the SPS Observer

Volume LI, Issue 3

FALL 2017

BUILDING COMMUNITY

CREATING A CULTURE WHERE PHYSICS STUDENTS THRIVE

+ SIX REASONS WHY THE HISTORY OF PHYSICS MATTERS
+ LOOKING BACK: THE BIRTH OF NUCLEAR PHYSICS
+ THE GREAT AMERICAN ECLIPSE


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1 Physics Ellipse
College Park, MD 20740

301.209.3007 (tel)
301.209.0839 (fax)
sps@aip.org
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ON THE COVER
SPS members at the University of Wisconsin River Falls (UWRF) pull the lever of a trebuchet during an on-campus fall outreach demonstration event. Photo by Kathy M. Helgeson, University of Wisconsin-River Falls.

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Physics and Pizza:
Joining a Global Community of Scientists

by Jacob Robertson, SPS Member, Austin Peay State University

ABOVE: Jacob Robertson, SPS Member, Austin Peay State University. **RIGHT:** Robertson speaking to a room of students at an on-campus STEM night. Photo by Dominic Critchlow.

I attended my first SPS chapter meeting only because there was free pizza. Little did I know how that meeting would lead to so many important aspects of my undergraduate experience. Not only did I join a social network within my department with Bad Physics Movie Nights (*Gravity* never gets old), Wednesday Mexican food outings, and Friday beer and hot wings, but my involvement also connected me to a larger community.

I started participating in campus events with my department, which opened doors for even more opportunities. For example, I worked with student government to provide solar eclipse glasses to students. Collaborating with other student organizations, especially ones outside of STEM, showed that our chapter is invested in campus life.

Becoming our chapter's public outreach director led me to interact with educators and community leaders at local schools and libraries. We even created a partnership with a local distillery to promote the recent total solar eclipse. This partnership provided our chapter a new outlet for outreach and also brought in extra funds for us to expand our outreach programs.

Being active in my local physics community led to greater opportunities to connect with a national community of physicists. When presenting my research with the Dark Energy Survey at an American Astronomical Society (AAS) conference, I attended an SPS poster practice session. Not only was this a great chance to work out my pre-presentation nerves, but I also met other SPS members from across the country and had the opportunity to discuss and share our chapter's activities. I also met SPS director Brad Conrad, who encouraged me to apply for an SPS internship. At this point I was unsure whether to apply, but Brad's encouragement convinced me to submit the application. I was accepted to the program and spent an amazing 10 weeks in Washington, DC, developing outreach resources for chapters. During this opportunity I met countless people at my own work site, the American Institute of Physics, and also at NASA, at NIST, and on Capitol Hill. These meetings led to valuable career advice and another DC internship.

SPS is not only its own community of physicists, but for many undergraduates like me, it is the first step into joining the global community of scientists. Looking back, it is hard to imagine my first step into this vast community of scientists was motivated by free food. From that first slice of pizza, my undergraduate experience has been enriched beyond imagining. Get involved and stick with it—you have so much to gain. Including free food. //

Why I Went to Graduate School

by Andrew P. Proudian, PhD Candidate, Colorado School of Mines

Like many, I spent a lot of time thinking about going to graduate school. I worked in process development at a startup company while I was in college along with doing university research, so I was definitely aware of the realities of both academia and industry.

However, more information isn't always better. I had to ask myself what I wanted for my life and career.

I liked the research and development aspect of both science and industry, so R&D was a "must have." After talking to people with careers that interested me, it was clear that to engage in R&D would require a graduate degree, regardless of whether I was in academia or industry.

So, one dilemma solved, but that opened up a huge array of questions: Master's or PhD? What kind of research? What program? What advisor? From my conversations with researchers at my university and in industry, I was pretty sure I wanted to stay in physics, which meant a PhD over an MS (for engineering, a master's is usually the better choice); plus, it's usually possible to opt for a master's while in a PhD program. The big question was what kind of research I wanted to do.

ANDREW PROUDIAN ACTIVELY RESEARCHING for his PhD coursework. Photo courtesy of Andrew Proudian.

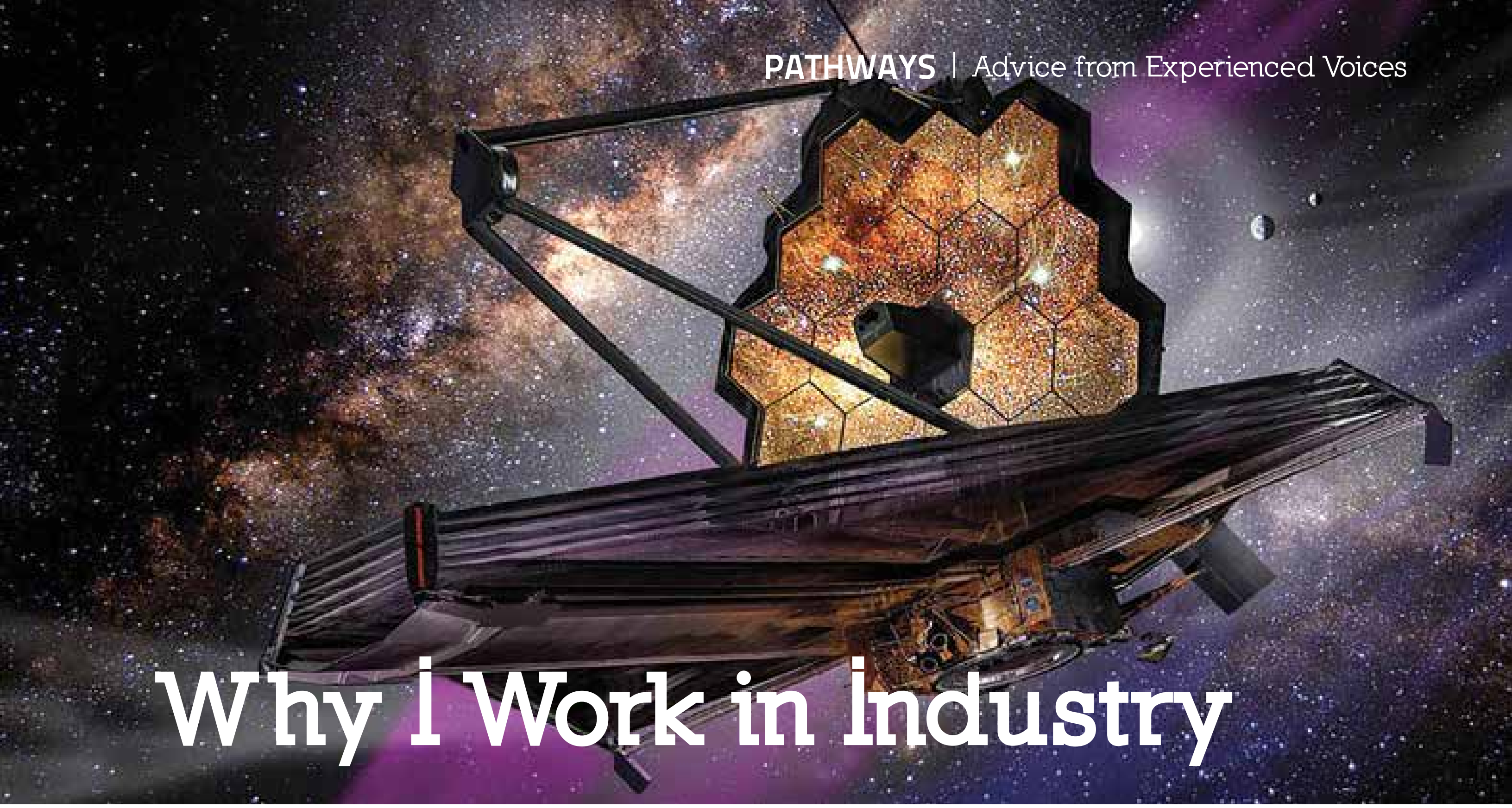
To discover research topics, I read a lot of books, magazines, and accessible journals; reading *Physics Today* cover-to-cover every month really helped. As I found interesting topics, I would explore them more thoroughly, looking at related articles and the authors' research websites.

Looking back, I could have made things easier on myself by engaging more people around me in the process of identifying my passion. I was interested in too many topics and could have used an outside perspective. I talked with a mentor and we had a good conversation about research and graduate school, but I wish we had talked three months sooner; he helped me figure out the core of my research interests. A trusted advisor is a huge benefit.

The same goes for graduate school, by the way. If there was just one piece of advice I could give to prospective graduate students, it would be to carefully select their advisor; it makes or breaks the graduate school experience. At every school I visited, I made sure that I not only had a good relationship with the advisor I wanted, but that I could also envision myself working with at least two other faculty members. Life is unpredictable, and you never know when a "sure thing" will fall through. I sat down with potential advisors to talk with them about their research interests, along with my own, and tried to envision working with them for the next five years. When I met my advisor, Jeramy Zimmerman, at the Colorado School of Mines (CSM), it was clearly a good fit.

I am now in my fourth year at CSM and am still very happy with my choices. I have a great advisor and am doing research that I love. This success is due in part to the careful deliberations I made when choosing a graduate school, but also to the amazing people who assisted me in my journey. //

Andrew Proudian is a fourth-year PhD candidate in applied physics at the Colorado School of Mines and president of the CSM Graduate Student Government. He can be reached at aproudia@mines.edu.



Why I Work in Industry

PHYSICS CAN BE USED EVERYWHERE!

by Kyle W. Elliott, Software Engineer, Space Telescope Science Institute

Two years ago, as I was getting ready to graduate from the University of Maryland with bachelor's degrees in physics and astronomy, I knew I wanted to be a contributing member of the physics community. At first I thought that meant a PhD. After all, those with PhDs are the ones publishing new research, right?

But I realized that you don't have to have a PhD to be a valued contributor to research. After all, what science can be done if the instrumentation is not sufficient?

I am currently working with the Operations Scripts Subsystem (Commanding) team of the James Webb Space Telescope (JWST) and making some intense, ground-breaking future science possible. I use the skills I learned as a physics and astronomy major, such as coordinate transformations and linear algebra, on a daily basis, and I must understand the reasoning behind certain scripts, such as those related to dithering, flats, and cosmic ray removal.

This is very satisfying work. While I was originally planning on attending graduate school for a PhD in astrophysics after my bachelors, after talking with various people—professors, mentors, supervisors, friends, and family—I came to the conclusion that industry makes the most sense for me at this point in time. I landed my first position after graduation in an internship with the US Naval Research Laboratory (NRL). This 10-month internship allowed me to greatly improve my software programming skills relative to science and engineering applications and made me a competitive candidate for the position I hold today.

My professional life has so far been filled with constant exposure to new research in physics and astronomy. To me that is just as nice as being a researcher—there is constant learning. Moreover, this is a good track to be on: I am still developing my skills, and the door is still open for me to apply to a PhD program later. I could also stay on this track and work my way up to, say, a principal software systems engineering position for a space telescope, which is a very prestigious and rewarding role.

Entering the workforce right after obtaining my bachelor's degree and working full-time also made it easy for me to maintain financial security, manage my time, begin a tuition-reimbursed master's education, and find a sense of balance with my hobbies and nonwork interests. I think a passion for physics and science in general can go hand-in-hand with sleep and a social life, and that it is by no means a betrayal of that passion to go into industry.

At this point in my career, I am happy with my choices. I am not a researcher (yet), and I do not think I will be doing traditional research anytime soon. But I realized that what I like most is using the skills and techniques associated with research to support teams. While going through graduate school may also have led me to this conclusion, I realized I do not need to be an academic or professional researcher to be a valued member of the scientific community and to have a wholly satisfying career. //

2017 Individual Award and Scholarship Recipients

SPS congratulates this year's winners and thanks the generous Sigma Pi Sigma and SPS donors whose support makes these awards possible.

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Multiple awards, ranging in value from $200 to $2,000, are made each year to individuals showing excellence in academics, SPS participation, and additional criteria. Learn more and see photos and bios of the recipients at https://www.spsnational.org/awards/scholarships.

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Awards are made to individuals for outstanding research conducted as an undergraduate. Winners are awarded $1,800 to present their research at an AIP Member Society meeting and receive $500 for themselves and $500 for their SPS chapters. The runner-up receives $250 for themselves and $250 for their chapter. Learn more at https://www.spsnational.org/awards/outstanding-undergraduate-research.

WINNERS

Matthew Huber
Rhodes College

Kathryn Regan
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RUNNER-UP

Brittney Hauke
Coe College

HONORABLE MENTION

Luciano Manfredi
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Please note that you must have an active, individual, dues-paying SPS membership to access the SPS Awards Application system. Chapter accounts are not eligible to apply.

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Consider a Circular Cow

by Gary White, SPS Advisor, The George Washington University, gwhite@gwu.edu

When herding cattle,[1] physics folklore suggests that it is occasionally useful to consider the concept of packing fraction *p*, defined here as the ratio of cow volume to total corral volume. Analytical results regarding the optimal packing arrangements for cattle in a corral are usually reported only under the vastly freeing assumption of bovine sphericity, and usually with some cheekiness or even outright smirking. Here, we seek to relax slightly the *perfectly* spherical supposition to include the addition of certain round appendages, while gleefully restricting our gaze to only the 2D case—or, in other words, viewing the corral from directly overhead. Thus, we "consider a circular cow" with certain circular appendages and the associated packing fraction, roughly as shown in Fig. 1, but not before surveying a tiny bit of the rich background of this celebrated problem.

FIGURE 1: One circular cow unit.

Beyond modern physics and solid state physics courses, the question of determining the maximum packing fraction of *perfectly* spherical cows in three dimensions has a long and storied history, dating at least back to Kepler.[2] He speculated, but had no proof, that the best packing fraction in 3D was the one in which the first layer is placed in a hexagonal configuration as in Fig. 3 (not the square configuration of Fig. 2), and subsequent layers were similarly arranged in hexagonal rafts but shifted so that spheres settle into the "low spots" between the spheres below them, much like oranges are stacked into pyramids in a grocery store. This arrangement can be shown to have a packing fraction to have a packing fraction *p* of 1/6 a cow volume (radius *R*) per tetrahedral pen volume (of side 2*R*), or

$$p = \left(\frac{1}{6}\right)\frac{4\pi R^3/3}{(base\ area)x(height)/3} = \pi/\sqrt{18} \sim 0.74$$

This means that for a given (large) pen, perfectly spherical cows take up about 74% of the space. The rest is empty space. Gauss took a stab at proving this result and showed that among *lattice* cattle arrangements Kepler's is the best, but that still left the seemingly unlikely possibility that irregular or random arrangements might be better. The question remained unresolved for many decades, and in 1900 Hilbert included the sphere packing problem among his famous 23 unsolved problems.[3] Finally, in 2014, more than 400 years after Kepler's investigations, Hale and collaborators published a formal proof, verified by automated proof-checking software. Due to the complex nature of the proof and its unorthodox validation, however, some might say that there is still a flyspeck of doubt. In another fairly recent twist, Paul Chaikin and his collaborators, including undergraduate researchers, have reported[4] that when ellipsoidal cows (think almond M&Ms) are *randomly* packed into a corral, the resulting packing fraction can perhaps be even higher than the Kepler arrangement (still about 0.74 or so), shocking the agricultural world, not to mention attentive confectioners.

But perhaps even more exciting is the very recent triumph of Maryna Viazovska in 8 dimensions. She has proven, in a real tour de force paper, that the best packing fraction possible for 8D spherical cows is $p = \pi^4/384 \sim 0.25$! Apparently, when packed into corrals of higher dimension than our meager three, there's a lot more empty space for the herd, even when packed as tightly as possible.

Visualizing 8D spherical cows and the subtleties of their packing is beyond the abilities of this author, however, so I'll return to what motivated this little reflection. Recently I attended an SPS intern event where a collection of the SPS cows (see Fig.1) were splayed out on a table, and the question arose organically: How tightly could these cows be packed without overlap? Clearly, more than a perfect circle was needed to do justice to this magnificent animal! Perhaps appending a rectangular head and a semicircular udder would be enough detail to start, completely ignoring the legs and tail, but even that seemed impossibly complicated, especially given that it took 400 years to get spheres alone!

So, in this treatment we deviate only modestly from the classic problem of perfect circle packing to consider what happens if you add an appendage or two, such as a head, with the constraint that it also has circular form, tangent to the larger circular body. It turns out that this type of two-circle problem has been pondered at some length already, but not precisely in the cattle context in which we are interested, so let's see how these results apply to our situation. Tom Kennedy[6] showed in 2006 that there are only nine possible values for the radius ratios in the *compact* two-circle problem—two of these nine can be represented by the configurations we visited before in Figs. 2 and 3.

First, let's take a look at the seemingly most obvious lattice arrangement in 2D, the square lattice shown in Fig. 2, ignoring the red circles and creepy cow eyes for now.

The large yellow circles represent our circular cow bodies, and we imagine that each cow body has a circular cow head up and right from the body (six heads are shown in red in Fig. 2), which we will be adding into the mix presently. We see by considering the square (which has side $2R$, where R is the radius of the yellow circles) in Fig. 2 that the packing fraction for this arrangement of yellow circles is simply the area of the yellow parts within the square divided by the area of the square:

$$p = \frac{4(\frac{\pi R^2}{4})}{(2R)^2} = \frac{\pi}{4} \sim 0.79.$$

But if we add in a circular cow head as shown we get a higher packing fraction: since the little circle outlined in red with radius r must satisfy $(r+R)^2=R^2+R^2$ according to the triangle shown in Fig. 2, we have $r=(\sqrt{2}-1)R$, so we get a new packing fraction, for a circular cow with a circular cow head, of

$$p = \frac{\pi+\pi(\sqrt{2}-1)^2}{4} \sim 0.92$$

The packing fraction for the hexagonal lattice shown in Fig. 3 is obtained by considering the parallelogram-shaped unit cell: the yellow area within it is again πR^2, but the area of the pen itself is now only $2\sqrt{3}R^2$. Thus, the packing fraction for the big yellow circles in this hexagonal array is then

$$p = \frac{\pi}{2\sqrt{3}} \sim 0.91$$

considerably larger than the square lattice with no heads. Adding in the small red-outlined circle as a (tiny!) circular cow head gives an extra area of πr^2, where r can be shown by similar geometric considerations as above to be given by

$$r = \left(\frac{2}{\sqrt{3}} - 1\right)R.$$

So the packing fraction for the hexagonal array with one cow head becomes

$$p = \frac{\pi+\pi(\frac{2}{\sqrt{3}}-1)^2}{2\sqrt{3}} \sim 0.93.$$

If a second head is evident on each cow (like the two-headed calf that always seemed to be a staple at the state fair), then the

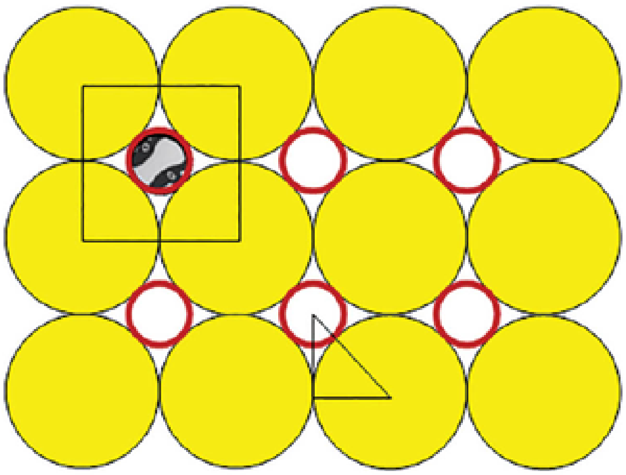

FIGURE 2: Circular cows with one circular head; initially we consider only the yellow circles outlined in black as our circular cows and get a packing fraction of $p/4$; next we consider each cow unit composed of two circles, the yellow body, and the little red-outlined circle as the head, improving $p \sim 0.92$.

packing fraction gets another contribution from the area of the little blue circles as well and goes up to

$$p = \frac{\pi + 2\pi(\frac{2}{\sqrt{3}} - 1)^2}{2\sqrt{3}} \sim 0.95.$$

Finally, among the other nine possible values of radius ratio, examination of the corresponding circle patterns in Ref. 5 shows there is only one other that corresponds to a one-headed cow, and it can be represented by the configuration shown in Fig. 4.This makes an excellent physics puzzler to leave you with: what do you get for the packing fraction of the arrangement in Figure 4? I find it to be slightly less than that of the one-headed version of Figs. 2 or 3. Feel free to email me with your solution. So it seems that among circular cows with one tangent circular head the best lattice packing fraction is 0.93, that of the hexagonal lattice with the red heads in Fig. 3. If you want to allow two-headed cows (or if the second circle represents some other body part), then p ~ 0.95 (Fig. 3, with the red and blue circles) wins out…at least that's what I get. There are several other two-headed cow possibilities among the nine allowed ratios, and some three- and six-headed possibilities as well. Check it out—it's fun stuff! As to the fine details of the packing fraction of the actual official SPS cow in Fig. 1, that awaits a more careful treatment that includes blocky heads and other, more adventurously shaped appendages, by some enterprising young scholar. //

1. I was not able to identify the first reference to the spherical cow meme, but other animals are similarly mistreated, including a "famous story" about a spherical chicken appearing as a letter in *Science* 28 Dec 1973 [**182**(4119):1296 (1973)] by Steven Stellman. Back in 1952, Alan Turing referred to the lack of spherical symmetry in horses in his article *The Chemical Basis of Morphogenesis* [Philos. Trans. R. Soc. London, Ser. B **237**(641):37–72 (1952)], though it is difficult to gauge the level of humor intended. Frequent air travelers today might speculate whether the airlines have leveraged some human-spherical-packing-fraction-in-cylinders models in their determination of modern flight legroom dimensions.
2. Kepler, Johannes, *Strena seu de nive sexangula (The six-cornered snowflake)* (1611). Kepler, along with contemporaries Thomas Harriot and Sir Walter Raleigh, apparently was interested in how best to stack cannonballs.
3. For a discussion of Hilbert's 23 unsolved problems, see https://www.math.uni-bielefeld.de/~kersten/hilbert/problems.html.
4. Donev et al., Science **303**(5660):990–993 (2004).
5. Viazovska, M., *The sphere packing problem in dimension 8,* Ann. Math. **185**:991–1015 (2017), arXiv:1603.04246 , doi:10.4007/annals.2017.185.3.7.
6. Kennedy, T., *Compact packings of the plane with two sizes of discs,* Discrete Comput. Geom. **35**:255–267 (2006), https://doi.org/10.1007/s00454-005-1172-4.

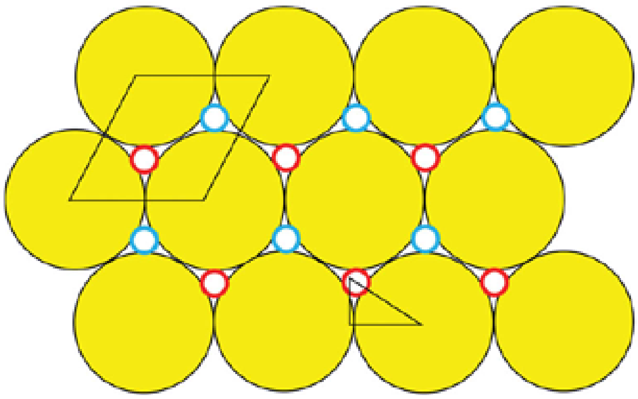

FIGURE 3: A hexagonal array has a better packing fraction, but the cows' heads are tiny.

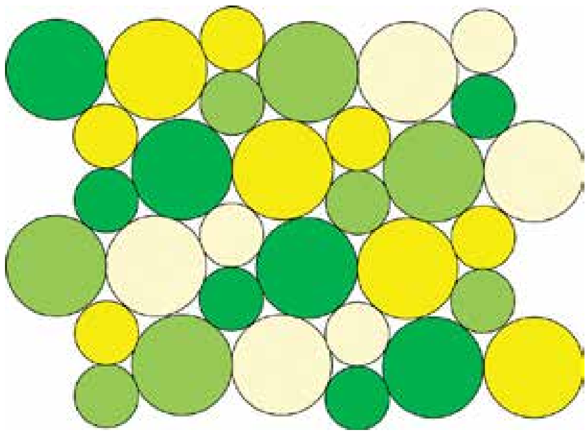

FIGURE 4: An alternate packing arrangement for circular cows with one circular head.

Understanding Solar Coronal Heating through Nanoflare Modeling

A NONTRADITIONAL STUDENT PROBES ONE OF ASTROPHYSICS' ENDURING MYSTERIES—AND DISCOVERS A PHYSICS COMMUNITY

by Kristine Romich, SPS 2017 Intern, California State University, Northridge

Suppose you're hanging out by a campfire. If you wanted to warm up, you'd move in closer to the flame. You wouldn't expect it to get hotter as you walk away! But that's exactly what's happening in the atmosphere of the Sun. The photosphere, or the Sun's visible surface, maintains an average temperature of just under 6,000 kelvin, whereas the corona—its wispy outer layer—can reach temperatures of several *million* kelvin.

The coronal heating problem is one of the outstanding mysteries in solar physics, and as one of the 2017 SPS interns, I had the opportunity to explore it myself. This summer I spent ten weeks in the heliophysics division at NASA's Goddard Space Flight Center, where I worked under Dr. Nicholeen Viall-Kepko to investigate whether nanoflares—short-lived energy bursts in the solar atmosphere—can explain the temperature evolution observed in the corona.

I never imagined I'd be doing anything of the sort. Three years ago, I was an administrative assistant in a corporate office. While I'd always been fascinated with space science, that fascination wasn't something I talked about much. My prior degree was in psychology. I can't blame my old friends for the funny looks they gave me when I announced that I was going to be an astrophysicist.

I wouldn't have gone back to school without the encouragement of my husband, who first suggested it. He told me he thought I'd be good at physics. I told him I thought he was crazy.

Within six months of enrolling at community college, I got a job as a physics tutor and as a learning assistant for an electricity and magnetism course. I signed up for SPS after a summer 2016 REU at the University of Wisconsin - River Falls, which has a thriving chapter. I figured joining a national community of physics students could only help me. I had no way of knowing

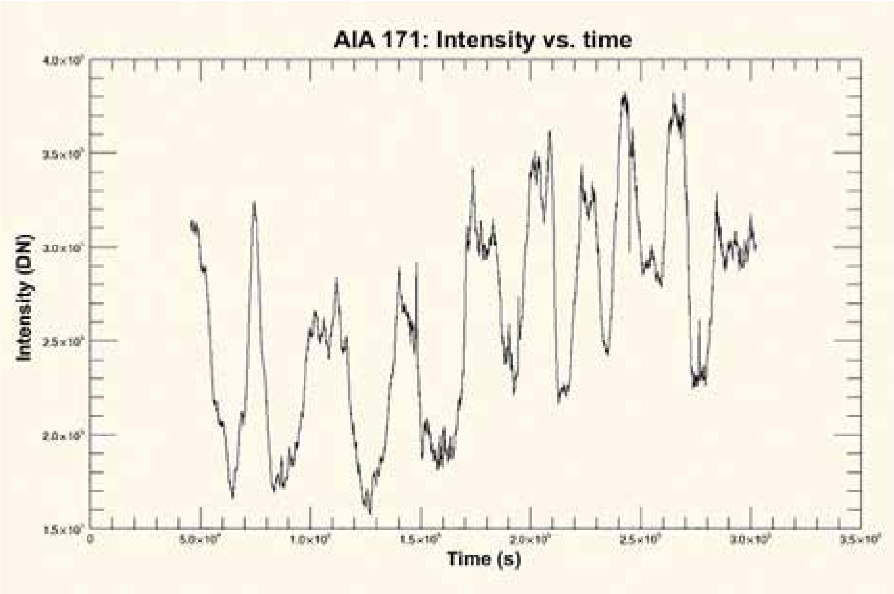

FIGURE 1: AIA continually monitors the corona in a variety of wavelengths. These data from the 171-Å channel, collected over a three-day period in June 2012, display clear intensity fluctuations, a signature of temperature evolution.

how much it would.

For one, now I can say I've worked at NASA.

At Goddard I wrote code to simulate nanoflares, with the intent of comparing their effect on the solar plasma to the real data gathered by the Atmospheric Imaging Assembly (AIA) aboard NASA's Solar Dynamics Observatory spacecraft. Using the AIA data, we can plot the intensity of light from a particular location on the Sun as a function of time. Figure 1 shows such a time series. The fluctuations in intensity indicate changes in temperature.

Since the temperature of the corona was first discovered, scientists have proposed a number of explanations for its heating mechanism. Many have since been disproven. Nanoflares are currently scientists' best guess as to what makes the corona so hot. We can't see nanoflares, but we're pretty confident that we can see what they do!

To test our theory, we first use my code to estimate the amount of energy released in a sequence of nanoflares. Next, we run it through a modeling code called EBTEL (Klimchuk et al. 2008, Cargill et al. 2012), which simulates the response of the plasma. EBTEL generates artificial intensity-vs.-time curves, which we can then compare to the real data (see Fig. 1).

One summer, unfortunately, isn't nearly enough time to complete a project of this magnitude. By the time the internship ended, I had just begun running analysis on the first set of simulated data. The next step is to run analysis on the real data. If we find similar patterns in our simulations, which assume nanoflare heating, and the AIA data, that tells us we're probably on to something! //

Kristine Romich earned her A.S. from Harold Washington College, one of the City Colleges of Chicago, in 2016. She currently lives in the Los Angeles area and is continuing her studies in physics at California State University, Northridge. This December, Kristine will present the research described here at the American Geophysical Union's Fall Meeting in New Orleans.

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Klimchuk, J. A., Patsourakos, S., & Cargill, P. J. 2008, *The Astrophysical Journal,* 682:1351.

TOP LEFT: Kristine (left) with fellow SPS Goddard intern Samantha Pedek (University of Wisconsin - River Falls). Photo by Kerry Kidwell-Slak.

ABOVE: Kristine Romich pictured with her 2017 Summer Internship mentor, Nicholeen Viall-Kepko of NASA Goddard. Photo by Hyun-Joo Kim.

A Summer Camp of Wonder

by Kendra Redmond, contributing writer

"At a young age, my daughter Kristiana loved science," says Roberto Ramos, SPS advisor at the University of the Sciences in Philadelphia and the zone councilor for Zone 3. "I promised myself I would try to explain every physics phenomenon in a way a child would understand—minimal jargon, minimal math."

The approach worked for Kristiana, and Ramos found that it works for older kids too. Inspired by his daughter and motivated by research showing that middle school girls are at high risk of losing interest in science, Ramos took action. He debuted a one-week summer camp for middle school girls in 2013 at his then-institution, Indiana Wesleyan University. Physics Wonder Girls Camp is now in its fifth season and its second summer at University of the Sciences.

The camp is packed with hands-on physics activities, games, conversations with scientists, and lab tours. This year, working in teams of three, girls cut PVC pipes, used power tools, soldered wires, and assembled and decorated submersible, remotely operated vehicles (ROVs) that they used to perform underwater missions. 2017 highlights included career talks by several female scientists, including two physicists, three food scientists, and a nuclear chemist who is also Miss USA 2017.

> "EVERYONE HAS THE ABILITY TO LEARN AND GROW, but not everyone has the right encouragement and opportunities."

Middle school girls are nominated to attend the camp by their science teachers and are selected on the basis of science grades, letters of recommendation, and a short essay. There is no charge for them to attend. Only 12 students are accepted into each session, but this year Ramos was able to offer two sessions and serve twice as many students.

2017 PHYSICS WONDER GIRLS CAMPERS pose with staff and guest Kara McCullough (back row, center), a scientist at the U.S. Nuclear Regulatory Commission and Miss USA 2017. Photo by Kim Sokoloff Photography/University of the Sciences.

Bringing the camp to life each summer is a big undertaking. The first four years were funded by the National Science Foundation, the most recent sessions by the Christian R. and Mary F. Lindback Foundation. The camp is staffed primarily by SPS students. For them, it is a chance to cement their physics subject knowledge and see first-hand the value of science outreach.

SPS member and physics and biology double-major Caitlyn McConnell was a 2017 camp counselor. "Not only did the lessons help me to solidify my own background in physics, but they also showed me that it can be taught to *anyone* without being convoluted. Everyone has the ability to learn and grow, but not everyone has the right encouragement and opportunities."

"What surprised me most was how easily [the campers] all opened up to us, the counselors, and made friends with each other," McConnell says. "Each girl brought a unique perspective on life to the camp, and I learned just as much from them as they did from me."

The camp culminates in a physics show presented by the campers to their family and friends. "When the camp opens the eyes of kids and parents to physics..., I know we've done a good job," says Ramos. His favorite quote is from an email sent by a parent. "Participating in this event," the parent wrote, "has opened new conversations between us about what our daughter's future might be." //

WHAT ADVICE WOULD YOU GIVE TO CHAPTERS INTERESTED IN STARTING AN EVENT LIKE THIS?

"Connect with organizers of other science camps. Learn from and build on their experiences. Most are willing to share the many lessons they've learned along the way. Think of innovative ideas or research materials that may already be out there that will appeal to the intended audience." – Roberto Ramos

INTRO:

BUILDING COMMUNITY:

CREATING A CULTURE WHERE PHYSICS STUDENTS THRIVE

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

I have always said that SPS is whatever it needs to be at each school, but the one element that every chapter shares can be a sense of community. It's this sense of community that makes SPS special, and we, together, have to not only acknowledge it but actively work to build a strong sense of identity as a department and as this society. We, collectively, as a diverse and inclusive whole, are SPS. And together, we can do amazing things.

Luckily, there are many different ways of helping everyone come together to build this sense of identity and establish a common purpose. Often, this is done through service and purposefully interacting with other members and chapters around the United States. We can do this through regional meetings (zone meetings) or even at national conferences, such as PhysCon, but the key is to realize that by working within SPS to solve problems, share our stories, and interact with those not within our own departments, we become stronger and better suited to meet the challenges that we will face.

The following features dive into different ways of building our community. By developing our SPS chapters as communities within a department, establishing strong communication within our regions (zones), and connecting to others within the broader physics and astronomy network, we can help our local chapters thrive. And since it is also impossible to know where we are going without considering where we have been, we have several features highlighting why physics history is so important.

And, as a community, we came together to celebrate and witness a historic eclipse that spanned the nation. As such, we have highlighted several SPS outreach efforts and groups that helped to make science a living, tangible thing to many. //

WE BUILT OUR COMMUNITY WITHOUT A SINGLE MOVIE NIGHT

by Patrick Carroll, SPS Member, Miami University of Ohio

Last academic year, the newly elected officers of our chapter, myself included, sat down to form an ambitious plan: to grow our SPS chapter into a more active and tight-knit community. We had only three rules for ourselves. First, we needed to be more active than the previous years. It did not matter if that meant service projects, social events, fundraising, or doing physics, so long as we were doing more than we had been. Second, every meeting needed to have a purpose. We were not going to just get together to say we did. Meetings became about things like planning events, playing with lab equipment, or meeting with visiting speakers. And last: no movie nights. The only thing that our chapter had done regularly had been a monthly pizza and movie night, but we felt that sitting in a dark room and staring at a screen in silence did not really help build the community we were looking for.

We thought hard about what kind of community we wanted to build. More involved in community service? More social? More diverse? Within our own department and chapter we noticed several issues we wanted to address. There were retention issues with physics majors after their freshman year, regardless of whether they were SPS members; upperclassmen tended to not interact with underclassmen; and our department and chapter were not as diverse as we would have liked. To try to address these problems, a handful of SPS members volunteered to begin a mentoring program for first-year students within our department. This was entirely student designed and led, and included a mixture of social events and guided discussions. This has led to first-year students becoming more involved and presenting research by the end of their freshman year. Further, this has led to them becoming more involved in SPS, including one even running for office.

Last year we also decided to learn about and build an interferometer, letting different students lead different aspects of the yearlong project. Some students researched the history of interferometers. Others worked on building it, and ultimately we presented the project as a physics education research poster at our Undergraduate Research Forum. This not only helped give a sense of accomplishment to those who were involved and the chapter as a whole, but it helped develop leadership and laboratory skills while also bringing those on the project closer together. It also encouraged us to aim for bigger and more intimidating projects in the future.

Our chapter activities don't stop with physics. For example, we held a large board-game-based charity fundraiser, which included other organizations on campus, because a few students had a passion for (and sizeable collection of) games. Your community will have its own personalities to build on. Do you have someone who is interested in a subject and would be willing to show others? Do some students have a special skill or passion they could come together to share? Maybe you have a large group of nontraditional, veteran, or international students who have resources, skills, or knowledge that would make for a wholly unique or new experience.

You are what makes your community, and the only way to grow that community is to get out there and be involved. Plan events. Ask for volunteers. Set goals. You will have successes and you will have failures, but every time you *try* your community will grow a little stronger and a little closer. In time, your SPS chapter will take on a life of its own. Finally, take pictures and keep a record of everything your chapter does over the year, big or small, because you will be surprised by how much you have accomplished and grown. Even if all does not go according to plan, you will still have an amazing and memorable time building your community. //

ABOVE: Members of the Miami University of Ohio SPS chapter, the Department of Physics, and their families come together to have a water balloon toss contest. Twice a year, in the Fall and Spring, the SPS chapter hosts a picnic for the Department of Physics. Photo courtesy of Jay Murdock.

LEFT MIDDLE: Members of the Miami University of Ohio SPS chapter demonstrate Lenz's law and the Meissner effect at Mega Fair, a campus-wide event which allows organizations to recruit new members. Photo courtesy of Amber Williams.

LEFT BOTTOM: The Miami University of Ohio SPS chapter, the Astronomy Club, and the Strategic Game Club pose for a group photo 21 hours into a 24-hour board game marathon. This event, part of the National Extra Life Charity Drive, helps support Cincinnati Children's and other Children's Miracle Network hospitals. Photo courtesy of Amber Williams.

PREVIOUS PAGE: Miami University of Ohio alumni Matt Dopkiss meets with sophomore physics students, followed by a lunch with SPS members. Matt was one of the Miami University of Ohio's "18 of the last 9," which recognizes 18 outstanding alumnus who graduated within the last 9 years. Photo courtesy of Matt Kuhn.

For a list of sample chapter activities that your chapter can do to remain active throughout the school year, check out page 20 of the 2017-18 SPS & Sigma Pi Sigma Information Handbook:

www.spsnational.org/sites/default/files/files/publications/info-handbook17-18.pdf.pdf

FEATURE

BUILDING COMMUNITY WITHIN YOUR ZONE

by Phoebe Sharp, AZC Zone 10, Rhodes College, and Will Slaton, ZC Zone 10, University of Central Arkansas

Every SPS chapter is different. Some are big, some are small. Some hold lots of events, some are laser-focused on one or two projects. That's one of the reasons why bringing chapters together by zone is so important—it lets chapters learn from one another, get ideas, and see what works.

Our zone, Zone 10, encompasses 57 chapters in Tennessee, Arkansas, Louisiana, and Mississippi, covering more than 150,000 square miles. Being separated by such great distances makes it difficult to come together physically multiple times a year. That is why our annual Zone 10 meeting is so vital. When establishing relationships between chapters at the Zone 10 meeting, we are hoping to encourage longer-lasting relationships between chapters that survive and thrive despite physical distances. We have been pushing to create these stronger relationships between neighboring chapters. For example, the University of Memphis, Christian Brothers University, and Rhodes College, all in Memphis, cohosted trivia nights. These fun evenings created an incredible sense of community between chapters and made for some friendly competition between the three schools.

With social media, it's hard to not get involved. Many chapters have their own Facebook or Instagram accounts already; this year, we want chapters to post pictures and updates from their personal events to our Zone 10 Facebook page to keep us all updated. This way, it will be easier for chapters to put together their chapter reports for SPS National, and we won't have to wait until spring to get ideas from other chapters. //

ABOVE: Rhodes College SPS members conduct eye-catching demos to attract new students to their annual kickoff picnic. Photo courtesy of Phoebe Sharp.

LEFT: Attendees at the 2016 Zone 10 Meeting at the University of Central Arkansas. Photo courtesy of Will Slaton.

What do the chapters have to say?

ELEANOR HOOK, RHODES COLLEGE:
Zone meetings are a fantastic place to meet other SPS members. Any activities that split up chapters and/or require participants to engage with one another are great for this. We also try to learn about other chapters' strategies for boosting participation and what their priorities are (i.e., outreach, social events, academic support).

SARAH PAZOS, LOUISIANA TECH:
Social media can definitely play a role! I love staying connected over the zone page! While we have a chapter page, it is mainly used to share interesting science news articles.

FEATURE • FEATURE

NOT-SO-SECRET SOCIETIES:

WHAT PROFESSIONAL SOCIETIES CAN DO FOR UNDERGRADS

by James Merrick, Managing Editor; Additional reporting contributed by Kendra Redmond and Rachel Kaufman

SPS provides important opportunities for physics *students* to connect locally, regionally, nationally, and beyond. You can join the even larger community of physicists by participating in one of the many physics-related professional societies, from the Acoustical Society of America to the Optical Society. Most of these are global societies that consist of students, post-docs, and professionals in academia and industry.

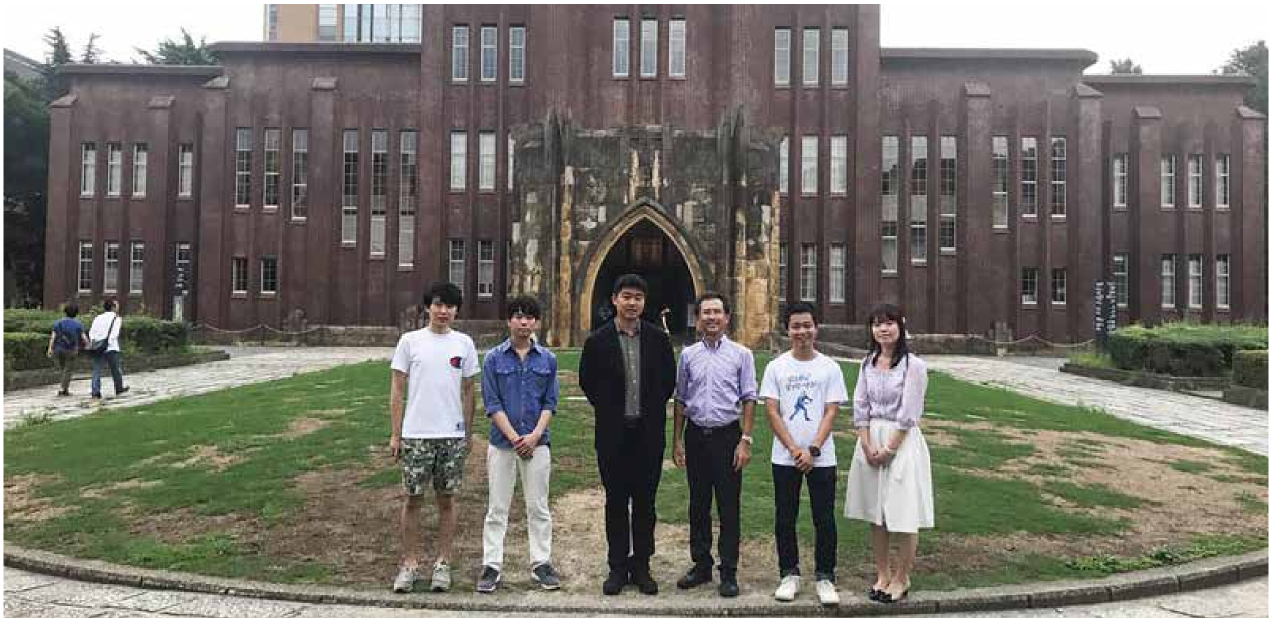
Professional societies differ in size, structure, topical areas, and benefits, but there are a few key components—scientific meetings, opportunities for professional growth and development, advocacy, and a community of potential collaborators, friends, and mentors.

By engaging in these broader professional societies, SPS students have the opportunity to network, learn from, and attend meetings with thousands of professional physicists. They can learn about emerging areas of research, attend talks by Nobel laureates, and present their research to audiences that extend far beyond their department and include potential collaborators. SPS students also can engage with their peers who share their passions through these unique professional opportunities in ways that may not be as accessible on a typical undergraduate campus.

One of the main benefits to joining a professional society is that undergraduates are exposed to technical areas that may not be represented on their campus, says Michelle Sander, an assistant professor in electrical and computer engineering at Boston University and a student ambassador for The Optical Society (OSA). "That can be helpful because it's somewhat random how [students] end up getting engaged in an undergraduate research project."

OSA is an international society that promotes the generation, application, archiving, and dissemination of knowledge in optics and photonics. Through student chapters and a newly formed student ambassadors program, the society aims to help students develop professional skills, learn more about research and career opportunities within optics and photonics, and network with the community.

Yoshitomo (Yoshi) Okawachi, a research scientist in the Gaeta Group at Columbia University and an OSA student ambassador, has developed some online content for OSA, including a video on networking at conferences. "Whether as a postdoc or as a professor or as a research scientist or someone from industry, [the OSA members] have a wide range of



backgrounds," he says. By sharing their experiences, they aim to help students develop and expand the community.

SPS students have the opportunity to attend meetings of professional physics societies, like OSA, sometimes with financial support from SPS National. Travel and reporter awards are offered to SPS students in an effort to encourage attendance at professional society meetings. Students can use travel awards to attend and present their research at professional society meetings. Reporter awards are also available to SPS students who wish to attend a professional society meeting and provide a report about their experience. Both awards provide funding of up to $200 to support a student's meeting attendance. To review eligibility requirements and other pertinent information, read more at www.spsnational.org/awards/travel and www.spsnational.org/awards/reporter.

As evidenced by articles written by SPS reporters, www.spsnational.org/meetings/student-experiences, professional society meetings can change the course of one's career. Last spring, Ithaca College SPS student Andrew Polcari attended the American Physical Society March Meeting as an SPS reporter. "I had no idea how connected the whole physics community is," says Polcari. "I plan to immerse myself in knowing more and more people, whether they are students, professors, or SPS board members."

Several professional societies offer mentoring opportunities to students and young professionals, such as the American Physical Society's National Mentoring Community (NMC) that facilitates and supports mentoring relationships between African American, Hispanic American, and Native American undergraduate physics students and local physics mentors. Other mentoring opportunities are based on research interests.

If traveling to a national meeting presents a challenge, many professional societies hold regional meetings and local meetings that allow for more opportunities to engage with potential collaborators and professionals. Last year, Olivia A. Krohn of California State University, Fresno, traveled to the American Physical Society (APS) Far West Section Meeting. In understanding the importance of regional meetings, she conveys, "Although not as large or epic as an [APS] April Meeting, or so specialized and focused as a divisional meeting, this sectional meeting had a special charm in staying close to home."

Many professional societies have become increasingly focused on undergraduates in recent years, creating online content, training sessions, and programs such as the OSA student ambassadors. "Having specific liaisons at this stage to help people in terms of the professional development side [is new]," says Sanders. "Five to ten years ago there was not as much emphasis on the professional development."

After your undergraduate career comes to an end, professional physics societies can remain a valuable part of your professional and personal life. Many societies include programming and resources for graduate students, early career professionals, and beyond. //

LEFT: The OSA Student Chapter at the Tokyo University attends the Traveling Lecturer Seminar in August 2017. Photo courtesy of the Tokyo University OSA Student Chapter.

TOP: The OSA Student Chapter at Osaka University attends the Traveling Lecturer Seminar in August 2017. Photo courtesy of the Osaka University OSA Student Chapter.

ABOVE: The OSA Student Chapter at the State University of Aerospace Instrumentation (SUAI) in St. Petersburg, Russia. Photo courtesy of the SUAI OSA Student Chapter.

GET CONNECTED!

Undergraduate SPS students are eligible for free membership in any two of the ten Member Societies within the American Institute of Physics umbrella. In addition, SPS members can join the National Society of Black Physicists and the National Society of Hispanic Physicists for free. For details on these partnerships, visit www.spsnational.org/about/membership/free-ms-membership. Students interested in areas not represented by these societies should explore memberships in other societies, too. Many other professional societies have discounted or free student memberships.

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6 Reasons Why the History of Physics Matters

by Lexxi Reddington, SPS 2017 Intern, University of Denver

ABOVE: Portrait of Niels Bohr Institute in Copenhagen in 1932. Photo courtesy of AIP Emilio Segre Visual Archives, Physics Today Collection.

RIGHT: Lexxi Reddington. Photo courtesy of AIP.

History is often disregarded in the study of physics, yet it is inherently connected to scientific inquiry through documentation of theory and subject matter through time. Scientific figures throughout history often serve as role models and examples for future physicists as well. Dredging up the history textbooks may seem like an absurd way to advance science, but consider: History involves ideas, theories, and equations that become the foundation for future improvements. Here are six reasons why understanding the history of physics could be useful to physicists and future physicists alike:

1. HISTORY DOCUMENTS HOW IDEAS DEVELOP AND CHANGE OVER TIME.

Aristotle profoundly shaped scholarship with his use of empirical evidence and reliance on logic. Yet, several of his theories were also wrong: he believed the heavenly bodies were made from “aether,” women had fewer teeth than men, and eels reproduced by spontaneous generation. These ideas were later disproved, using Aristotle’s same methods of empirical evidence and logic.

2. HISTORY ILLUMINATES THE SCIENTIFIC METHOD.

Galileo Galilei was one of the first to quantify science by insisting that phenomena be explained mathematically and proved experimentally. He even developed several instruments to further advance his observations. Galileo encouraged scientific work to be measurable, and therefore repeatable, which later became a hallmark of the scientific method. Over time, scientists further developed the scientific method to augment the legitimacy of scientific conclusions. History therefore offers insight into how today's accepted scientific practices and processes evolved.

3. HISTORY SHOWS THE HUMANISTIC SIDE OF PHYSICS IN A HISTORICAL AND CULTURAL CONTEXT.

Niels Bohr founded the Niels Bohr Institute in Copenhagen in 1921, which later became a refuge for scientists fleeing German-occupied territories during World War II. He contributed greatly to the physics community, not only in his discoveries, but also in helping save the lives of numerous scientists. Bohr showed that science is about much more than just lab work and equations—it's about making life better for all of humanity. In using his physics career and notoriety, Bohr was able to do just that and literally save lives.

4. HISTORY CHRONICLES THE SIGNIFICANT COLLABORATIONS AMONGST PHYSICISTS.

The European Organization for Nuclear Research (CERN) is one of the largest and most advanced centers for scientific research in the world. CERN is possible only through significant collaborations between multiple countries. To this day, CERN continues to contribute scientific knowledge and new discoveries, such as with the Compact Muon Solenoid (CMS) project, through the combined efforts of scientists across the globe. This collaboration is critical to the progression of science because it combines the talents, ideas, and perspectives of different people toward accomplishing a shared goal. Examples of collaborations throughout history demonstrate how more can be achieved when people work together.

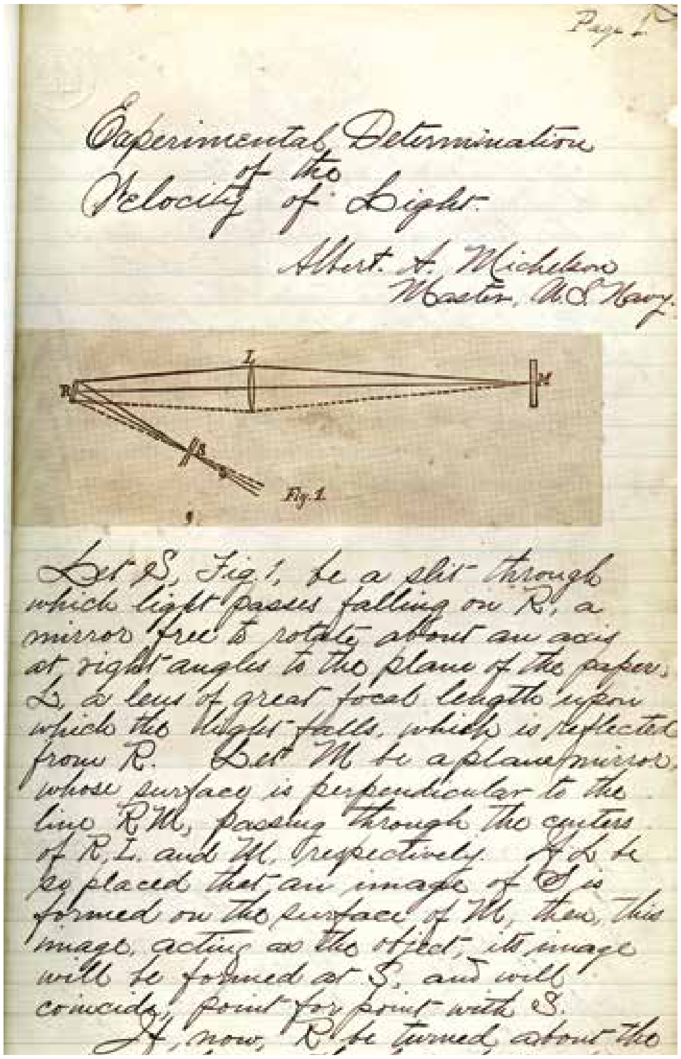
5. HISTORY DETAILS HOW PHYSICISTS THINK.

Albert Michelson was a physicist and the first American to receive the Nobel Prize in Science. He is best known for his work in measuring the speed of light and in the Michelson-Morley experiment. The notebook he used to document his ideas, calculations, and conclusions on the speed of light offers insight into his thought processes and methods. His notes are thorough and detailed, which shows how methodical he was in the documentation of his experiments.

6. HISTORY INSPIRES PEOPLE TO PURSUE PHYSICS AND MAKE NEW SCIENTIFIC DISCOVERIES.

J. Robert Oppenheimer is often referred to as the "father of the atomic bomb," due to his work on the Manhattan Project. Oppenheimer lobbied for international control and limitation of nuclear power. Opposing politicians retaliated by revoking his security clearance, which effectively severed his political influence. Despite this, Oppenheimer continued to teach, work, and promote the positions he believed in. Oppenheimer is just one example of a historical figure who advocated for people to pursue physics and who proves that adversity should not impede scientific work.

Still not convinced that the history of physics matters? At the very least, historical precedent motivates physicists to challenge common perceptions and popular opinions in search of the truth. Nicolaus Copernicus was one such scientist who denounced the widespread belief that the Sun revolved around the Earth and instead used scientific evidence to lobby for a heliocentric model. Copernicus faced significant opposition for this model, but that did not stop him from promoting the truth about the solar system. In that sense, the history of physics is a record of civilization's past achievements, new knowledge, and still unanswered questions. Such a record is worth knowing. //


Page 1

Experimental Determination of the Velocity of Light.

Albert A. Michelson
Master, U.S. Navy.

Fig. 1

Let S, Fig. 1, be a slit through which light passes falling on R, a mirror free to rotate about an axis at right angles to the plane of the paper. L, a lens of great focal length upon which the light falls, which is reflected from R. Let M be a plane mirror, whose surface is perpendicular to the line RM, passing through the centers of R, L, and M, respectively. If L be so placed that an image of S is formed on the surface of M, then this image, acting as the object, its image will be formed at S, and will coincide point for point with S. If, now, R be turned about the

SCANNED IMAGE OF ALBERT MICHELSON'S NOTEBOOK on the velocity of light. Photo courtesy of the Niels Bohr Library & Archives, American Institute of Physics.

LOOKING BACK: The Birth of Nuclear Physics

by Brittany Maynard, SPS Member, Hampton University

Nuclear physics is a startlingly young science, especially considering the advances it has led to in medicine and energy.

The first hints of this new science came with—of all things— a glowing piece of paper. In 1895, in a laboratory at the University of Wurzburg, Germany, physicist Wilhelm Röntgen was experimenting with an electric tube. Upon turning it on, a piece of chemically coated paper near him began to glow. This astonished Röntgen. He turned the electric tube off and the glow disappeared. He turned the tube on and off several times before realizing that the tube produced something invisible that was interacting with the paper. He called this effect "x-ray radiation." For his discovery Röntgen received the first Nobel Prize in Physics, awarded in 1901. Physicists sprang into action. If this tube could cause radiation, what else could?

One physicist intrigued by Röntgen's work was French scientist Antoine Henri Becquerel. A colleague suggested that the "glowing" uranium salts he owned could be giving off radiation, so Becquerel set out to see if this was true. After one long day of experimenting in 1896, Becquerel had plans to take photographs outside, a hobby of his. However, the weather turned sour so he threw the photographic plates into a drawer—the same one that contained the uranium salts. When the weather improved he used the plates, but upon developing them found they were corrupted. Was this the evidence of radiation Becquerel was looking for? Further work revealed that uranium was indeed a source of radiation and had corrupted the plates.

After learning of Becquerel's discovery, a young woman made it her mission to study radiation. Marie Curie was Polish but had immigrated to France to study physics because women in Poland were unable to study at universities at that time.

RIGHT: Marie Skłodowska-Curie. Public domain.

BELOW: Brittany Maynard. Photo courtesy of the author.

Curie showed that the intensity of radiation in a uranium compound correlated only with the concentration of uranium, proving that uranium atoms, not molecular interactions, were responsible for radioactivity. This was important because at the time, many scientists thought that atoms were indivisible objects. Later, when studying the uranium mineral known as pitchblende, Curie came to the startling conclusion that there was something much more radioactive than uranium hidden in the pitchblende.

Working with her husband, Pierre, Curie isolated a tiny amount of a new element, more radioactive than uranium, and heavier too. They named this element polonium after Poland, the country which gave birth to Marie Curie yet denied her a higher education. Later that year the Curies found a second element, radium. Becquerel and the Curies shared the 1903 Nobel Prize in Physics for their work on radiation. The following year the Curies began perhaps their most important work, discovering that tumors shrink when injected with radium. This "Curie therapy" is the basis of a cancer treatment still being perfected today.

Over the next several years, the quest to understand radiation led scientists to further investigate the structure of the atom and eventually to the discovery of the nucleus in 1911. Trying to break apart the nucleus became something of a sport in the early part of the 20th century, and eventually a new device called a particle accelerator was created for that express purpose. Nuclear science is a growing field even today, leading to significant advancements in medicine, clean energy, and our understanding of the universe. To think it all started with a rainy day.... //

SPECIAL FEATURE

The Great AMERICAN ECLIPSE

In anticipation of the 2017 Great American Solar Eclipse, the SPS National Office announced the Solar Eclipse Grant, encouraging chapters to participate in the solar eclipse and create outreach demonstrations for members of their community. Chapters awarded the grant received SPS-branded solar eclipse safety glasses and access to astronomy-related demonstrations. After the eclipse, chapters submitted reports detailing their events. Three SPS chapters' reports, including Linn-Benton Community College (OR), University of Rochester (NY), and William Jewell College (MO), are featured in this article.

TOP LEFT: Community members at William Jewell College view the partial eclipse from a telescope equipped with a solar filter. Photo by Cara Dahlor.

TOP MIDDLE: Curiosity is for all ages! SPS members at University of Rochester open their demonstrations from only campers to the public, allowing interested community members to engage with their demos. Photo by Samantha Tetef.

TOP RIGHT: Students and members of the community look up at the sky from their seats at William Jewell College's Greene Stadium. Photo by Hannah Wilson.

LEFT: William Jewell College students gaze up at the partial eclipse. Photo by Hannah Wilson.

TOP, PG. 27: The Linn-Benton Community College SPS chapter prepares their first batch of nitrogen ice cream for a full crowd. The ice cream was a huge hit on a hot day! Photo courtesy of Eric D. Slyter.

BOTTOM, PG. 27: Linn-Benton Community College SPS members instruct the eager crowd on proper viewing techniques of the eclipse through solar telescopes during the partial eclipse. Photo courtesy of Eric D. Slyter.

LINN-BENTON COMMUNITY COLLEGE ECLIPSE FESTIVAL IS A SIGHT TO REMEMBER

by Eric D. Slyter, SPS Member, Linn-Benton Community College

Our Linn-Benton Community College (OR) (LBCC) Eclipse Festival was incredibly successful! Several Society of Physics students such as myself had been looking forward to this spectacular event for more than a year. I talked about the possibilities of opening up our campus to anyone to come stay the night Sunday and share this experience with us Monday morning. The idea got around, and we got approval! Students made this happen, and SPS helped, too.

We worked hard and recruited more than 40 volunteers. We had friends, family, faculty, and administration joining in to ensure that this was a successful community outreach event. We were also joined by another college. Lane Community College brought more than 10 volunteers, including professional astronomers and meteorologists, to help provide an educational and entertaining atmosphere. We had several attractions, including a large sundial and a scale model of the Sun, Earth, and Moon. There was even free nitrogen ice cream for everyone!

Some of our instructors and volunteers put on a show called "The Life and Death of Suns," which brought about 200 people into our theater. LBCC's Professor Greg Mulder was the host and did a great job giving the crowd a fun and interactive lecture with some insight on up-to-date science about fusion reactors, energy use, infrared cameras, and the Large Hadron Collider. He really showed us how important science is. There was live music and a firedancer. We then stayed up late into the night watching the stars.

We woke up to a nice breakfast at 7:00 a.m. Monday, and after some last-minute safety instructions and passing out a few more solar glasses, *the eclipse* began. Classes were cancelled, but we had more than 370 people from across the country that came and camped out on our soccer field. We also had an unknown number of people sneak in and camp in the parking lot. Another small parking lot filled up Monday morning, so there were at least 500 people there with us. Most of us made our way out to the campsite where the solar viewing equipment had been set up.

The sight was spectacular. When totality hit, the crowd roared, cheered, and blew whistles. I can say that in preparing for that moment I had read at least six different eclipse books (even corresponded with Tyler Nordgren) and every article and piece of history I could find. I searched for months for pictures to put in presentations and to share with friends. I had read poetry, seen art, I even saw a quilt made into an eclipse and—Nothing. Comes. Anywhere. Close. to the sight I saw that morning. I will never forget it. I don't believe any level of communication or comprehension or understanding could give someone the sense of what it is to see an eclipse with your own eyes. I still get goose bumps (like right now!) when I think or talk about it. My retinas are safe, but that image of the sun will be burned into my mind as long as I live.

Another thing I won't forget for a while: We got rave reviews. Everyone seemed to have a great experience, and we gave that to them! We started tearing the event down and gave away all of the posters that were hung up—the crowd seemed to love that! We picked up a whopping ½ bag of garbage after everyone left. There was a bee sting and somehow someone stepped on a nail, but other than that, no one got hurt and nothing caught on fire. The night was quiet, and no one was rowdy or caused a fuss. It was just a nice bunch of people.

Thank you for granting us with the 734 solar viewing glasses. It meant a lot to people to have access to free and safe solar viewing, especially at a time when there were so many fakes going around. It was nice to say, "These came from SPS and they are absolutely safe." As a community college we were proud to not to have to charge anyone for a fun and educational experience. We opened up the event and daily activities to our local community, asking for donations only, and were able to raise $530. There was also some money left over from the fees that were charged to overnight campers. There is talk of giving it back as a legacy item somehow. Some ideas are repairing our clock tower, building a larger sundial, making a time capsule, putting it into a scholarship, or building some sort of monument to remember the August 2017 eclipse. //

COLLABORATION WITH THE ROCHESTER MUSEUM AND SCIENCE CENTER TO EXPLORE LIGHT AND NATURE

by Adina Ripin, SPS Member, University of Rochester

On August 21st, our SPS chapter teamed up with the Rochester Museum and Science Center (RMSC) to give campers and the public an unforgettable experience viewing the partial solar eclipse and exploring hands-on demonstrations about Earth, space, and light. During the summer, the museum offers Curiosity Camps for kids aged 5 to 15 years old. In the morning, from 9:00 to 11:00 a.m., these 180 campers were sent in groups to explore exhibits by the museum as well as participate in the hands-on demonstrations we conducted in the lobby. We were thrilled to be able to provide a pair of free solar eclipse glasses to each camper thanks to the grant we received from SPS!

After the campers had a chance to explore the exhibits, the event was then opened to the public. Heavily advertised to the Rochester community by the museum, it was a huge hit, with an estimated 5,000 people in attendance in addition to the 180 campers. From 11:00 a.m. to 3:00 p.m., the public was given a chance to explore the museum exhibits for free, in honor of the occasion, as well as participate in our hands-on demonstrations.

Because the semester had not yet started, we were limited in terms of the number of volunteers, but we were able to compensate with our enthusiasm! Our four volunteers on the day of the event were able to successfully carry out a variety of hands-on demonstrations that helped participants explore the nature of light and why we should care.

One of our more popular demonstrations involved spectroscopy. We set up gas spectrum tubes for hydrogen, helium, and neon and handed out diffraction gratings so the participants could view the emission spectra of the elements, as well as white light. Our volunteers explained why each element has a different spectrum, and encouraged the participants to think about how it allows astronomers to determine what makes up far-away bodies. This was a huge hit with both the campers in the morning and the general public later in the day, as many had never seen an emission spectrum before.

Participants also had fun making giant bubbles to observe their rainbow colors while volunteers explained this phenomenon, introducing the concept of light behaving as a wave and the resulting interference. They were also able to get a visual explanation as to why the sky is blue during the day and reddish at sunset by observing a glass tank filled with water and condensed milk. A volunteer explained Rayleigh scattering and shined a flashlight through the tank, encouraging participants to observe any differences in color in the tank based on the different positions of their head with respect to the flashlight.

Our most popular activity was, by far, making pinhole projectors out of index cards and popsicle sticks. While we were able to give campers solar eclipse glasses to use to observe the 70 percent totality, we also encouraged them to make the projectors so they could compare their observations. The activity was also a big hit with the general public, who we were not able to supply with eclipse glasses, as many of them did not have an alternative viewing option.

In addition to the demonstrations and activities offered by our chapter, the museum had various viewing stations for the eclipse, including a showing of the NASA live stream as well as telescopes with solar filters set up outdoors. The planetarium in the museum invited the local astronomy club to talk to the public about what they were observing. The museum also had exhibits showcasing the science of Earth's atmosphere, climate change, and the solar system.

Overall, we received a lot of positive feedback from campers and the general public alike; our collaboration with the RMSC and the grant from SPS allowed us to participate in creating a memorable eclipse viewing experience for 180 campers and about 5,000 members of the general public. More than that, we were able to create excitement for learning about the physics we observe every day, and prepare everyone for the total solar eclipse in 2024 when Rochester will be in the path of totality. //

WHO DOESN'T LOVE BUBBLES? Campers made giant bubbles and were then able to explain why they observed them to be rainbow colored using principles of interference. Photo by Samantha Tetef.

THE DAY OF THE ECLIPSE

by Megan Anderson, SPS Member, William Jewell College

‘Twas the day of the eclipse, when all thro’ the campus,[1]
Skies darkened with a storm passing o’er Missouri and Kansas;
The Eclipse safety glasses[2] were guarded with care,
In hopes that clear skies would soon be there;
The physics students[3] had pulled themselves out of their beds,
While visions of totality danc’d in their heads,
And the professors[4] had taken not a bit of persuasion
To pull out their telescopes for the rare occasion—
With one student’s[5] research on solar filters done,
The Physics Department knew how to capture images of the sun.
Additionally, two posters sat on the tables
With educational images, captions, and labels.
These were thanks to a summer research scholar,[6]
Who could describe an eclipse to every caller;
She and a colleague[7] were now sharing this novelty
At a viewing party hosted by a college trustee.
But now I did look, so lively and quick,
To see the weather gradually become less ick.
More rapidly than spherical cows the Physics Department then came,
And their Department Head pointed, and call’d them by name:
“Now! Denver, now! Dalton, now! Emily, and Eric,
“On! Zach, on! Macy, on! Jacob, and Kitt;
“To the bottom of the hill! to the football field turf!
“Now the rain is gone we won’t get caught in the surf!”
As electrons in a magnetic field the students then began to move,
Soon reaching their destination where they got in a groove.
The alumni-physicist DJ[8] provided them with a well-crafted selection
Of songs that could withstand any critic’s inspection:
And one was announced as a heartfelt submission,
Made by the Music Department,
it was an eclipse composition.
As I listened and welcomed guests from far and near,[9]
I could feel the sun begin to disappear:
The moon was dress’d all in black, from its side to its side,
And the sun’s crescent-like appearance seemed bona fide:
The flaming sphere of orange and yellow,
Was now the moon’s copy-cat fellow:
Its brightness – how it dwindled! its shape how strange,
Its glow was like sunset on a great open range;
Its curved smile was shrinking degree by degree,
And all grabbed their glasses, eager to see;
The surroundings became dim and street lamps turned on,
Only a few more moments until the sun would appear gone.
Just when the dusk seemed heavy enough to touch,
The glasses went black and of cheers there were such
As rang through the city and into the sky,
Because we could observe a cosmic ring with the naked eye;
Two minutes passed of us staring, mouths agape,
Until the announcement of “Glasses on” for we’d again see the sun’s shape.
With our telescopes, we offered all a last look at the sun,
Then we had to gather our demos and be on the run,
For clouds had returned and rain was imminent,
And our supplies were not equipped to stay out in it.
We sprang into action, to our team gave high-fives,
And back to the department we went like bees to a hive:
The momentous occasion made us have to admit
The Total Solar Eclipse of 2017 was something we’d not forget.

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1. William Jewell College in Liberty, Missouri
2. Thanks, SPS!
3. The William Jewell College Society of Physics Students
4. Dr. Maggie Sherer, Dr. Blane Baker, and Dr. Patrick Bunton
5. Daniela Marin
6. Caeley Pittman
7. Abby Christensen
8. Bradley Dice, William Jewell College ’16
9. Approximately 1,200 people attended the event.

Regaining Momentum

by Elizabeth (Lisa) Pham, SPS Member, California State University, Chico

In 2017, Lisa Pham received the Aysen Tunca Memorial Scholarship from SPS, in addition to many honors from California State University, Chico (Chico State).

I was born to Vietnamese boat refugees. My parents escaped their war-torn home as unaccompanied teenagers leaving behind everything they knew. Both of my parents strongly encouraged me and my five siblings to pursue higher education as they had. Straight out of high school, I started my studies at Scripps College for Women.

In 2013, I took a leave of absence and moved to Chico, California. I had been taking a full load of science and math classes while working three part-time jobs to pay for school. Over time it became clear that my schedule was unsustainable. After much deliberation, I chose to get a job and focus on my health and well-being.

After leaving school, I was very insecure in my abilities as a physicist and as a student. I felt like I had failed my family and myself. However, at each job I held, my bosses and colleagues urged me to return to school. With their support and encouragement, I transferred my credits to Chico State and shakily returned to the classroom in the fall of 2015. I was terrified of failing yet again—or even worse, realizing that I was inherently flawed.

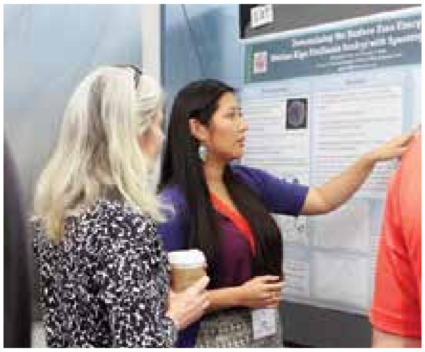
From my first day at Chico State, SPS made me feel like part of the community. I quickly joined the students and faculty members who are often in the department late into the night and on weekends, helping each other through problem sets or sharing pizza. The club truly feels like a family, looking out for one another and accepting everyone. As one semester became two, I found myself regaining momentum.

Last spring, I became president of our SPS chapter. I received a grant to spend a summer conducting biophysics research and presented at PhysCon. In May, I was chosen to share my story with 10,000 people at commencement. I have come to realize that with the right circumstances and resources, I am finally living up to my full potential. In December, I will graduate with my bachelor's in physics—something that I once deemed impossible.

My bosses, professors, and classmates have supported me so much; I am now passionate about doing the same for others. As SPS president, I established a peer mentorship program where students can discuss any questions or concerns that come up, on classes, life balance, sexuality, mental health, etc. I regularly have coffee with students to find out about their concerns and share my own personal experiences. After graduating, I hope to become a technical manager and offer similar support to my coworkers and local students.

As part of these efforts, I strongly promote work-life balance. Really taking care of yourself—eating well, moving around, getting enough sleep—is not often prioritized by busy students. Yet, I have learned that when I prioritize my health, I can work more efficiently and effectively. Small steps towards a healthier, more balanced lifestyle can make a big difference! //

For more information on SPS scholarships and the 2017 awardees, see pg. 8 and visit https://www.spsnational.org/awards/scholarships.



ABOVE: Pham presenting her research poster at PhysCon 2016. Photo courtesy of Chico State SPS.

TOP: Lisa Pham sharing her story during the California State University, Chico commencement in May 2017. Photo courtesy of Jason Haley, Chico State photographer.

Learning to Lead Through SPS

by Matthew Huber, SPS Member, Rhodes College

When I started college, I wasn't actively looking for opportunities to enhance my leadership skills—I was much more interested in passing my classes! Stumbling across my school's Society of Physics Students chapter soon proved to be a turning point in my college career. Though I didn't realize it at the time, every step on my path from an uncertain freshman to a confident vice-president of the Rhodes College SPS chapter has helped hone my leadership skills, preparing me well for life after college.

When I arrived at Rhodes, I didn't know much about SPS. However, after attending meetings and talking with members, I saw how exciting and fun involvement in the chapter would be. When I asked if I could help plan some activities, little did I know I would get thrown into a leading role for our main event of the year—the Pumpkin Drop! I took on the task of purchasing dozens of pumpkins to be frozen with liquid nitrogen and thrown from the top of our physics tower.

Over-eager to complete my responsibility on time, our physics department ended up babysitting 60 pumpkins for over two weeks before Halloween, filling the hallways and lounge!

> "Leadership requires trusting others and giving them what they need to succeed."

My next big step forward was to plan a new event, an SPS-sponsored Yule Ball. This winter formal was held the week before finals. Nothing like this had been done at Rhodes for years, so we had to lay a lot of groundwork to make sure the event ran smoothly. Arranging the venue, music, advertising, and refreshments was certainly a challenge! I gained experience working with and leading a team, and learned the importance of clear communication.

During my first few years volunteering, I wanted to do as much as possible myself to make sure everything got done. However, leadership requires trusting others and giving them what they need to succeed. I was the SPS treasurer for two years, but by my junior year I had moved into a different role. Having confidence in my successor gave me the freedom to lead in other ways. As my SPS responsibilities have grown, I've called on my peers for help many times. The more I work with others and support them in our activities, the more confident I become in my own leadership abilities.

I'm excited for this coming year, my last as an undergraduate member of SPS. My involvement in SPS has given me leadership experiences at the local, regional, and even national level that I would not have gotten if I had solely focused on my classes. I've grown so much as a result.

ABOVE: Matthew Huber, SPS Member, Rhodes College.

LEFT: Huber demonstrates superconductor levitation at the 2015 Rites to Play spring festival. Photo by Sean Denby.

HERE ARE A FEW THINGS I'VE LEARNED ALONG THE WAY:

- Deliberately reach outside your comfort zone
- Ask for responsibilities
- Work your way into larger roles over time, utilizing past experiences
- Suggest a new event and offer to plan it
- Teach your position to others, helping them grow with you
- Emulate the leadership skills of those you enjoy working for

And finally, as I have learned firsthand, take advantage of the time you have now to further your involvement in SPS. The time will fly by! //

Hillary Head

BS, Physics, Austin Peay State University

WHAT SHE DOES:

Head is a telescope operations specialist. She operates and helps maintain the Dunn Solar Telescope in Sunspot, New Mexico. Sunspot is a remote community in the Sacramento Mountains.

HOW SHE GOT THERE:

Head is in love with astronomy, and has been since she took an undergraduate-level course at Austin Peay as a high schooler. Her professor invited her on a data-collection trip to Kitt Peak National Observatory, and after that trip, she was sold.

Three internships (including two at Fermilab) and four data-collection trips (three to Kitt Peak, one to Chile) later, Head realized that she liked the hands-on aspect of research most. "Collecting data, doing the troubleshooting... I realized maybe I should be looking for jobs like that." Her undergraduate advisor helped her narrow down her options, and she landed a job at the Dunn Solar Telescope.

BEST PART ABOUT HER JOB:

"The data that we collect is actually being used for a lot of new science. When I was looking for jobs… the major things for me [were] getting to stay a part of the scientific community and contributing to new research in a way I find enjoyable."

MOST FRUSTRATING PART ABOUT HER JOB:

You might think it's living in a remote community with roughly 20 other people around, but the most frustrating part of her job is actually funding uncertainty. "It's hard to plan for the future, and that's what's really challenging," she says. "It seems like science is always the first thing to get cut."

HOW SHE'S BUILDING COMMUNITY:

"We have our monthly potlucks and game nights to keep the community together," she says. In addition to her coworkers, just across the ridge is the Apache Point Observatory. Occasionally the two groups get together to connect, talk about work, and learn from each other.

One of the other advantages to working at the Dunn Solar Observatory, Head adds, is that the telescope is open to the public. "There are no glass walls that keep [tourists] away from us. I like being able to talk to people and inspire their interest. The tourists we get are [often] retired science teachers or engineers." //

Samantha Spytek

BA, Physics with Concentration in Education from Virginia Tech

WHAT SHE DOES:

Spytek is a future physics teacher, halfway through an accelerated master's in education at Virginia Tech.

HOW SHE GOT HERE:

Spytek got the teaching bug at the age of 13 as a volunteer at an art camp for younger kids. "That was the first job I ever had, but I ended up going to school for physics." Spytek says she loved teaching but thought she should follow in the footsteps of her mother, who is a researcher. "I felt that as a woman, all these other women have paved the way for me to go into research." But a conversation with a professor about her passions helped her realize that teaching was her passion. Spytek eventually added the physics education concentration to her physics major.

Last year, Spytek worked on a multidisciplinary team that created a virtual reality simulation of a high energy accelerator for use in the classroom. She has spent two summers teaching astrophysics at the Center for Talented Youth at Johns Hopkins, a summer program for gifted students in grades 7–10, and another summer interning at the American Institute of Physics, creating lesson plans on underrepresented groups in physics. Now Spytek has a year ahead of her for practical classes and student teaching, at the end of which she'll have a master's in education and be licensed in the state of Virginia.

BEST PART ABOUT HER PROGRAM:

"I like showing my students how applicable physics is. When they're motivated, I'm motivated."

"I also really like the community of teaching," she adds. "It's a very nice, fraternal feeling."

MOST FRUSTRATING PART ABOUT HER PROGRAM:

"Grading is not fun!"

WHAT SHE'S LEARNED:

"As long as you can demonstrate enthusiasm, that's the most important thing."

HOW SHE'S BUILDING COMMUNITY:

At Virginia Tech, the physics department has a club called the Ladies of Robeson (named after the building that houses the physics department) that helps get female students together for bowling or movie nights. Spytek also helps out with the "Day in the Life of a Physics Major" program, designed to assist incoming high school students considering a physics major. "I'm sort of passing the torch down to a girl who I convinced to come to VT, but I'm always interested in talking to prospective students," she says. //

Hidden Realities:

Lawrence Krauss's Trip to Alaska

by Georgeanna Heaverley SPS Member, University of Alaska Fairbanks

Once I chose to return to school to study physics, joining the Society of Physics Students has been the highlight of my career at the University of Alaska Fairbanks (UAF). We are a small chapter, but we have done everything from judging local science fairs to organizing large fundraisers, hosting stargazing parties, and even sending 12 students to the 2016 Quadrennial Physics Congress in San Francisco. But our most ambitious goal was to bring a renowned physicist to UAF to hold a public lecture, and we wanted to think big.

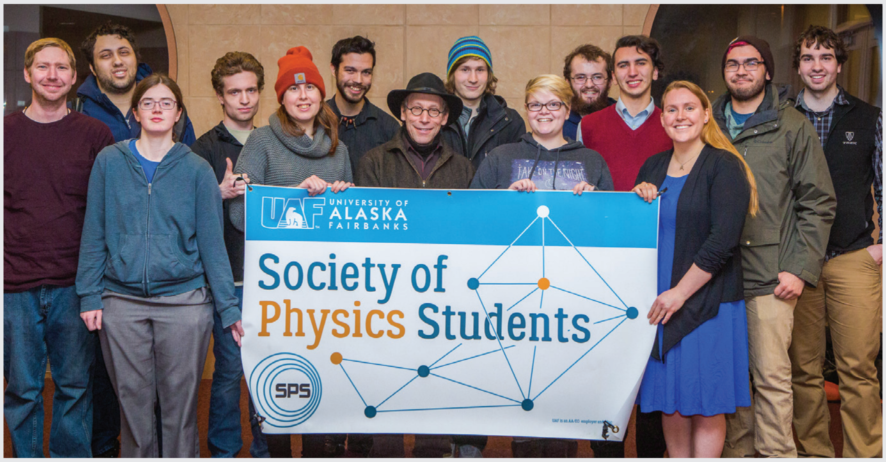
A past generation of SPS members had brought Nobel laureate Richard Feynman to UAF. We set our sights just as high as our predecessors had. On a tepid evening last May, in the company of the increasingly persistent midnight sun, I sat down with two other SPS members and composed an email to Dr. Lawrence Krauss, a renowned theoretical physicist, author, and educator.

I first saw Lawrence Krauss on the Science Channel five years ago, on the program *How the Universe Works*. I could see his affinity for the public understanding of science, and he quickly became my favorite physicist. His documentary with Richard Dawkins and his bestselling book, "A Universe from Nothing," were the inspiration behind my decision to go back to school as an older student and get a degree in physics.

We invited Krauss to visit Fairbanks and share his expertise, noting that it would greatly inspire us as future physicists, and making sure to mention Professor Feynman's past trip. I was not sure we would even receive a response.

Within one hour of sending the invitation, Krauss personally responded. "It is hard to turn down an invitation like this, especially to follow in Feynman's footsteps," he wrote. "Let's try and make this happen." We were ecstatic.

After long negotiations, we arrived at a deal and a date was set. It was 20º below when Dr. Krauss landed in Fairbanks, typi-



ABOVE: Lawrence Krauss presents to a packed audience in Fairbanks, Alaska.

LEFT: The University of Alaska Fairbanks SPS chapter poses with renowned physicist Lawrence Krauss. Photos Courtesy of JR Ancheta, University of Alaska, Fairbanks

TO READ THE FULL VERSION OF THIS ARTICLE, CHECK-OUT
www.spsnational.org/meetings/meeting-notes/hidden-realities-lawrence-krauss's-trip-alaska

cal for early March. Our Society's vice president, Riley, and I met him at the airport. We set off on the short ride to the hotel, and as we drove away from the lights of the airport Dr. Krauss received the greatest welcome that Alaska could give him—a front row seat to the aurora borealis. He could not contain his awe as the vivid green ribbons danced across the sky. Even Riley and myself, both lifelong Alaskans, agreed they were some of the best lights we had ever seen. We left Dr. Krauss to marvel at one of the crown jewels of Alaska, and made plans to pick him up in the morning.

Dr. Krauss's public lecture was titled, "Hidden Realities: The Greatest Story Ever Told… So Far," and it was about his upcoming book of the same title. Over 500 people turned out to hear the lecture. The auditorium was standing room only!

Dr. Krauss was electric as he discussed the progression of humankind's understanding of the universe and the great minds that got us there. From Plato to Faraday, from Maxwell to Einstein and Feynman—he explained our grasp of the physical phenomena that surrounds us.

He explained the importance of the Higgs boson in a way everyone could actually understand. He stressed the importance of scientific discovery and how it contributes to our picture of reality. One point that truly resonated with me was a quote from experimental physicist Robert R. Wilson, the first director of Fermilab. Dr. Krauss told us that when asked by Congress if the new particle accelerator would contribute to our national security, Wilson responded, "It has nothing to do directly with defending our country, except to make it worth defending." These words remind me how important it is to remember this very thing: scientific inquiry and discovery make our lives worth something.

After the lecture, Dr. Krauss signed autographs, posed for photos, and answered questions for nearly an hour. After leaving the auditorium, he said the size of the crowd was truly humbling; he did not expect that kind of showing.

The following day was packed with uniquely Alaskan activities. We toured the Cold Regions Research Engineering Laboratory permafrost tunnel, spotting remnants of Pleistocene animals and huge chunks of ice, all tens of thousands of years old. We viewed sculptures at the World Ice Art Championships, and even sent Dr. Krauss on a short dogsled ride.

As I said goodbye to Lawrence Krauss that night, I thanked him for giving such an incredible lecture, and for coming to our frozen town with such a positive attitude, willing to take on the adventure of Alaska.

To all the little SPS organizations out there: Set your sights high. We never could have dreamed we would be hosting such a renowned scientist in our little town in Alaska. These things don't happen every day. It was certainly hard work to organize this trip, but what we accomplished is proof that you, too, can do it. All you have to do is ask. //

My Adventures at the International Conference of Physics Students

by Nick DePorzio, Former Associate Zone Councilor (AZC) Representative, Northeastern University

Maybe you've calculated a Lagrangian, but have you ever walked in Lagrange's shoes? You know how a rocket flies, but do you know how to fly it? You've fantasized about superpowers, but have you proved you could have one? This summer, hundreds of physics students from across the world gathered in Turin, Italy, for the 2017 International Conference of Physics Students. In addition to touring the city Lagrange called home, reliving an astronaut's tale of piloting the space shuttle, and deducing the electromagnetism in Electro and Magneto's superpowers, the multinational assembly of undergraduate, master's, and doctoral students broadened their understanding of the physics community they are a part of through the friendships they made and the issues they united behind.

If you've been to a two-day professional conference, you might expect to find yourself with a few hours of free time in between events. This conference was nothing like that. Seven days of back-to-back events began with an early welcome and training for the delegates representing several dozen countries. As the United States delegate and a first-time attendee, my initial insecurity was displaced by warm welcomes.

The conference officially opened on the campus of the University of Torino. Greetings from various officials of the European science agencies were followed by an anxiously anticipated lecture from the author of *The Physics of Superheroes:* Professor James Kakalios. After the lively presentation, we recessed into the classically ornate courtyard of the Palazzo dell'Università, where food, conversation, and dancing progressed long into the night.

In the following days, we would be treated to six more lectures, two poster sessions, a series of workshops, multiple rounds of oral presentations, and a physics scavenger hunt through the city. No topics were off limits in the great sea of knowledge spanning from condensed matter to high energy, including discussions of science outreach, the present scientific climate, and even the history of the conference itself

(as presented by an 11-time conference veteran). Numerous coffee breaks kept the events in motion and morale high. After each long day of proceedings was an opportunity to bond with the other attendees and share experiences. A costume party honored the opening lecture, the "That's Amore" party honored our Italian hosts, and, most moving of all, the Nation's Party offered each delegation the opportunity to share the cuisine and culture of their home country with the other participants.

Of course, there was business to be done as well, at the Annual General Meeting, where student delegates elect new leadership of the organization, decide on the locations of future conferences, and work to solve issues facing the physics student community. I was warned going in that this infamous event had lasted as long as 8 hours in recent years. Our meeting ran 13 hours!

In the course of attending this conference, I learned that not all problems in our field are technical—some are social, some are a consequence of external political agendas, and others become apparent when practices normal to one culture are interpreted in the context of another. This conference also made clear just how limited are my means, or the means of any individual. There is an immense amount of knowledge locked away in the works of other languages I will never learn, and modes of thought contained within cultures I may never experience. Surely then, working with a diverse collection of people, each person possessing partial access to these realms of understanding, is absolutely necessary if we hope to answer the most difficult questions. //

TOP: Hundreds of physicists from around the world gather in Turin, Italy, for the 2017 International Conference of Physics Students. Photo courtesy of Marianna D'Amato.

ABOVE: International Conference of Physics Students organizers meet with participants to get them registered for a fun-filled seven-day conference. Photo courtesy of Marianna D'Amato.

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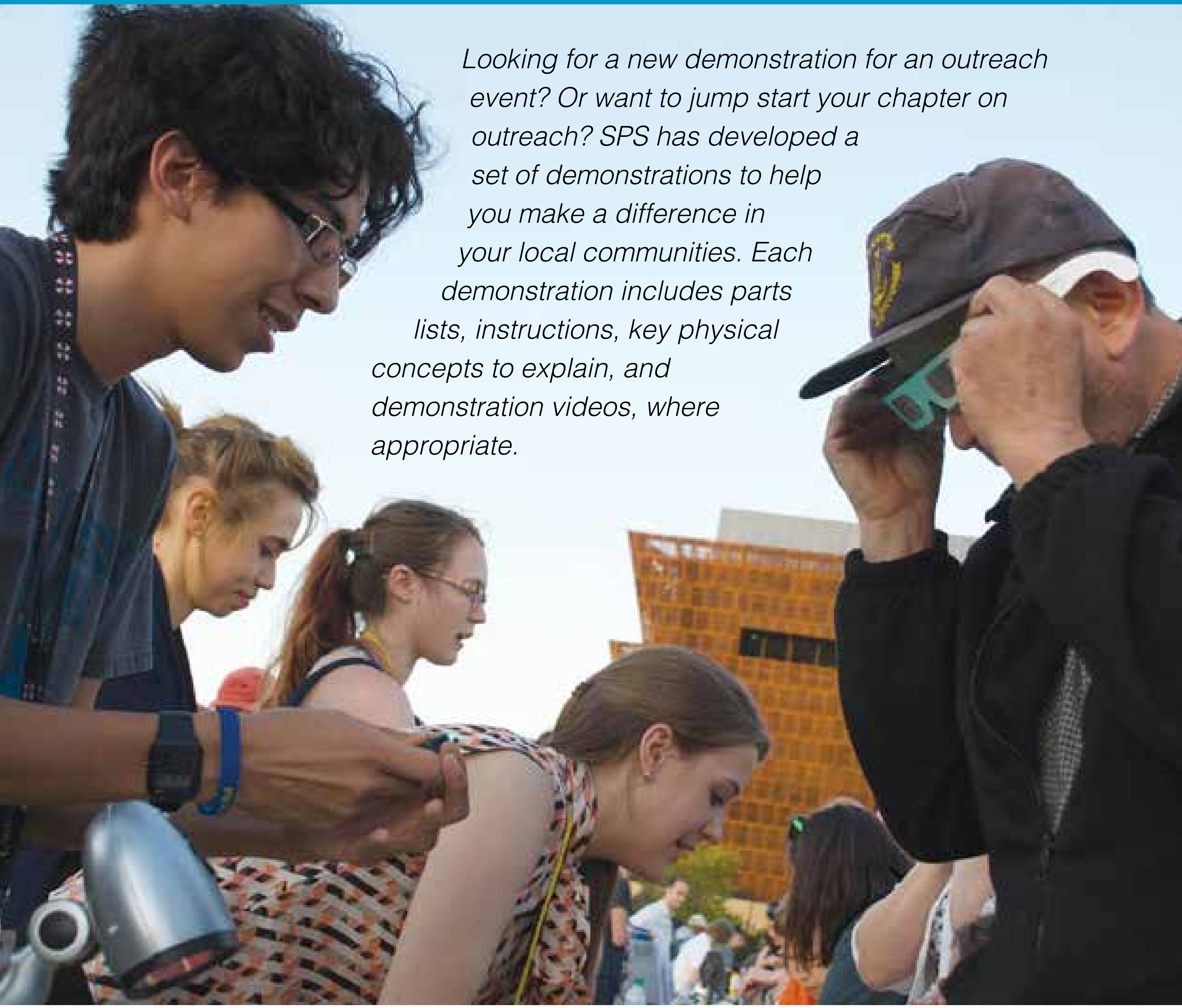
Demonstrations for SPS Chapters



Looking for a new demonstration for an outreach event? Or want to jump start your chapter on outreach? SPS has developed a set of demonstrations to help you make a difference in your local communities. Each demonstration includes parts lists, instructions, key physical concepts to explain, and demonstration videos, where appropriate.

LEARN MORE AT:
www.spsnational.org/programs/outreach/demonstrations

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