $5,000 for his or herself, their chapter, and their department. The winner was recognized at the Winter 2019 AAPT Meeting in Houston, Texas. The runner-up's chapter receives a $100 gift card for a pizza party and other chapter activities. Learn more at www.spsnational.org/awards/outstanding-chapter-advisor.

WINNER

Roberto C. Ramos, University of the Sciences (see page 29)

RUNNER-UP

Alina Gearba-Sell, United States Air Force Academy

NOMINEES

Tirthabir Biswas, Loyola University New Orleans

Martin DeWitt, High Point University

Robert Craig Group, University of Virginia

Donna Hammer, University of Maryland, College Park

Jose L. Lopez, Seton Hall University

David Peak, Utah State University

Justin K. Perron, California State University, San Marcos

2017–18 SPS OUTSTANDING CHAPTER AWARDS

The SPS Outstanding, Distinguished, and Notable Chapters are determined each year by the National Council through careful review of the photos and information provided through the SPS chapter reports. Designations are made based on chapter involvement in local, zone, and national SPS meetings, participation in SPS programs, outreach efforts, student recruitment, and interaction with their department and department alumni. To earn these designations, SPS chapters are encouraged to stay active and engaged by participating in an array of activities. Sample activities can be found through the SPS Information Handbook—www.spsnational.org/about/governance/sps-information-handbook.

OUTSTANDING CHAPTERS

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Adelphi University (NY) (Zone 2)
Augustana College (IL) (Zone 9)
Baylor University (TX) (Zone 13)
Bethel University (MN) (Zone 11)
Bridgewater College (VA) (Zone 4)
California State University, Fresno (CA) (Zone 18)
California State University, Sacramento (CA) (Zone 18)
California State University, San Marcos (CA) (Zone 18)
Carthage College (WI) (Zone 9)
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Coe College (IA) (Zone 11)
Colorado Mesa University (CO) (Zone 14)
Colorado School of Mines (CO) (Zone 14)
DePaul University (IL) (Zone 9)
Emory University (GA) (Zone 6)
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Florida State University (FL) (Zone 6)
Georgia Institute of Technology (GA) (Zone 6)
Grove City College (PA) (Zone 7)
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Rhodes College (TN) (Zone 10)
Rochester Institute of Technology (NY) (Zone 2)
Siena College (NY) (Zone 2)
South Dakota School of Mines & Technology (SD) (Zone 11)
South Dakota State University (SD) (Zone 11)
Southwestern Oklahoma State University (OK) (Zone 12)
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Texas Lutheran University (TX) (Zone 13)
Texas Tech University (TX) (Zone 13)
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University of Kentucky (KY) (Zone 8)
University of Louisville (KY) (Zone 8)
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Longwood University (VA) (Zone 4)
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Messiah University (PA) (Zone 3)
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Murray State University (KY) (Zone 8)
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Sam Houston State University (TX) (Zone 13)
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Smith College (MA) (Zone 1)
St. Joseph's University (PA) (Zone 3)
St. Peter's University (NJ) (Zone 3)
Stevens Institute of Technology (NJ) (Zone 3)
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Swarthmore College (PA) (Zone 3)
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The University at Albany, SUNY (NY) (Zone 2)
University of Central Missouri (MO) (Zone 12)
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University of Nebraska–Lincoln (NE) (Zone 11)
University of Nevada, Reno (NV) (Zone 18)
University of Northern Iowa (IA) (Zone 11)
University of South Alabama (AL) (Zone 6)
University of Tampa (FL) (Zone 6)
University of Texas at Austin (TX) (Zone 13)
University of Wyoming (WY) (Zone 14)
Wake Forest University (NC) (Zone 5)
Wallace Community College (AL) (Zone 6)
Xavier University of Louisiana (LA) (Zone 10)

DIRECTOR'S RECOGNITION

The Director's Recognition is awarded to those chapters that have made tremendous strides in their local chapter, zone, and national activities over the last academic year.

Dillard University (LA) (Zone 10)
Rockhurst University (MO) (Zone 12)
Saint Anselm College (NH) (Zone 1)
Wallace Community College (AL) (Zone 6)

APPLY NOW FOR SCHOLARSHIPS AND INDIVIDUAL AWARDS

Visit www.spsnational.org/awards to learn about exclusive opportunities for SPS members to be recognized. Awards of $1,800-$5,000 are available for students and advisors. These awards are generously funded by donations from Sigma Pi Sigma members, friends, and alumni of SPS.

Deadline: March 15

The Physics of Pumpkin Chucking, Part 2

by Ravn Jenkins, SPS Member, College of William and Mary, and Brad Conrad, SPS & Sigma Pi Sigma Director

We looked at the physics behind launching pumpkins with a pneumatic air cannon in the last issue of The *SPS Observer*, but now it's time to go old-school—dropping pumpkins from the roof! For maximum splatter, we recommend filling the pumpkins with liquid nitrogen!

…DID YOU SAY LIQUID NITROGEN?

Yes! Nitrogen has a boiling point of 77 K (brrr!), so its liquid form is called a *cryogenic*. For some points of reference, pure water freezes at around 273 K, and the lowest recorded natural temperature is around 184 K (at Vostok Station on the Antarctic Plateau).[1] Many physics experiments use liquid nitrogen (LN_2) as a coolant, but it's also perfect for freezing a pumpkin into a solid block of shatterable organic matter, as seen in Fig.1.

(Obvious) Disclaimer: Do not use LN_2 without proper protection, training, and the appropriate permission!

PUMPKIN PHYSICS

For science, let us suppose we want to calculate the force a pumpkin will exert on the ground at the moment of impact after falling from some known height. Let's start with considering a pumpkin in free fall. A pumpkin of mass m will experience a gravitational force downward, $F_g = mg$, and a drag force F_d in the opposite direction of motion:

$$F_{net} = F_g - F_d$$

If the pumpkin is assumed to be moving through a uniform fluid (air) at a velocity v and has a cross-sectional area A perpendicular to the air flow, we can approximate the net force on the pumpkin F_{net} as

$$F_{net} = mg - \tfrac{1}{2}\rho v^2 C_d A$$

where ρ is the mass density of air (1.225 kg/m^3) and C_d is the drag coefficient of the falling object.

While there are many ways of doing this, we can estimate the average velocity with some good old conservation of energy. Before the pumpkin is released from rest at height h, the pumpkin has energy stored as gravitational potential energy $U = mgh$. Let's assume that all of the pumpkin's potential energy is converted to kinetic energy right before it hits the ground, which is not a poor assumption:

$$mgh = \tfrac{1}{2} mv^2$$

Then the final velocity of the pumpkin should be given by

$$v = \sqrt{2gh}$$

To find the cross-sectional area, we must first consider the pumpkin's shape. Pumpkins have three common shapes: oblate spheroid, prolate spheroid, and sphere. Fig. 2 shows each pumpkin shape and the corresponding cross-sectional area A. For the sake of this discussion, let us assume that the pumpkin is falling stem-up and will not spin. If you want a challenge, look up how spinning affects drag.[2,3]

Finally, we must decide on the drag coefficient for the pumpkin. While there are a lot of complexities, Fig. 3 shows a simplified list of measured

Figure 1: Pouring liquid nitrogen into pumpkins. Pretty cool! Photo courtesy of Ravn Jenkins.

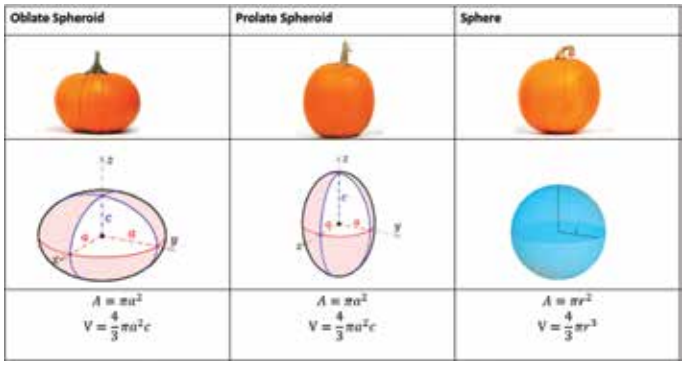

Figure 2: Illustration[4,5,6] of correlating cross-sectional pumpkin shapes, with cross-sectional area *A* and volume *V*.

drag coefficients for various shapes, with an approximate Reynolds number of 10^4, as the size of the object affects the value.

The drag coefficient of a sphere, $C_d = 0.47$, is a close-enough estimate for the drag coefficient of all pumpkin shapes.

Putting it all together, we find the final value for the force on the pumpkin right before it hits the ground:

$$F_{net} = mg - \rho g h C_d A$$

Shape	Drag Coefficient
Sphere → ●	0.47
Half-sphere → ◖	0.42
Cone → ◀	0.50
Cube → ■	1.05

Figure 3: Drag coefficients for various shapes[7].

NOW, FOR THE PUMPKIN PUZZLER

A. Chucking the squash: Say we're dropping the pumpkin pictured in Figure 1 off the roof of the physics building. If the height and equatorial circumference of the pumpkin are 30 and 65 cm, respectively, the height of the roof is 9.1 m, the hollowed pumpkin has a mass of 6.2 kg, and we fill the pumpkin halfway with liquid nitrogen, what will the acceleration of the pumpkin be right before it hits the ground? More importantly, how does this differ with an uncarved pumpkin? Does mass even matter (pun intended)?
Hints: What shape is the pumpkin? The density of liquid nitrogen is 808.4 kg/m³ at 25°C at 1 atm.[8]

B. Some devilish differentials: How would we calculate the velocity without using conservation of gravitational potential energy to estimate?
Hint: Use the identity $\int_0^x 1/(a - bx'^2)\, dx' = (\tanh^{-1}(\sqrt{a/b}\, x)/\sqrt{ab})$.
Check your answers against our solutions.[9] //

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MORE HALLOWEEN FUN

Bookmark these activities for your chapter's fall calendar

Ghoulish Galileo: Bring your pumpkin drop to the next level by replicating Galileo's experiment! Will two pumpkins dropped at the same time hit the ground simultaneously? Bonus points if someone dresses up as Galileo!

Spooky Physics Conference: Once a year, William and Mary's chapter of SPS transforms into the SSP, the Society of Spooky Physics! Undergraduates present satirical talks of physical explanations for the paranormal to a panel of esteemed spooky science experts (aka graduate students and professors in costumes). The graphs are ghoulish, the tables are terrifying, and the equations will haunt your very soul!

Have your own setup? Reach out to us on social media or email us at sps@aip.org with a picture, your specs, and how well theory compares to experiment!

How I Built a Hovercraft

by Bryan Gaither, Sigma Pi Sigma Member and Laboratory Manager, Austin Peay State University

As a professional mad scientist, one of my favorite hobbies is building over-the-top physics demonstrations to get young people excited about science.

I built this hovercraft to not only be an attention-grabbing demo, but also to promote our new engineering physics program. The hovercraft also marked the debut of the Fantasy Factory—a workshop where we build anything and everything awesome—at Austin Peay State University.

The main focus of this build is to demonstrate Newton's laws of motion. I like to explain the hovercraft as a two-dimensional representation of docking a spacecraft to the International Space Station. With the cushion of air under the craft, there is no reference of friction to the ground. (And in fact, NASA uses a similar hovercraft in its "Astronaut Training Experience," a tourist experience at Kennedy Space Center, to simulate the zero-friction environment of space.)

I built a very basic version of this hovercraft with my science teacher in the second grade. That craft was tethered by a corded leaf blower, so it couldn't go very far. I have waited a long time for the battery technology to power a cordless leaf blower enough to lift me and 100 pounds of fire extinguishers.

For my Mark III version, I used plans from sciencebob.com[1] as a reference but modified it slightly. The original plans call for a round plywood base over a tarp used as a bladder. A leaf blower inflates the bladder, giving a basic hovercraft, albeit one with no steering or brakes.

I used ¾-inch plywood for the 4-foot-diameter base, just as ScienceBob did, but swapped out 20-gauge clear vinyl from the craft store for the bladder. This allowed some flexibility in the bladder to handle uneven surfaces.

I also added steering, courtesy of two 20-pound CO_2 fire extinguishers. These tanks have tubes that go to the base of the pressure vessel and force liquid CO_2 through the nozzle. The liquid has the mass and a large enough expansion coefficient to provide a decent amount of momentum to the craft. The thruster assemblies are hard-mounted to the hovercraft base, and pressure washer quick-connects allow riders to change exhausted tanks quickly.

The default valves on the extinguishers limit the hovercraft to binary thrusting: fully on or fully off. I coupled a handlebar setup and brake cable assemblies from the local bike shop with compound bow cams from the local archery shop and attached them to ball valves to create variable thrust for propulsion. The cams give a 2:1 advantage, so a short pull of the brake lever translates to a longer travel in the cable, moving the ball valve from closed to wide open.

I used 80/20 extruded aluminum to build the central structure to mount the handlebars and safely secure the fire extinguishers.

I demoed the new version in front of a bunch of kids on campus for the Junior Govs Summer Camp. It was actually the first time I had tested the Mark III more than a few feet. The kids were really excited to see a "crazy mad scientist" in an Iron Man mask flying around the gym!

Of course, I'm not done. I already have a plan for the Mark IV.

I'd like to add a momentum curtain to provide a larger pocket of air under a larger skirt surrounding the hovercraft.

My goal is to start on land, navigate a boat ramp, and go full throttle down the river near campus. It is not a guarantee, but it sure is a dream of mine. //

Reference:

1. https://sciencebob.com/build-a-hovercraft-you-can-ride/

Bryan Gaither testing the handlebars of the Mark III hovercraft. Photo courtesy of Bryan Gaither.

A Collaborative *Cosmic Triptych*

by Teddy Anderson, SPS Member, University of Utah

Our SPS chapter was growing quickly, and we wanted to find a project to engage as many people as possible from the physics department and beyond. The idea for a mural began with the desire to add color and interest to the main hallway of the physics building. Our department chair, Dr. Ben Bromley, had given us the green light on several smaller projects throughout the year, and when we brought him our idea for a mural, he was on board.

We decided to pursue a partnership with the University of Utah Center for Science and Math Education's Refugees Exploring the Foundations of Undergraduate Education in Science (REFUGES) program to create the mural. For six years, the REFUGES program has been helping middle and high school–aged kids from refugee families to prepare for college, and we knew they would be good partners for a large-scale project to paint a mural depicting different astronomical objects.

Dr. Bromley helped us plan a central theme and present the idea to the REFUGES students. They helped us further refine the theme. Says Dr. Bromley, "It's great that the REFUGES students went with a big bang theme, a trek through cosmic time. The scale was grand, worthy of the commitment and enthusiasm of the club and the students working together!"

Interest in the project was strong from the start. We paired 15 undergraduate volunteers with 15 kids from REFUGES, and each team chose a celestial body or two to research, sketch out, and paint. Buying and transporting the materials was the biggest challenge, but when it came time to paint, everything went smoothly: We were blessed with good weather and plenty of outdoor space.

Our biggest stroke of luck was having a skilled painter on hand—an undergraduate volunteer named Emmelyn Redd. Emmelyn is an animation major, and she heard about the project while taking an introductory astronomy course. Says Emmelyn, "The kids planned out the design and painted what each of them wanted, in the time they had. I used their design and foundation, and took the project on, to refine it and touch it up visually. It was a fantastic opportunity to help the kids and work on a sizable painting for permanent display."

The finished mural is 4 ft × 10 ft and is on display on the main floor of the James Fletcher Building, which is home to the physics department. It catches the eye of everyone visiting the physics department and has helped increase interest in the club. "Our department is truly fortunate to have SPS here on our campus, strengthening our own community and reaching out to help others," says Dr. Bromley. Our club members would agree. The mural serves as a reminder of the power of collaboration, in physics and beyond. //

LEFT: Students begin designing three panels of art depicting a cosmic journey through time. Photo courtesy of Teddy Anderson.

ABOVE: *Cosmic Triptych* on display in the University of Utah James Fletcher Building. Photo courtesy of Teddy Anderson.

physcon PREVIEW

Making **Waves** and Breaking **Boundaries**

by Steve Feller, Co-Chair of PhysCon 2019

Rhode Island is officially known as the Ocean State. That is appropriate for the nation's smallest state, one that has over 400 miles of beach but is only 37 miles wide, east to west. PhysCon 2019 is almost ready to make waves in Providence, the state capital.

When most people think of Rhode Island, they imagine salty air, the sounds of the waves, sandcastles, beach food, seaweed, and gulls squawking. But from now on, you should also think of CERN, LIGO, neutron stars, the cutting-edge labs at MIT, Brown, and Harvard, the world-class facilities at the Woods Hole Oceanographic Institution and Naval Submarine Base New London, hands-on workshops, engaging demos, and all of the camaraderie we know happens at our fantastic conferences. All this and more awaits you at PhysCon 2019.

The theme of the November 2019 conference, *Making Waves and Breaking Boundaries*, is a perfect play on words. Besides conjuring the Ocean State, "making waves" has a wonderful connection to physics. Think of light, sound, X-ray diffraction, neutron diffraction, electron diffraction, MRI, refraction, telescopes, optical and electron microscopes, interference, de Broglie waves, earthquakes, DNA, radar, sonar, RNA, standing waves, music, and holograms. The list could go on.

Breaking boundaries is exactly what we like to do in physics. What physicist doesn't dream of challenging paradigms, inventing new techniques, or discovering novel materials? We live in one of the most active periods in the history of physics, and breaking boundaries is possible for any physicist, no matter what field you specialize in.

Please join us in Providence. In the pages that follow, you'll learn more about our plenary speakers and get a sneak peek at some of the highlight events and activities for PhysCon 2019. You'll also find information about how you can and should start fundraising now to make the trip to Providence financially possible for as many students as possible. We look forward to seeing you at PhysCon 2019, November 14–16! //

The author and his spouse enjoying a beach vacation. Photo courtesy of Steve Feller.

physcon 2019 Physics Congress

Speaker Bio

Jocelyn Bell Burnell Returns to PhysCon

by Rachel Kaufman, Editor

Photo courtesy of AIP.

One of the most famous female astronomers will return to speak at PhysCon for the fourth time. Dame Jocelyn Bell Burnell, known both for her discovery of pulsars in 1967 and her scientific leadership in the decades since, will serve as honorary chair and provide the opening talk as well as scientific context for our other speakers.

Bell Burnell was a graduate student at Cambridge—one of the very few women in the program—searching for quasars when she noticed the "scruff" on the paper charts produced by a new radio telescope. That "scruff" was the first detected pulsar.

Pulsars are rapidly rotating neutron stars, and beyond being interesting in their own right, they have been used to study the "stuff" in space outside of any solar system and indirectly detect gravitational waves.

Many students know what happened after Bell Burnell's landmark discovery. Bell Burnell's advisor, Antony Hewish, and another astronomer, Martin Ryle, were nominated for, and subsequently won, the Nobel Prize for their role in pulsar discovery in 1974. Bell Burnell has said that she understands the logic of rewarding supervisors rather than students; she also told this magazine in 2012 that not winning the Nobel meant she was "carried on a great wave of sympathy and a great wave of feminism…. It's a waste of energy worrying about that kind of thing."

Afterward, Bell Burnell had a wide-ranging career in astronomy, studying stars in almost every band of the electromagnetic spectrum. She has headed the Royal Astronomical Society and served as the first female president of both the Institute of Physics and the Royal Society of Edinburgh.

The accolades are still coming. Earlier this year, she was awarded a Special Breakthrough Prize in Fundamental Physics, a recognition that comes with a $3 million award. The prize was awarded "for fundamental contributions to the discovery of pulsars, and a lifetime of inspiring leadership in the scientific community," prize organizers said.

Bell Burnell told Space.com earlier this year that she plans to spend the $3 million to fund graduate students from underrepresented groups in physics through the Institute of Physics.

"I feel that I made my contribution in part because I felt an outsider," she told the outlet. "I was one of very few women, and I wasn't from the southeast of England, the affluent part of the country. So, I think increasing diversity of the workforce actually allows all sorts of things to develop."

At the Breakthrough Prize awards ceremony in November, she added in a brief speech that "One of the most delightful things is that some people have... been in touch, saying, 'How can we also contribute and add to this fund?' So hey, Breakthrough, we might have a breakthrough."

For more about Bell Burnell's career, check out "Resolved: Noted Scientist Shares Her Journey" in *The SPS Observer,* Winter 2012 issue. //

Speaker Bio

Such Great Heights: Sandeep Giri

on building products, quitting academia, and putting internet in the sky

by Rachel Kaufman, Editor

Sandeep Giri spent years developing manufacturing facilities in Puerto Rico to enable the building of giant balloons and their payloads that X (an Alphabet company; formerly Google X) needs to run Project Loon, an ambitious project to bring the internet to remote and rural areas using a network of stratosphere-based balloons.

Hurricane Maria destroyed the facility in two hours.

Undeterred, Giri (at the time Loon's manufacturing engineering manager) and his team leapt into action. Within a few weeks, they had steered an adequate number of balloons into the skies above Puerto Rico, restoring connectivity for text-messaging and email back to 200,000 Puerto Ricans. The newly built facilities sustained this service for months. This was an important milestone for the Loon project, which had never provided internet service at this rapid pace or scale before.

Born to a blue-collar family in India, Giri says he's grateful for the emphasis his parents placed on education. By chance, at a forum for Indian students interested in getting student visas to study in the United States, he met a professor from Coe College (Iowa) in the lobby of a Calcutta hotel. "Coe was not even on my radar, I hadn't even heard of the college or Iowa. But the professor insisted, 'Why don't you apply?'" Giri applied right in the lobby, and was subsequently accepted and offered a generous scholarship (for which he is still grateful).

At Coe, initially, Giri was aiming for a computer science major. Then, by chance, he met physics professor Steve Feller, who invited Giri to his lab to work on glass research. "I had never done research," Giri says. "I had never really done experiments on fundamental science... That's what got me—it was totally new to me." He went on to earn his undergraduate degree in computer science and physics, and a master's in materials science; he then went on to pursue a PhD.

As Giri has related in the Fall 2018 issue of the *SPS Observer*, his PhD was going well when he met a friend of a friend in industry. "[The employees there] were using the same vacuum deposition technique I was using in my grad school lab... It seemed like a direct application of what I had been doing. I was like, I can use my skills to actually build a product?" He considered dropping out of school and getting to work.

It was a tough decision. His PhD results were actually "looking super interesting," and he'd just passed his qualifying exams at Stanford, which had a low pass rate. "Mentors were telling me, 'Are you sure? You're quitting a prestigious PhD at Stanford?' But I went with my instinct that I wanted to build products."

Giri landed a job at Qualcomm, working on microelectronics devices for displays in consumer electronics, and learned "all the phases of product development." He even helped develop patents for anti-stiction coatings for microelectronics that he eventually helped incorporate into their products while living in Taiwan.

After a few years, a friend recruited him to Google, where his product development experience came in handy for working on the ill-fated smart glasses known as Glass. "From our end, we did good work," he says. "It was a solid product."

After Glass wound down, Giri joined Loon. "I never thought I would work on balloons—this was an audacious idea Google was behind," he said. He developed the manufacturing engineering branch, bringing it up from scratch and launching manufacturing facilities in Nevada and Puerto Rico. The launch of balloon-based internet service to Puerto Rico after Maria was "a big win" for the project. Google is still working on further developing Loon, using the manufacturing facilities Giri helped build (and rebuild).

Now, surprisingly, Giri has come almost full circle to his early physics days, working on building the next generation of processors for Google's machine learning and artificial intelligence.

"These are extremely fast—some of the fastest computers in the world. I'm part of the team that helps design and build them. "We are kind of approaching the end of Moore's law," he adds, referring to the observation that the number of transistors in a circuit doubles every two years but that the laws of physics dictate that transistors can only be miniaturized so far. "This is something I studied back in high school physics, and now I am living it," he says. //

Alphabet's X "moonshot factory" received permission from the United States FCC to deploy Project Loon in Puerto Rico. Credit: iLighter *Flickr* (CC by SA 2.0).

physcon
2019 Physics Congress

Speaker Bio

A Nobelist's Next Move
John Mather

by Rachel Kaufman, Editor

How do you look back at the earliest days of the universe? John Mather knows. As the scientific leader of the Cosmic Background Explorer (COBE), John Mather kept a team of 1,500 focused on the prize: looking back at the earliest days of the universe, at light that no one had seen before.

And he's going to do it again, looking back to within 200 million years of the big bang as the senior project scientist for the James Webb Space Telescope (JWST).

"We're looking for those rare things that are at the earliest times in the universe—that's something that I'm really excited about," he told Space.com in a 2011 interview. Mather will bring the excitement of JWST and its potential to answer unanswered questions to PhysCon as a plenary speaker.

Born in Roanoke, Virginia, in 1946 and raised in New Jersey, Mather grew up interested in math and science. He wrote in 2006 that his earliest school memory, from age 6, was "realizing that one could fill an entire page with digits and never come to the largest possible number, so I saw what was meant by infinity." A voracious reader, he hid books under his desk and read rather than pay attention to lessons.

By fourth grade, given a radio kit for Christmas, he quickly was entranced and saved his allowance for a better one to listen to broadcasts from around the world.

He majored in physics as an undergraduate at Swarthmore and moved to Berkeley for graduate research. There, he worked on a project to measure the cosmic microwave background (CMB). Arno Penzias and Robert Wilson had discovered the CMB in 1964 when their new radio telescope picked up a low but steady signal, even after they had eliminated every imaginable source of interference (including pigeon droppings in the antenna). The cosmic microwave background is the earliest electromagnetic radiation in the universe, and its structure is some of the best evidence we have for the big bang.

"I started right in," Mather wrote. The project was to build a far-infrared spectrometer that would be taken to a mountain in California and pointed at the sky. The spectrometer yielded some "interesting" data, so the next step was to attach a spectrometer to a balloon that would raise it above the Earth's atmosphere to get a better picture of the CMB. This half of the project did not go quite as well. As Mather recalled:

> I'm afraid that my skill was stronger in understanding than it was in implementation, and it's a true story that the antenna on the balloon payload fell off while it was on the launch pad. It was my solder joint that failed. Fortunately, this fault was noticed, and the payload was launched successfully.
>
> However, it also was true that we had gotten tired of testing, and our instrument did not work, for three different reasons. It was an awful feeling—one that stayed with me for the rest of my life.

Luckily Mather was still able to finish his thesis, writing about the ground-based observations and the design for the balloon instrument. After graduating, he went on to new adventures—but quickly turned back to the cosmic microwave background and began working on what would become COBE. In 1989, the instrument was launched; in 1992, the spacecraft's measurements of the "wrinkles" in the CMB made the front page of the *New York Times*. In 2006, he and collaborator George Smoot were awarded a Nobel Prize for their work.

Mather says JWST is now his "major passion." James Webb, scheduled to launch in 2021, represents "the hopes and ambitions of the 10,000 astronomers who have already used the Hubble," he told Space.com in 2011. Immensely more powerful than Hubble, JWST will be able to see further back in time to see the earliest galaxies in the universe. "I'm pretty confident there will be surprises out there," he said, "things that will be worth all this work." //

Photo credit: NASA.

Speaker Bio

physcon 2019 Physics Congress

Dr. First
Jami Valentine Miller

by Rachel Kaufman, Editor

Photo courtesy of Jami Valentine.

It can be lonely being the first. But Jami Valentine Miller—the first African American woman to get a physics degree from Brown University and the first African American woman to get a PhD in physics from Johns Hopkins University—is used to being the first.

Thanks to her work founding African American Women in Physics, other "firsts" may feel a little less lonely.

Miller was born in Philadelphia, where she realized her aptitude for math at an early age. This led her to a middle school magnet school for math and to a high school program that gave her college prep over the summer.

After those experiences, "I knew I was going to major in a science or engineering field," Miller said. "It felt completely natural. It didn't feel at all odd to be a black girl in Philadelphia who wanted to [do that]."

At a college fair at her high school, she was recruited to a historically black college and university (HBCU), Florida A&M University, where she earned a BS in physics. At the time, FAMU didn't have a graduate program in physics, so she went to Brown for her master's, then Johns Hopkins for her PhD.

"One of the things HBCUs do is they prepare you for life in the real world," Miller said. "In the real world, you're not going to be in a situation that's 95% minority. [At Brown], I made friends, I socialized. It was definitely a culture shock because Tallahassee is not Providence… It was different, but I was prepared."

Fast–forward 7 years, and Miller was just finishing her dissertation in materials for spintronic applications when her advisor insisted she get a job lined up before defending. She applied to as many positions as possible and heard back from the US Patent and Trademark Office.

"It was 8 months of paid training. I was like, 'I'll take this job while I wait to hear back from my true passion—a postdoctoral position.'" But patent examining turned out to be Miller's dream job, and she's still there. "I enjoy the work, [and] it's related to my dissertation."

At the same time she was finishing her dissertation, Miller became acutely aware of how few other black women she knew in physics, and she started an Excel sheet to track the few she knew of.

"At the time there were less than 50. I'd meet these women at different conferences [and track] who they were, what were their careers. I posted it on my website at Hopkins." That Excel sheet eventually grew into African American Women in Physics (http://aawip.com/), a site to celebrate African American women "who are doing amazing things," Miller says.

"It's also a safe space where people can discuss their concerns or any situations they might be in, because most people are going to be the only African American woman—possibly the only African American or the only woman [in their program]."

The women trade advice on navigating their careers and "talk about what it's like to be the first" African American woman in their program. "If you didn't go to Stanford or Howard, you were probably going to be the first," Miller says.

Now, Miller is celebrating the accomplishments of these women while also showing that physics is central to everything. At PhysCon, when she returns to the city where she got her master's, she'll discuss how physics and intellectual property are related.

"I'm biased," she says, "but everything is physics. If you want to be an electrical engineer, all you have to do is figure out the vocabulary …because they're still doing physics, they're just calling it something slightly different…. Even if you're just [building a] table, a table has to be balanced. There's physics in there. If you're interested in it, go for it." //

Speaker Bio

Energizing Change
Ellen Williams

by Rachel Kaufman, Editor

Ellen D. Williams has a storied career in surface statistical mechanics, nanoscience, and energy technology.

Now, the former head of the Advanced Research Projects Agency-Energy (ARPA-E) is bringing her wisdom, experience, and climate optimism to PhysCon to inspire the next generation to use their physics knowledge to solve the world's most pressing energy problems.

Climate change "is very scary, [but] I have to be optimistic. We can do it—and we just have to do it," Williams says.

In a way, coming back to energy innovation—both at ARPA-E and in her post-ARPA-E career—is coming full circle for Williams, who was very excited about environmental issues way back in high school. But as an undergraduate, she became "more oriented toward physical chemistry," and eventually, surface science. Her research at the University of Maryland focused on studying the growth of materials used in semiconductors.

For decades she did this work, racking up numerous publications, awards, and honors along the way. Then in 2010, BP came knocking.

"I was invited to apply for the position of chief scientist at BP, and I thought, 'How could I possibly do that?' And then I thought, 'Maybe I could.'" Williams was still interested in energy and climate change, and, at that time, BP was investing in solar and biofuels, so it seemed like a match. During her tenure at BP, Williams ran a sustainability initiative at the company and led the creation of reference publications on oil and gas's impact on the environment, specifically on water, land, and scarce materials, in addition to climate change.

In 2014, she was tapped by Ernest Moniz, then the US secretary of energy, to head up ARPA-E, the DOE's agency focused on identifying and funding cutting-edge energy technologies. "It's a great agency, it was a wonderful job. I had an incredibly productive time there," she says. When asked for examples of the types of innovative technologies that ARPA-E supports, Williams says there are so many that it's hard to select just a few. She describes radiative cooling–the development of materials that emit waste heat to outer space and create passive cooling. She also is enthusiastic about developing plant-based photosynthesis to extract carbon dioxide from the air and store it as solid materials in the soil. She offers other examples in energy storage, low-energy materials processing techniques, high-power lasers for accessing geothermal energy, energy implications of vehicle automation, and pauses to say, "Obviously I could talk about this all day."

With the change of administration in 2016 came another job change, and Williams found herself back at UMD, teaching, researching, and consulting on energy technology innovation. "It was actually a bit of a surprise [to be back in the energy field]," after all these years, she says. "I went away from that path [but] it never left me. But the skills I developed through my life made it possible for me to make that transition," she says. Williams adds that undergraduates should also focus on developing their "skills…. Find the things that excite you and that you can do well, and get really good at them. And then you can take those skills and go out and find the problems where you can have an impact." //

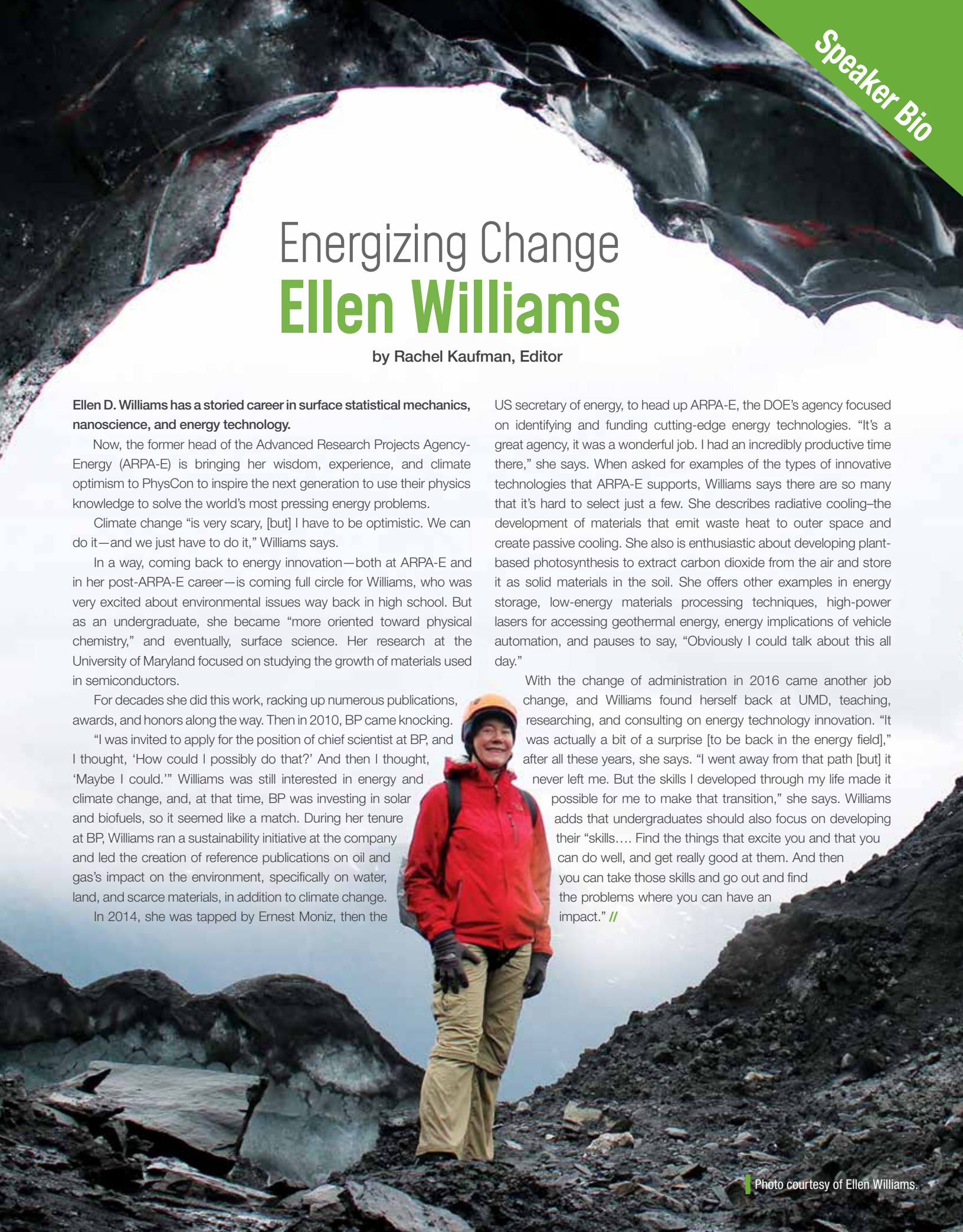

Photo courtesy of Ellen Williams.

PhysCon 2019 Highlights

by Kendra Redmond, Contributing Editor

Whether you're already planning your route or are new to this PhysCon thing, here's a roundup of highlights that will have you counting down until November for the 2019 Physics Congress.

1. A Prime Location

PhysCon attendees will gather in the heart of downtown Providence, Rhode Island—a location with big-city amenities and a small-town feel. Physicists will fit in well here, as eight college and university campuses are located in the city, along with a natural history museum, plenty of outdoor recreation space, and many historic attractions that reflect its manufacturing roots. Today, Providence's economy is largely based on health care, education, and finance, and there's a growing culture of artists and foodies. There are several world-class labs nearby, some of which PhysCon attendees will have a chance to visit.

Chapter Spotlight: Brown University

Located a mile from the PhysCon 2019 home base (the Rhode Island Convention Center and Omni Hotel), Brown University's SPS chapter is a local host of PhysCon. An active group known for their weekly "high energy chocolate" events and custom physics monopoly game, the chapter is looking forward to sharing the progress they've made in fostering a positive, healthy environment for physics students, says SPS chapter president Jacob Jackson. While in town, Jackson encourages PhysCon attendees to experience Blueno in person, chill on the main green, check out the ridiculous rock tree, dance with the tinfoil people, and get breakfast at Louie's at 5 a.m. If you're not sure what any of that means, just ask the local hosts when you arrive!

2. Unique, Inspiring Tours

Physics students have a wide range of interests, from science research to communication and history, and PhysCon tours are unique ways to explore these interests in and around Providence. More tour sites will be released soon, and the details of many of them are difficult to set too far in advance, given the nature of research, but you won't be disappointed.

Tour Spotlight: Naval Submarine Base New London

Home to the US Navy's submarine force, Naval Submarine Base New London is about 60 miles southwest of Providence, situated near the coast and along the Thames River. It is home port to 15 attack submarines and hosts the primary training facility for submariners and a medical research lab. The USS *Nautilus*, the first nuclear-powered submarine, is moored near the main gate and open to visitors of the adjacent Submarine Force Museum. The base is also located near General Dynamics Electric Boat's main construction yard, where most of the US Navy submarines are built.

LEFT: The Los Angeles–class attack submarine USS *Providence* (SSN 719) transits the Thames River as it departs Naval Submarine Base New London for a six-month deployment. Credit: U.S. Navy photo. Public domain.

LEFT: The Parkinson & Frodsham transit instrument, Liverpool, circa 1838, from the Ladd Observatory history of science collection. Photo by Mike Umbricht / Ladd Observatory.

RIGHT: Observer Frederick Slocum using a spectroscope on the 12" refractor at Ladd Observatory, March 15, 1905. Photo courtesy of Department of Physics, Brown University.

Tour Spotlight: Ladd Observatory

Founded in 1891, Brown University's Ladd Observatory offers visitors a unique view of the evolution of astronomy and its role in society. It also offers great views of the skies. The observatory's historic 12" refracting telescope is still operational and features its original mount and counterweight-driven gear drive. Other observatory highlights include a transit room and a historic collection of astronomical instruments and timekeeping devices. A vibration-free, temperature-stable clock vault built into the refracting telescope's support base houses three clocks once used for precision timekeeping.

BELOW: USS *Nautilus* (SS-571), the US Navy's first nuclear-powered submarine, on its initial sea trials, 10 January 1955. Public domain.

3. Honest, Relevant Resource Panels

What's it really like in physics graduate school? What should you look for in a thesis advisor? Where can you get support as an LGBT+ scientist? What's the best way to handle harassment in the lab? Can you get a good job with a bachelor's degree in physics? What if you bomb the physics GRE? Is there room in the lab for mothers of young children? These are just some of the questions that swirl around the anxious minds of physics majors. PhysCon panels are a chance to voice these questions and have them and others addressed by real people sharing real experiences.

4. SPS Chapter Showcase

Each SPS chapter is unique—whether yours has found its niche on campus or is still looking, the SPS chapter showcase will be full of inspiration. From research posters to t-shirts and favorite demos, each chapter will have a space to fill with materials that represent their chapter and reflect its unique culture. Chapters will also be encouraged to bring items to share: demo instructions, fundraising guides, stickers, posters, and nerdy giveaways.

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Carla Ramsdell brings a cooking demonstration into a physics of energy and sustainability class. Photo courtesy of Marie Freeman, Appalachian State University.

Stanley Micklavzina performs an acoustics demonstration during a "Physics of Rock 'n' Roll" show for the Oregon Museum of Science & Industry's Science Pub. Photo by Dean P. Walton.

5. Engaging Workshops on Real Issues

Have you ever attended a conference and spent the entire time listening to what other people have to say? That doesn't happen at PhysCon. PhysCon features an array of hands-on workshops designed to engage attendees in exploring meaningful issues and developing concrete skills. You'll be able to choose the workshops that interest you most from among a range of topics such as political advocacy, entrepreneurship, and how to get a job with a bachelor's degree in physics.

See more at sigmapisigma.org/congress/2019

Workshop Spotlight: Food, Energy Efficiency, and You

Carla Ramsdell is a mechanical engineer, physicist, environmental steward, and food enthusiast. In a word, her interests are linked together by thermodynamics. Through interactive, hands-on workshops, Ramsdell will take PhysCon attendees on a journey to address the energy impacts of our food choices. Is chowing down on frozen pizza or carryout more energy efficient? What role does food play in climate change, and can your personal habits really make a difference? From conductivity to emissivity and cast iron skillets to Instant Pots, these research-based workshops will put your physics and cooking skills to the test and transform your home kitchen into a science laboratory.

6. An Incredible Demo Show

You've probably attended a physics demo show. You may have even helped orchestrate one. But you've never seen one like this. PhysCon will bring together legendary physics demo expert Stanley Micklavzina from the University of Oregon and others for a fantastic show, fueled by an audience of 1,500 enthusiastic physicists.

7. Lunch with a Side of Inspiration

How often do you get to ask a professional physicist to pass the ketchup? During "Lunch with the Scientists," a special meal at PhysCon 2019, each table will be hosted by a physical scientist eager to get to know the next generation of physicists, share their story, and give advice. This is an intentional but relaxed opportunity to network with a professional physicist outside of your department—maybe even outside of academia. Regardless of the food, this lunch is likely to be one of the highlights of your entire PhysCon experience. (Although the food should be good too!)

8. Grad School and Career Fair

Your next step awaits, and Sigma Pi Sigma is here to help you figure out what to do. A favorite PhysCon event, the joint grad school and career fair will include representatives from physics and physics-related graduate programs, internship sites, and employers around the country. You'll get to talk to recruiters and representatives face-to-face about what they're looking for and see whether you'd be a good fit. If you already have a plan in place, you'll still enjoy collecting pencils, Frisbees, and the other freebies that fill the exhibit hall. //

TOP: Attendees at PhysCon 2016 networked and noshed with professionals during Lunch with the Scientists.
LEFT: Jocelyn Bell Burnell and a 2016 PhysCon attendee connect over a meal.
RIGHT: PhysCon 2019 will provide multiple opportunities for students to explore careers.

Photos courtesy of AIP.

physcon PREVIEW

Making the M

by Mary Ann Mort, Tori Eng, and Brittney Hauke, student

By now you know that PhysCon brings together physics students, faculty, alumni, and other scientists from across the globe for the largest gathering of physics undergraduates in the country. We attended PhysCon in 2016, and it was a life-changing event.

PhysCon 2016 included exciting workshops, talks, and tours (one of our favorites was a visit to Google's semisecret R&D lab). But some of our best memories, and those of our fellow attendees, came from the "in-between" times.

During meals, we were encouraged to sit with people we had never met before. Mort recalls two of her friends sitting at a table of strangers. There they met Dr. Patrick Brady. His name didn't mean much to them at the time, but they talked about life and what motivates them. Little did they know he was one of the plenary speakers—he gave a talk on the groundbreaking discovery of gravitational waves later on—and he name-dropped both of them for being stellar young physicists. It made their whole year.

At the poster session, Mort was in deep conversation with a physics major from Oregon State University when she realized his mentor was someone she had met at a different conference. Mort learned a lot about materials science from him, and they exchanged info. After PhysCon, they kept in touch and both ended up being SPS interns in DC together for a summer. This just goes to show that the people you meet at conferences will pop in and out of your life when you are engaged in the physics community.

Just like PhysCon 2016, PhysCon 2019 will offer a diverse group of speakers, a variety of tour sites and workshops, and opportunities to share your research, but it will be even more ambitious! We're planning on making waves and breaking boundaries with more students, a larger palette of interactive workshops and panels, more networking, and a few new events (see pages 20–23 for a list of highlights). Here are a few pieces of advice to help you get the most out of your experience, during the scheduled and the "in-between" times:

Just like PhysCon 2016, PhysCon 2019 will offer a diverse group of speakers, a variety of tour sites and workshops, and opportunities to share your research, but it will be even more ambitious!

Eat at least one meal with strangers

Although a bit scary for many people, this is a great way to make new friends from different backgrounds and schools. These random people will broaden your network and may be your future colleagues and friends. Photo courtesy of AIP.

Bring business cards and keep them in your lanyard

By doing this you not only look professional, but you make it super easy to establish connections and maintain those relationships after PhysCon. Photo courtesy of AIP.

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ost of PhysCon

members of the PhysCon 2019 Planning Committee

Take at least five pictures

The fun was real, and it was certainly a whirlwind experience, but one thing all previous attendees agree on is that they wish they had more pictures. Snapchat is great, but take some real photos so you can look back on all the good times. Give yourself bonus points if you include students from a different university. Photo courtesy of AIP.

Go to the dance party

Do we really need to explain why? It's a dance party! We watched the CEO of the American Institute of Physics break it down in 2016—it was awesome! Photo courtesy of AIP.

Plan your schedule

Some PhysCon events will happen in parallel, so, to keep from feeling overwhelmed, you'll want to decide which events you want to attend ahead of time. Ideally, you want to go to as many events as possible. PhysCon 2019 will be a very busy conference, but you can always catch up on sleep when it's over! Photo courtesy of AIP.

Take at least one night to explore Providence (ideally with some new PhysCon friends)

Do you know the next time you will be in Providence? We don't! So take a night to explore this historic city and get to know some PhysCon attendees better. There will be time to get dinner with new friends on Thursday and Friday. Photo credit: GoProvidence.com.

Be yourself and have fun

There are thousands of people at PhysCon, and one of them is bound to be a new friend of yours by the time it's over. At PhysCon 2016 we had a balsa wood plane–throwing competition, laser battles on the ceiling, and accidentally mistook butter balls for white chocolate. PhysCon 2019 is going to be even better. Don't get too serious, relax a little, be yourself, have fun, and you are bound to have an extremely memorable experience. //

The Dos & Don'ts of **Fundraising for PhysCon**

by Danielle Weiland, SPS Programs Coordinator

Thinking of going to PhysCon this year? Worried about how to pay for it? Whether you'll be the only chapter member attending PhysCon 2019, or your chapter is bringing the whole crew, this article provides best practices, fundraising ideas, and SPS National resources to help you start the fundraising process NOW! As a veteran of the 2012 and 2016 PhysCons, I've learned a lot about what it takes. As your chapter begins the fundraising journey, consider these suggestions and determine what mix of ideas works best for you. You can never think too outside the box when fundraising, so get creative and share your ideas with other chapters too!

Best Practices

There are endless ideas for fundraising, and some will work better in different settings and situations. So talk to other nearby chapters or confer with your zone councilor or associate zone councilor for some additional inspiration. You can find contact information for your local zone councilor and associate zone councilor at http://www.spsnational.org/about/governance/national-council.

- **Start Now!** With less than a year until PhysCon, you may already be behind on meeting your fundraising goal. Plan on holding at least one fundraising event per month (big or small) from now until November.
- **Talk to Your SPS Advisor.** Your advisor may be your best resource. While this may be your first time planning for a large conference, your advisor has probably attended at least one in their lifetime. Even better, your advisor will be able to help you navigate the resources available through your department and school.
- **Set Goals.** After talking with your chapter and advisor, you should have an idea of how many students plan to come to PhysCon and how much money you'll need to raise. Set monthly goals and brainstorm fundraising events. Keep to the plan!
- **Investigate All Resources.** You have so many opportunities to raise money for your chapter—the hardest part is finding time to act on all of them!
  - ❍ See if your department can put forth or match any funds that you raise.
  - ❍ Work with your school's alumni department to see if there are any potential donors they could link you with.
  - ❍ Reach out to local industry and tech companies to see if they would sponsor student travel.
  - ❍ Keep an eye out and apply for SPS Travel and Reporter Awards this spring.

TOP: The 2016 PhysCon Planning Committee checking out tour locations in San Francisco with the author front row center. Pictured at Google X. Photo courtesy of Tracy Schwab.

Simple Fundraising Ideas

If you are just starting to fundraise for your chapter, here are a few simple but effective fundraising ideas.

- Students often forget to eat during busy days. Take advantage of this and sell coffee and donuts or pizza and soda once a month or during exam weeks. Make sure you pick a high-traffic location and focus on class change times. Remember that inclusivity is an SPS value, so try to provide gluten-free, dairy-free, and/or vegan options.
- Put on physics demo shows and sell tickets or ask for donations. This takes a bit more planning, but incorporating performance (such as a light show, music, jokes) will really help your outcome, especially when asking for donations. You can download easy, fun, and inexpensive demos from SPS at http://www.spsnational.org/outreach-demos.
- Get professors to volunteer for "Pi a Professor" on Pi Day (March 14). Sell tickets on a per-throw basis and use whipped-cream-filled pie tins. You can maximize this event by also selling pies and holding a digits-of-pi recitation competition.

Large Impact Fundraising

Large impact fundraising events can be a great way to bring in huge resources, but they can be a bit more challenging to implement. These ideas often require a bit more finesse (or paperwork!) and require different steps than your normal fundraising events.

- **Request additional funds through student government –** If your SPS chapter is an officially recognized club or organization at your school, you can often request funds annually or can request special allocation funds on a one-time basis. In either case, it is important to highlight why you and your peers attend PhysCon; it may even be beneficial to reach out to alumni for testimonials. With this process you should expect to fill out some forms, speak directly to the student government board, and maybe even give a presentation. Each school's process is different, so be sure to find out the details as soon as possible. Use your advisor as a resource to help determine the best course of action for requesting these funds.
- **Work with your alumni department –** If your school has an alumni office, stop by and discuss the opportunity for alumni to support student travel. Make sure to bring as much promotional PhysCon material, information about the conference and costs, and past attendee testimonials as possible. This will help you guide conversation and hopefully get a little more traction and assistance from the department. You can find promotional content for PhysCon at http://www.sigmapisigma.org/congress/2019/fundraising.
- **Find local sponsors –** If your school has a development or corporate partnership office, be sure to reach out to them and see if there are organizations that would be willing to sponsor your travel. If not, you may have to do a bit more legwork in reaching out and directly contacting local industry and tech companies, or even local restaurants and businesses that have a strong community presence. Again, talk to your advisor to see if they are in touch with any alumni who may be supportive. //

SPS National is Here to Help!

You can find many of the tips mentioned, along with the top ten student fundraising tips, a travel cost calculator, and more, at https://www.sigmapisigma.org/sigmapisigma/congress/2019/fundraising. Watch the website for Student Travel Award information in spring 2019!

TOP: Travel poster made by Eleanor Sayre of Kansas State University.

LEFT: Danielle Weiland presenting at PhysCon 2012 on behalf of the Wisconsin Space Grant Consortium High Altitude Balloon Launch Team. Photo courtesy of Eric Ireland.

A Week of Physics "Phun" at Marshall University

by Sean P. McBride, SPS Advisor, Jon Keaton, SPS Member, and Ryan Vincent, SPS Member, Marshall University

Nearly 200 high school students from the communities surrounding Marshall University in West Virginia came out to the university on Friday, October 19th to experience hands-on physics demonstrations, receive a taste of phase changes with liquid nitrogen ice cream, explore the cosmos with the department's portable planetarium, and investigate the nanoworld using a scanning electron microscope (SEM) at the College of Science. They were also treated to a pizza lunch, topped off with a quick game of projectile motion skeet ball and prizes!

"High School Physics Day is an opportunity for all physics majors and professors here at Marshall University to provide fresh minds with the same excitement we ourselves feel when observing the laws of the universe through interesting, thought-provoking, and sometimes tasty demonstrations," according to Jon Keaton, Marshall University physics major.

Physics graduate student Ryan Vincent had the opportunity to teach high school students and some excited high school teachers the science behind scanning electron microscopy. "Most students in high school have had little to no exposure to state-of-the-art research practices such as scanning electron microscopy, so being able to share my interest and knowledge of the physical principles that go into it was truly an invaluable experience for them, as well as for myself," says Vincent. "Being able to inspire curiosity and watching the pure joy and amazement on the students' faces as they operated the controls of the SEM to acquire an image was rewarding within itself."

High School Physics Day was the grand finale of Physics Week at Marshall University. Physics Week is an annual department-wide effort to engage students and faculty in reaching out to young minds and planting seeds of curiosity. In addition to High School Physics Day, Physics Week includes research talks by faculty and alumni, as well as lectures by a distinguished guest. This year, the physics department hosted world-renowned sports physicist Dr. John Eric Goff. He spoke twice, giving a colloquium talk, "Friction Challenges from the Sports World," and an evening presentation for the public called "A Summer of Great Sports Science."

High School Physics Day and the other Physics Week events were a collaborative effort. Faculty, undergraduate students, and support staff transported equipment across campus and set up demonstrations. Senior physics students and graduate students proctored lab midterm exams, freeing up faculty members to participate in all of the events. Dr. Sean P. McBride, chair of the recruitment committee for physics, and Nichole Jervis, senior administrative secretary, played a large part in the organization of the entire week, but the week's success would not have been possible without the support of all members of the department, support from the dean's office in the College of Science, and support from the university. //

TOP LEFT: Assistant Professor Dr. Curt Foltz explains the phase changes of matter as he and hungry students whip up several batches of liquid nitrogen ice cream. Most students in the morning demo session did not mind having dessert before lunch.

ABOVE LEFT: Assistant Professor Dr. Sachiko McBride demonstrates to students the concept of how pressure is the applied force divided by the area over which the force is exerted. The demo she made consisted of a bed of sharp nails with a simple latex balloon sandwiched between the nails and a safety plate. Students were amazed at the amount of force required to eventually pop the balloon.

ABOVE RIGHT: Associate Professor Dr. Maria Babiuc-Hamilton brought an electrifying demo to High School Physics Day with handheld Van de Graaff generators that produced static electricity. The students enjoyed controlling the direction of the Mylar shapes and trying to get them to touch and stick to the ceiling of the room.

Photos courtesy of Sean P. McBride.

A Better Way of Explaining Physics:

Dr. Roberto Ramos named 2018 SPS Outstanding Chapter Advisor

by Kendra Redmond, Contributing Editor

The SPS Outstanding Chapter Advisor Award is the most prestigious award given by SPS, bestowed annually on the basis of the leadership, student leadership development, support, and encouragement the advisor has provided to their chapter.

For his leadership and guidance of the SPS chapter at the University of the Sciences, and previously at Indiana Wesleyan and Drexel University, Dr. Roberto Ramos is the 2018 SPS Outstanding Chapter Advisor.

"There's got to be a better way of explaining this."

These words would echo in Roberto Ramos's mind as he sat through physics lecture after lecture as an undergraduate. "I felt compelled by the need to make complicated ideas clearer, to restate things in ways that connect with the listener," he explains. This compulsion led Ramos to a life of teaching and connecting with students—in the classroom, in the lab, and even on the streets of Pennsylvania in the annual Philadelphia Science Carnival.

Rather than thinking of students as passive audience members, like his professors did, Ramos sees students as his partners. He describes his philosophy this way: "I think of students as partners in probing the physics in our surroundings and in promoting physics as a field."

His goal is not just to equip students to be good physicists, but also to be good citizens. "The idea is to raise a culture of physics majors not just skilled in laboratory or theoretical techniques, but also trained in applying for external grants to promote physics as a discipline and career," he explains. As an SPS advisor, he has often used the SPS awards program to help students develop these skills and build confidence. "Students who submit proposals to SPS and who get funded are encouraged and empowered to think of themselves as scientists who can make a difference," he explains.

LEFT: Ramos's love of physics extends beyond working hours. He is an amateur astrophotographer, a bargain hunter for research parts, and an enthusiastic traveler who finds physics everywhere. Here, he and his son enjoy a visit to the Leaning Tower of Pisa. Photo courtesy of Roberto Ramos.

RIGHT: Ramos (second from left) poses with SPS officers and members from the University of the Sciences during the spring 2018 SPS Zone 3 meeting. Photo courtesy of Brad R. Conrad.

In his three years as the SPS advisor at the University of the Sciences, his current institution, the chapter has received 11 national SPS awards. Many of the awards have been in support of outreach programs that engage groups that are traditionally underrepresented in physics, such as women and minorities. Similar efforts at each of his previous institutions, Drexel University and Indiana Wesleyan University, have left a legacy of SPS outreach efforts that remains today.

In addition to outreach, Ramos actively engages students in research. He has taken students to regional and national conferences, created forums for them to share their research on campus, and involved students in his own research in experimental low-temperature physics, superconductivity, and applied quantum mechanics.

"In my lab, undergrads routinely cool samples down to 2 degrees Kelvin and—on a good day—to sub-Kelvin temperatures to study their quantum properties," he explains. "It's a lab where classroom lessons in quantum mechanics and thermodynamics 'come alive,' and students learn skills in cryogenics, vacuum systems, fabrication, and low-noise transport measurements."

Ramos has found a better way to explain physics than through stuffy lectures—by connecting with one student at a time, actively engaging them inside and outside of the classroom, and empowering them to make a difference. It's not easy, though, and it requires a long game. Sometimes it's hard to know if you're making a difference, he says. "Until that one day, years later, when you receive a handwritten card or an email out of nowhere thanking you for pushing them to be better scientists, and better versions of themselves. All because you saw what they could be and what they could do, before they even realized it themselves." //

Editor's note: You can read about one of Ramos's outreach efforts in "A Summer Camp of Wonder" in the Fall 2017 issue of *The SPS Observer*. https://www.spsnational.org/the-sps-observer/fall/2017/summer-camp-wonder.

Planes, Planets, and Plenty of Physics at the SPS Zone 11 Fall Meeting

by Michael Thompson, Zone 11 AZC and SPS Member at South Dakota School of Mines & Technology, and Jace Waybright, SPS Chapter President at South Dakota State University

The SPS Zone 11 Fall 2018 meeting at South Dakota State University (SDSU) was a smashing success, complete with an airplane building competition and fiery demos.

Teams designed and built planes using balsa wood, metal washers, super glue, and other materials. Then each was given three tries to toss their planes across the room and compete for the greatest distance. It was a close contest, but the team "Right Hand Rule" won and received a recognition award. Other planes landed in pieces. Minnesota State University Moorhead later wowed the crowd with a Rubens' tube, which demonstrates wave physics with fire, during a showcase of chapter demos.

The crash landings and demo showcase were just a few of the weekend's events. The meeting kicked off Friday afternoon with a tour of a local manufacturer of high-tech signs, Daktronics. SPS members particularly appreciated the quality assurance labs, where they found a scanning electron microscope and a large Faraday cage designed to test electromagnetic interference.

At a star party led by Dr. Judy Vondruska from SDSU, we got a fantastic view of both the moon and Saturn while they were still above the horizon. Because of the rapidly falling temperature (it got down to 5 deg F!), the telescopes had to be constantly adjusted as the lenses contracted. This was followed by a warmer event, a Jeopardy-like physics trivia game. Students divided into groups, and we went through 50 questions on a variety of topics, from special relativity to Nobel Prize winners.

The meeting featured two fantastic speakers, Dr. Richard Schnee, from South Dakota School of Mines and Technology, and Dr. Richard Schultz, from Idaho State University. Dr. Schultz talked about a new generation of nuclear reactors and their benefits, while Dr. Schnee talked about the LUX-ZEPLIN dark matter detection experiment and the importance of low-radioactive backgrounds. SPS members were very enthusiastic to learn about these diverse physics research areas.

Attendees also toured both a materials science lab and a nuclear lab on campus, respectively led by SDSU physics professors Dr. Parashu Kharel and Dr. Robert McTaggart. Both tours emphasized collaborations with companies and universities like 3M, the University of Nebraska—Lincoln, and the University of Northern Iowa. Dr. Kharel also talked about how undergraduates are involved in his research on the synthesis and characterization of novel magnetic materials.

The meeting concluded with research poster presentations and a graduate school fair, during which physics and engineering graduate schools from around the region spoke with SPS members about the possibility of graduate study at their institutions. The poster presentations showcased the fantastic work SPS members and undergraduates do in physics, covering topics from the physics of glass to the Transiting Exoplanet Survey Satellite (TESS).

Layne Tieszen, president of the South Dakota School of Mines SPS chapter, reflected on the meeting: "It was great to see a higher chapter turnout this year, as it fostered plenty of interaction between our chapters. These interactions helped spread ideas for SPS activities and also strengthened individual networks, which can be invaluable."

After an engaging meeting, Zone 11 SPS members left excited about physics and the possibilities for their chapters in the coming year. //

ABOVE: Zone 11 meeting attendees pose for a group photo. Photo by Yung Huh.

LEFT: One of the home-made airplanes goes the distance during the Zone 11 competition. Photo by Michael Thompson.

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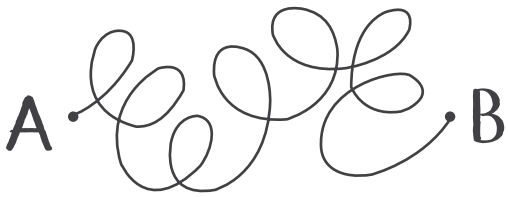

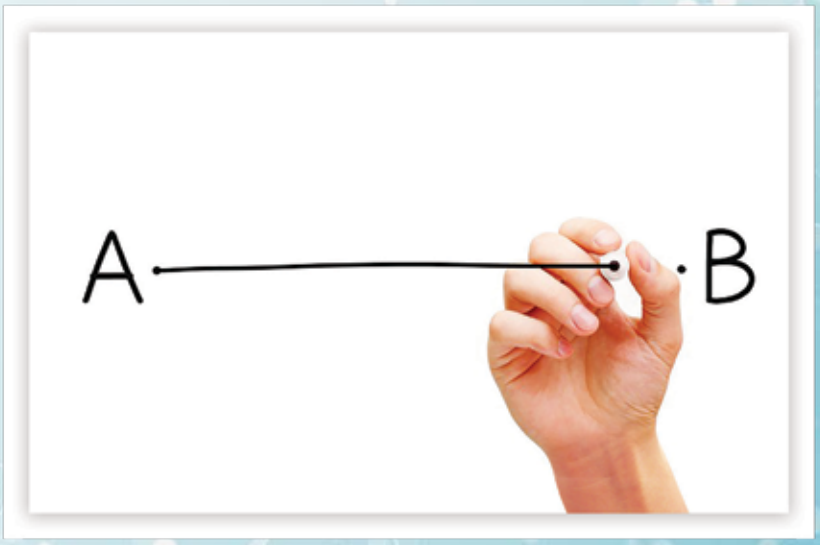

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