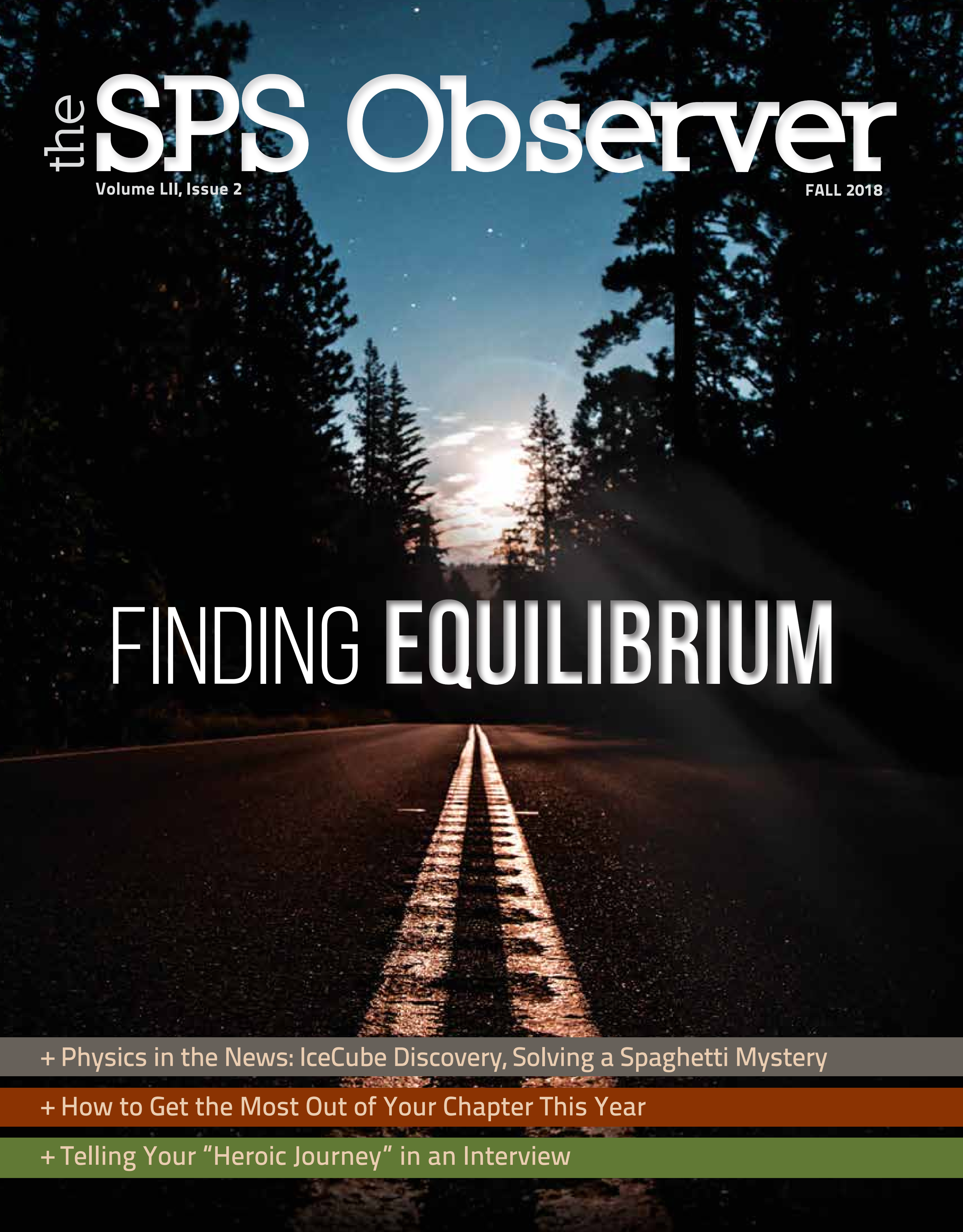


the SPS Observer

Volume LII, Issue 2 FALL 2018

FINDING EQUILIBRIUM

+ Physics in the News: IceCube Discovery, Solving a Spaghetti Mystery
+ How to Get the Most Out of Your Chapter This Year
+ Telling Your "Heroic Journey" in an Interview

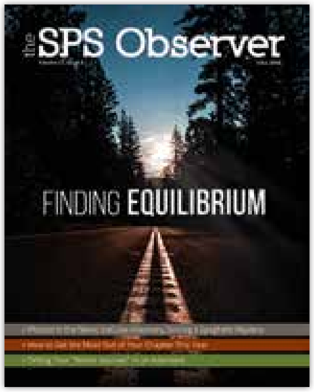
TABLE OF CONTENTS

FALL 2018 ▪ VOLUME LII, ISSUE 2

FEATURES

Special Feature

DEPARTMENTS



ON THE COVER
Each person's career is not a destination, but a path that they follow. The same can be said about finding equilibrium.

SOCIETY OF PHYSICS STUDENTS

1 Physics Ellipse
College Park, MD 20740
301.209.3007 (tel)
301.209.0839 (fax)
sps@aip.org
www.spsnational.org

Find SPS on:

The SPS Observer (ISSN 2160-1305) is the magazine of the Society of Physics Students, published quarterly by the American Institute of Physics. Printed in the USA. Standard postage paid at Freeport, OH. POSTMASTER: Send address changes to The SPS Observer, One Physics Ellipse, College Park, MD 20740-3841.

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

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

Other Member Organizations:
Sigma Pi Sigma physics honor society
Society of Physics Students
Corporate Associates

AIP | American Institute of Physics

Belonging in Physics with SPS

by Alina Gearba-Sell, PhD, President of the Society of Physics Students and Associate Professor, Department of Physics, United States Air Force Academy

Greetings and welcome to a new and exciting academic year!

I am the president of the Society of Physics Students and faculty advisor of the SPS and Sigma Pi Sigma chapters of the United States Air Force Academy. I previously served as faculty advisor of the University of Southern Mississippi chapter and zone councilor of Mississippi, Louisiana, Arkansas, and western Tennessee. Overall, I have had the honor and privilege to mentor students for almost 15 years.

"SPS is the best thing for your career since choosing to study physics" is what the poster on my office door says. I firmly stand by this. SPS is an undergraduate's first professional society and, in many cases, their first physics community. Through local impacts and national initiatives, SPS provides professional development, networking opportunities, and last, but not least, a sense of belonging. I missed out during my undergraduate career by not having the support of a national student organization. The one thing I want to do during my presidency is to make sure that both students and their faculty mentors are aware of the opportunities SPS has to offer.

SPS provides several types of scholarships to benefit various student demographics. Through its unique summer program, SPS offers research, education and outreach, and science policy internship positions. SPS also provides research and outreach awards, as well as travel grants to present scholarly work at professional meetings. Other professional development resources to check out are the Careers Toolbox, SPS Jobs and GradSchoolShopper.

Another way SPS helps guide the future of the community is by bringing together students from across the globe for the Physics Congress. PhysCon is unlike any other physics meeting; it is part conference, part workshop, part retreat, and most importantly, a congress. The next PhysCon will be held in 2019 in Providence, RI. The theme we chose for this congress, "Making Waves and Breaking Boundaries," couldn't have been more appropriate for the SPS community, the next generation of physicists who will not only advance the field but also advocate for community engagement, inclusivity, and diversity. If your chapter hasn't done so already, start planning now for what is shaping up to be the largest gathering in the world for physics undergraduates.

My involvement with SPS has always been rewarding, but serving as president takes that to a whole new level. I became acquainted with students of all backgrounds from across the nation who work tirelessly on increasing their community engagement, are passionate about making physics an inclusive and diverse community, and are ardent advocates of communicating science. These young men and women displayed one characteristic in common: the determination to succeed no matter what it takes. This issue of *The SPS Observer* is dedicated to the concept of mental grit as an essential and integral component of maintaining a balanced undergraduate experience and, ultimately, a healthy SPS community.

Since a new academic year is starting, I ask each of you to reach out to every student interested in physics, make them feel included, listen to their personal stories, and support them. Our community as a whole will only grow stronger because of who we are as individuals. Together we can accomplish amazing things. //

For additional resources to help kick your chapter's year off well, check out: www.spsnational.org/resources/current-members

How to Get the Most Out of Your Chapter This Year

by SPS National Office

Summer is over and the school year has started—but that also means exciting opportunities with your SPS chapter. Here are some tips to help your chapter make the most of this year.

Set big goals.

Your chapter might focus on increasing SPS membership, recruiting new physics majors, hosting outreach activities or developing new outreach tools, being more involved on campus, or attending more physics meetings and raising money to offset travel costs.

Other goals to consider:

- Establishing or improving your SPS student lounge
- Planning physics-related field trips
- Increasing the number of physics majors in the department—you can visit intro-level classes and invite students to SPS events
- Inviting faculty or senior-level students to give talks or lead lab tours

If you still need help finding direction, gather input from other chapter members, your advisor, and other nearby chapters.

Post the goals in a prominent place and revisit them at each meeting to stimulate ideas and celebrate progress.

Recognize that your chapter can be an awesome force in your physics department!

A strong and active SPS chapter can make earning a physics degree more fun, fulfilling, and productive for everyone involved.

Be consistent.

Make SPS a highly visible, important, and REGULAR part of the life and culture of your department. Whether weekly, monthly, or something in between, meetings should be at a regular, fixed time so that attending becomes a regular habit. Always invite faculty! Meetings are usually more fun with food, so add pizza, cookies, tea, or whatever your chapter prefers. With consistent meetings you are more likely to accomplish your chapter goals and build a strong community.

Be visible!

Be visible in your department community. Make sure that everyone in the department—faculty, students at all levels, and staff—knows about SPS events and feels welcome. Research has shown that a strong sense of community within a department increases recruitment and retention, making the challenging process of earning a physics degree more enjoyable and rewarding for everyone involved.

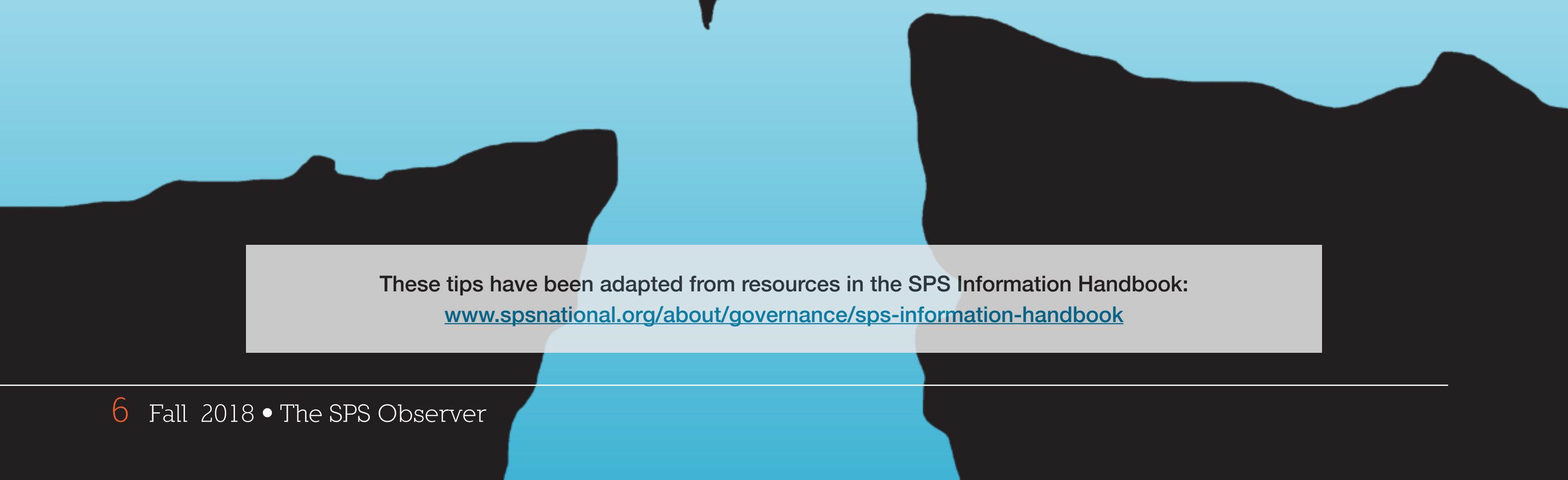
Be visible in your campus community. SPS chapters have a history of hosting great campus events. Host a splashy demo show, pumpkin drop, or liquid nitrogen ice cream booth. Physics departments are usually small, but they can have a large impact on the culture of their institution.

Be visible in your local community. Reaching out through events provides a larger purpose for your chapter and is a great way to build community, give members teaching experience, and reinspire homework-laden physics students.

Be visible in the physics community. Start building your professional network by attending meetings, visiting laboratories and companies, joining professional physics societies, and being active in online forums. You will be amazed at the opportunities available in the broader physics community.

Join the network.

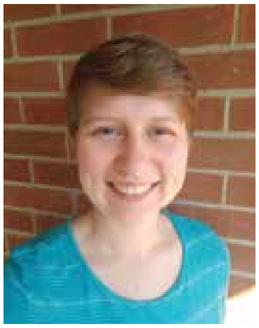
SPS is more than just local activity. SPS has thousands of members and chapters at hundreds of different institutions! Be inspired, challenged, and encouraged by SPS members from around the world virtually through Facebook and Twitter, and in person through SPS zone meetings, joint chapter activities, and professional physics meetings. These students are likely to be your future collaborators, peers, employees, and bosses, so start making connections now. Every geographic "zone" has an elected student and faculty representative whose job is to facilitate connections within their region, so reach out to them! Make sure you find out about SPS activities, meetings, awards, scholarships, internships, and more by being a dues-paying member of SPS National. //



These tips have been adapted from resources in the SPS Information Handbook:
www.spsnational.org/about/governance/sps-information-handbook

Julianna Richie

BS Physics, Southern Illinois University, Carbondale



What she does:

Richie is a research technician and the contact point for the MINT program at the University of Michigan. MINT, or Multimodal Integrated NeuroTechnology, is a technology hub aiming to advance scientific tools for the neuroscience community. Richie works on the carbon microthreads initiative, which turns carbon fibers into electrodes that can read brain activity. She builds and tests probes, helps users debug problems, and promotes the probes to labs that might be interested in using them.

How she got here:

Richie spent all four years of her bachelor's degree working in a materials lab, soaking up different aspects of materials science. She originally intended to work in energy (interning at the Colorado School of Mines' Renewable Energy Materials Research Science and Engineering Center, where she worked on iron sulfide cathodes), but decided to apply for a "software job" at UMich—a job that evolved into her current research technician position. "They said, 'Our grant has changed and you're actually going to be doing this,' and I said 'Cool, bring it on.'" The researchers at UMich were using cyclic voltammetry (a concept used in energy work) to track chemical reactions in the brain, so Richie's research experience with renewable energy materials became a huge advantage.

Best part about her job:

"The most rewarding part is knowing that the things I am fabricating on a daily basis are actually getting used in studies that are going to help us understand how the brain works. I get to talk to people who want to collaborate with us because they think they can help people having a stroke, or help reduce overdoses. Knowing that actual research is happening is rewarding."

Most frustrating part of her program:

"I am a physicist in a biology lab and I don't know a lot of the nomenclature. In meetings I'm taking frantic notes, then going back and looking things up and saying, 'Oh, that's what they were talking about.' But I love the challenge of collaborating and talking to new scientists. It's challenging to come in and be brand new and not know anything, but then I know these other things from my physics background that connect to what we're doing. It's exciting to find out where the connections come from."

How she uses physics:

"Everyone in my lab has a background in biology or engineering, and I come in with physics experience. In engineering, you get the equations and use them to make a new, awesome thing. In physics, it's like, 'Well, how did we even get the equation?' So in the lab, when we're faced with a problem, I'm always asking how we got to that problem in the first place. I'm coming at problems from a different angle." //

2018 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.

SCHOLARSHIPS

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

SPS LEADERSHIP SCHOLARSHIP:

Mitchell Ahlswede
University of Wisconsin–River Falls

Brandon Barker
University of Tennessee–Knoxville

Aaron Coe
Bethel University

Dylan Frikken
University of Wisconsin–River Falls

Siddhartha Harmalkar
University of Maryland–College Park

Aman Kar
University of Wyoming

Camden Kasik
Juniata College

Connor Murphy
Grove City College

Jesus Perez
California State University–San Marcos

Samantha Smiley
DePaul University

SPS OUTSTANDING LEADERSHIP SCHOLARSHIP:

Emily Churchman
Texas Lutheran University

AYSEN TUNCA MEMORIAL SCHOLARSHIP:

Brittney Contreras
University of Tennessee–Knoxville

HERBERT LEVY MEMORIAL SCHOLARSHIP:

Daniel Morales
Texas Lutheran University

AWIS KIRSTEN R. LORENTZEN AWARD SCHOLARSHIP:

Sophia Sanchez-Maes
Yale University

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

Erin Brady
High Point University

SCIENCE SYSTEMS AND APPLICATIONS, INC., ACADEMIC SCHOLARSHIP:

Shae Machlus
Florida State University

PEGGY DIXON TWO-YEAR SCHOLARSHIP:

Vincent Thompson
Indiana University of Pennsylvania

SPS AWARD FOR OUTSTANDING UNDERGRADUATE RESEARCH

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

WINNERS

Luciano Manfredi Console
Loyola Marymount University

Sophia Sanchez-Maes
Yale University

RUNNER-UP

Collin Wilkinson
Coe College

HONORABLE MENTION

Brandon Barker
University of Tennessee–Knoxville

2018 SPS SUMMER INTERNS

The SPS summer internship program offers 10-week positions for undergraduate physics students in science research, education, and policy with various organizations in the Washington, DC, area. Students are placed in organizations that use the interns' energy and diversity to engage in meaningful assignments relevant to their host organization and promote advancement of physics and astronomy.

Samuel Borer
University of Maine
AIP Mather Policy Intern

Mikayla Cleaver
Gettysburg College
AIP/Society of Rheology History Intern

Collin Flynn
Coe College
NASA Goddard Space Center Intern

Nathan Foster
Tufts University
AIP FYI Science Policy Communications Intern

Kristen Larson
University of Illinois–Chicago
AIP Niels Bohr Library and Archives Intern

Sarah Monk
University of Maryland–College Park
AIP Mather Policy Intern

Daniel Morales
Texas Lutheran University
NASA Goddard Space Center Intern

Jesus Perez
California State University–San Marcos
NIST Research Intern

Elon Price
North Carolina State University
APS Career Programs Intern

Phoebe Sharp
Rhodes College
APS Public Outreach Intern

Brigette Smith
Coe College
The Optical Society Intern

Michael Welter
High Point University
SPS Communications and Web Development Intern

Amanda Williams
Weber State University
SPS SOCK (Science Outreach Catalyst Kit) Intern

Stephanie Williams
University of Maryland–College Park
AIP Center for History of Physics Intern

Krystina Williamson
Columbia University–Barnard College
AAPT Teacher Professional Development Intern

REMINDER: UPDATED AWARD APPLICATION SYSTEM

It's now even easier for you or your chapter to apply for awards, scholarships, and internships from SPS National!

You can now access the online awards portal via a single sign-on through your SPS membership account. Simply visit membership.spsnational.org, click "SPS Awards Application" at the top menu bar, and log in using your SPS membership username and password.

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.

Contact us at 301.209.3007 or sps-programs@aip.org with any questions.

The Physics of Pumpkin Chucking, Part 1

by John Andersen, Professor, Rochester Institute of Technology; Brad R. Conrad, Director of SPS and Sigma Pi Sigma; and Michael Welter, 2018 SPS Communications and Web Development Intern and SPS member, High Point University

As a physics student, you're obviously concerned with the important questions of the universe. For the most serious among us: How can you launch pumpkins with a pneumatic air cannon for maximum distance and speed … for science?

To answer this question, we first need to dive into a bit of detail on pneumatic air cannons.

WHAT IS A PNEUMATIC AIR CANNON?

A pneumatic air cannon is basically a giant peashooter! Well, similar to one. In this case, a pumpkin is placed inside a tube, and a sudden burst of high-pressure air rapidly accelerates the pumpkin down the tube toward certain destruction. Often, this is done using a diaphragm and an air chamber assembly powered by an air compressor, but the main takeaway is that the kinetic energy given to the pumpkin comes from the adiabatic expansion of air!

NOW, FOR THE REAL QUESTIONS: HOW FAR WILL A PUMPKIN PROJECTILE GO? AND HOW FAST?

For a given initial angle and launch speed, with no air resistance, the projectile range x can be calculated as:

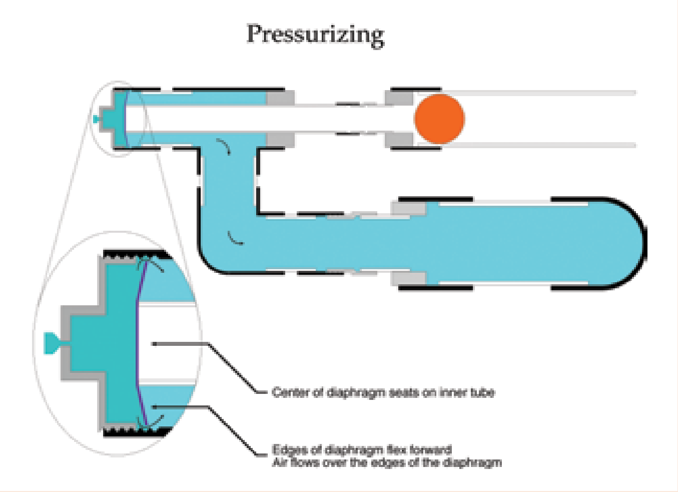
$$x = \frac{2v_i^2 \sin\theta \cos\theta}{g}$$

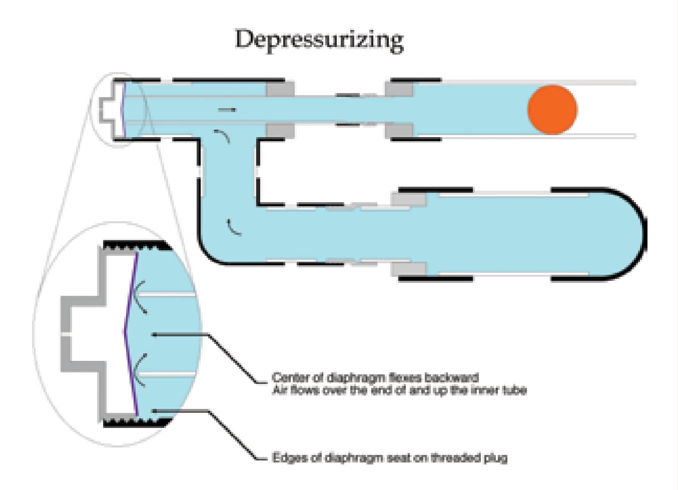
The optimal projectile range x_{max} occurs at angle of π/4 radians, so:

$$x_{max} = \frac{v_i^2}{g}$$

HOW DOES IT WORK?

While the specifics of construction depend on payload size and the desired maximum velocity, the general process for a representative type of pneumatic air cannon is shown in the illustration, which outlines how a cavity is pressurized and then this pressurized air is used to accelerate a payload using a diaphragm trigger. Figures courtesy of Rochester Institute of Technology.





Air resistance, in general, shortens the pumpkin flight time, but you can experiment with different parameters using an amazing PhET simulation,[1] which conveniently has a built-in pumpkin setting.

The launch speed can be determined from the parameters of the air cannon. For adiabatic expansion, $PV^{\gamma}=P_oV_o^{\gamma}$, where the exponent γ is an experimentally determined 7/5, and the initial and current pressures—P_o and P respectively—are absolute. The volume of the air reservoir V_o is assumed to push the pumpkin along a length L_m with an area A, so that the expanded volume becomes $V=V_o+AL_m$. The pressure P can then be written as $P=P_o(1+\frac{AL}{V_o})^{-\gamma}$, where pressure P_o undergoes adiabatic expansion into a tube of length L. By calculating the work done by a differential step and integrating over the length of the tube, we can arrive at an expression for the velocity upon ejection (assuming no friction along the length of the tube) in ambient pressure $p_a = 10^5$ Pa:

$$v_1^2 = \frac{15}{4\pi}\frac{p_a V_o}{\rho R^3}\left(1+\frac{p_o}{p_a}\right)\left[\left(1-\left(\frac{V_1}{V_o}\right)^{-\frac{2}{5}}\right)-\frac{2}{5}\frac{\left(\frac{V_1}{V_o}\right)-1}{\left(\frac{p_o}{p_a}\right)+1}\right]$$

A more complete derivation can be found on SPS National's website.[2]

For a normalized expansion volume ratio $\frac{V_1}{V_o}=13/9$ and an initial normalized pressure ratio $\frac{p_o}{p_a}\cong 11/2$, we arrive at $v_1 \cong \frac{17}{20}\frac{p_a V_o}{\rho R^3}$.

Now let's get real. A tube radius of 0.05 m, a tube length of 2 m, a pressure reservoir of 0.03 m³, and a density of water $\rho \cong 10^3$ kg/m³ (used for the density of fruit) predict a launch velocity of roughly 150 m/s!

YOUR TURN!

Below is a 60-frame-per-second composite picture of a grapefruit being launched in a similar fashion. If the launch tube has an outside diameter of 4.5 inches, how fast was the object going? How does the measured speed compare with the speed predicted by the no-friction theory? Hint: The measured speed should be slower.

Image courtesy of Matthew Aggleton, Rochester Institute of Technology.

If you're looking for a challenge, calculate the coefficient of friction with the answer above. Verify your answer at https://goo.gl/ip8YwL. In case you're curious, the impact crater was ~1/4 mile away.

It's also worth noting that the air drag coefficient is about 0.5 for a wide range of speeds. At very low speeds and sufficiently high speeds, the coefficient is quite different[3] and is a function of the Reynolds number and how smooth the surface of the projectile is. Notice that the dip in the air drag coefficient occurs at lower Reynolds number for rough spheres. This is why golf balls have dimples.

For an extra challenge, consider surface roughness. Use your calculated launch speed for the smooth grapefruit from the image, the density of air (1.2 kg/m³), and the dynamic viscosity of air (18 mPa°s) to determine an estimate for the air drag coefficient in this case. Is it close to what you would expect? //

Want to test it yourself? Check out these resources for building your own pneumatic air cannon:

Rohrbach, Z. J., Buresh, T. R., & Madsen, M. J. (2011). *Wabash Journal of Physics* **PHY381**, V4.3. http://www.iontrap.wabash.edu/adlab/papers/S2011_Buresh_Rohrbach_air_cannon.pdf

Rohrbach, Z. J., Buresh, T. R., & Madsen, M. J. (2011). *American Journal of Physics* **80**, 24. https://doi.org/10.1119/1.3644253

Denny, M. (2011). *The Physics Teacher* **49**, 81. https://doi.org/10.1119/1.3543577

Model your system yourself:
https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_en.html

Interested in how far a pumpkin can actually go?
http://blogs.solidworks.com/solidworksblog/2014/10/the-science-of-behind-chucking-pumpkins.html

Or make your own vacuum cannon:
https://www.spsnational.org/sites/default/files/files/awards/2015/final-report-sps-marsh-white-texas-lutheran.pdf

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

1. https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_en.html
2. https://www.spsnational.org/sites/default/files/files/publications/observer/2018/Puzzler08222018.pdf
3. Drag of a sphere. Retrieved on 2 August 2018, from https://www.grc.nasa.gov/WWW/k-12/airplane/dragsphere.html

Mapping the Neutron Flux Distribution Near a Medical LINAC

by Jackson Nolan, Molly McDonough, and John Thomas, SPS Members, Suffolk University

Because of the great interest in visiting Mars by NASA, private companies, and governments around the world, we are interested in studying the neutron shielding effects of different materials. Astronauts on a Mars mission will be exposed to space radiation, which might have profound health effects. Shielding astronauts from neutrons is especially difficult because they do not carry a charge.

In order to study shielding effects, we first needed a source of neutrons. We found this in a medical linear accelerator (LINAC) through a collaboration with the medical physics department at Massachusetts General Hospital (MGH). LINACs are used in the radiation treatment of cancer patients, and they produce neutrons as a by-product.

The next step in this research was to map the neutron flux, in neutrons per cm^2 per second, around the LINAC. From published simulations of medical LINACs, we know there is a dominant peak in neutron production centered at a high-energy peak of 1 MeV and a low-energy peak around 0.025 eV. We wanted to determine the neutron flux associated with these peaks for this particular machine so that we could calculate the Q value, or neutron production coefficient, as neutrons emitted per Gy. (Gy is the SI unit for an ionizing radiation dose.) We could then compare that number with published values for other 15 MV machines.

First, we investigated the high-energy neutron flux using bubble detectors—an easy and inexpensive method of detecting neutrons above 200 keV. Bubble detectors contain a gel that is packed with microbubbles of organic fluid. When energy is transferred from an incoming neutron to a microbubble, the microbubble expands and forms a visible bubble a few millimeters in diameter. The detectors are calibrated so that the number of bubbles after irradiation corresponds to the fluence of neutrons to which the detector was exposed.

For our experiments, we positioned the detectors in a straight line emanating radially out from the head of the LINAC. After radiating the detectors, we analyzed the relationship between fluence and distance from the head. (We also made distance measurements at different angles with respect to the LINAC head but determined there was no significant angular dependence.) Then we calculated the neutrons per area for a given radius and integrated over $4\pi r^2$ to obtain the Q value for the machine in neutrons/Gy. Our results indicate a high energy flux of 10^6 neutrons/cm^2/Gy, which is on the same order of magnitude as published values for 15 MV machines.

While bubble detectors are useful tools for neutron detection, they have limitations. For instance, the calibration is only accurate to 20 percent. The bubble detectors can be reused by means of a built-in plunger that recompresses the bubbles, but after several cycles we observed that sometimes the recompression failed to eliminate all the bubbles. Additionally, bubble detectors have a threshold energy limit of 200 keV.

To determine the low-energy neutron fluence, we performed a neutron activation analysis using thin metal foils with high purity. The process works this way. When neutrons bombard a thin, pure metal foil, they create radioactive isotopes. By studying the radioactive emissions and decays from a foil, you can work backward to determine the amount of incident neutrons.

For this analysis to work in practice, you need a metal that reacts with neutrons in your specific energy range of interest and that produces an isotope with a reasonable half-life. For us, this meant the half-life must be short enough to achieve high activity and good statistics following an hour-long irradiation by the LINAC, but long enough so that the activity did not decrease too much before reaching our detector. As a detector we used a high-efficiency beta detector that belongs to MGH, so we also needed the isotope to emit beta rays when it decayed. Based on these considerations, we chose copper, indium, and gold foils 0.5 inch in diameter and 0.002–0.01 inch thick.

Analyzing the foils was an interesting challenge. Some of the beta rays were shielded internally by the foils, depending on their energy, point of origin within the foil, and trajectory outward. In addition, a given isotope has a well-defined maximum energy for the beta, but there was a distribution of energies. For these reasons, we needed a correction factor to estimate the total number of betas emitted based on the number that escaped. This correction factor depends on the foil.

Our results indicate a low-energy neutron flux on the order of 10^4 neutrons/cm^2/Gy, which is in the range of published values for similar machines. The next step in this process is to continue foil irradiation and analysis using a variety of materials, both shielded with cadnium covers to absorb thermal neutrons and unshielded to create a full map of the neutron flux around the LINAC. This will allow us to eventually use the LINAC to test a variety of materials for their durability during long-distance space missions where high levels of radiation will be absorbed.

Through this process, we have learned a variety of new skills, from teamwork and leadership to innovation, perseverance, and analysis. This opportunity has helped us grow academically and allowed us to explore areas of physics we may not have been exposed to otherwise. //

Acknowledgments: The Suffolk University team includes physics majors Paul Johnson, Mario Rojas, Allen Alfadel, John Thomas, Jackson Nolan, Erick Bergstrom, Molly McDonough, Brian Hassett, and Dylan Barbagallo, along with faculty research advisor Dr. Walter Johnson and educational coordinator for medical dosimetry Jacky Nyamwanda. The LINAC is from the Massachusetts General Hospital Oncology Department, and our collaborators are Dr. David Gierga and Tara Medich. This research project would not have been possible without a 2017–18 SPS Chapter Research Award.

Telling Your "Heroic Journey" in an Interview

by Brian Schwartz, SPS Advisor, Carthage College

Over the last few years, the Carthage College physics department has increased its emphasis on what we call the "professional development" of our students, whether they plan to further their education or to enter the workforce. One aspect of this is helping students describe their experiences and skills in a way that resonates with potential employers, particularly with someone who is not necessarily familiar with what a physicist really does.

The model we suggest is based loosely on "The Hero's Journey," an idea described by Joseph Campbell in *The Hero with a Thousand Faces* but known to many through stories and films ranging from *Star Wars* to *The Brave Little Toaster.* The hero-to-be usually comes from a nondescript background but has something inside that makes them extraordinary. A "call to adventure" leads the hero to a series of challenges and the guidance of a mentor. Through both successes and failures the hero grows in strength and wisdom and understanding and, after completing some great quest, is transformed into something greater than could have been imagined. Our hero is then ready and responsible for making the world a better place.

We want our students to approach the interview process with the goal of telling a true story about themselves that is more engaging and reflective than what would appear in a transcript or on a resume. A good story integrates one's personality and training and experience into a narrative that is universally appealing. Here's a compressed version of what this might look like:

The call

The story begins with the "calling" to become a physicist, something like, "I've always wanted to know how things worked, and physics seemed like a way to figure that out …" Your call should convey what makes you extraordinary and why or how you chose the path you have been following.

The training

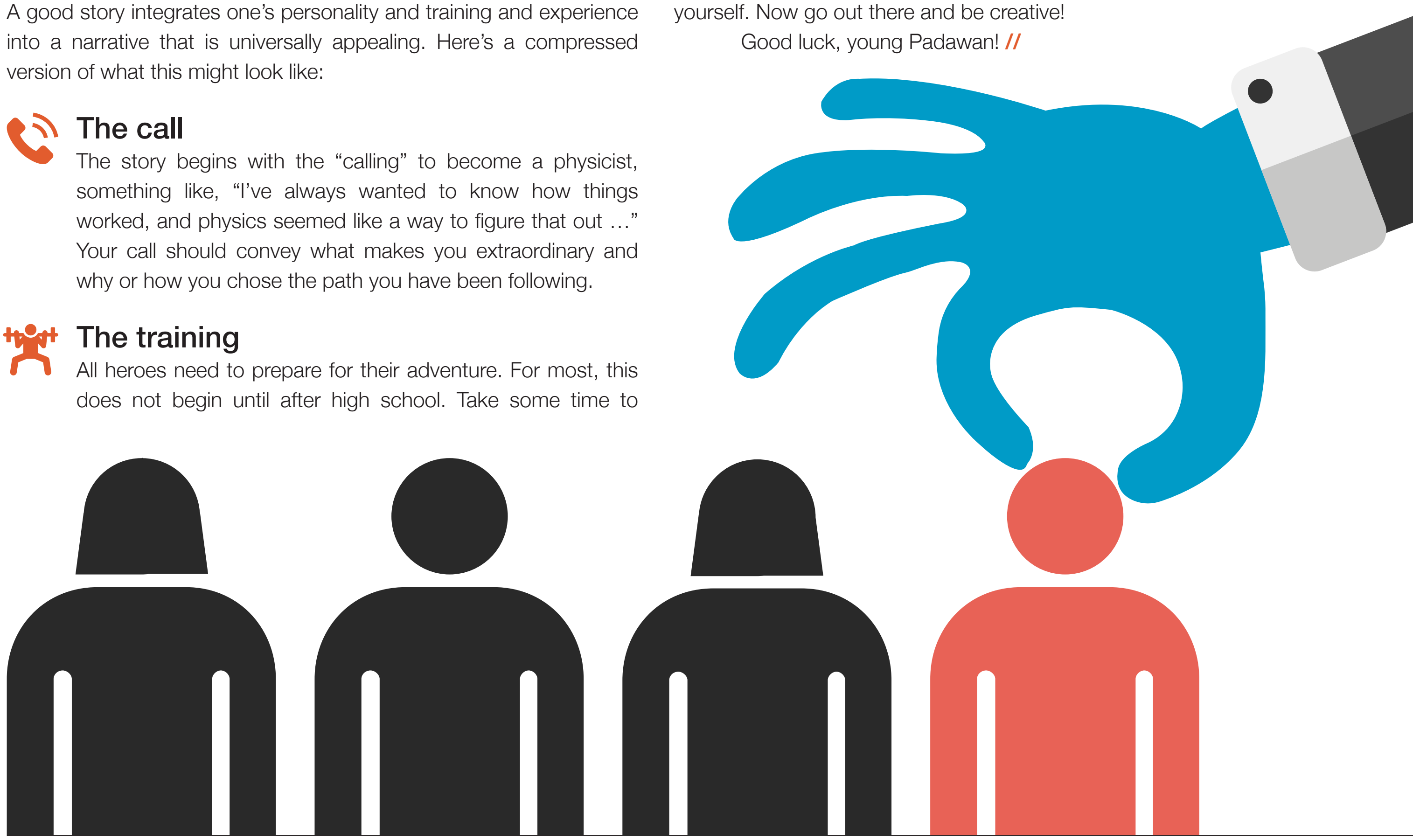
All heroes need to prepare for their adventure. For most, this does not begin until after high school. Take some time to reflect on those experiences that have made you what you are today. "My beginning years of college were (great, but/rough, because) I wanted to do something more than just take physics classes—even though they were fun and I got to work with some really smart people." Keep in mind that some of your most formative experiences happened outside the classroom, whether through outreach activities, public lectures, self-designed projects, or deep and serious conversations with other students and mentors.

The quest

Finally, cast some key transformational experience as a quest, "I had this amazing opportunity (REU/internship/research project …)," with a very specific object or goal that you helped to achieve. "It was challenging. At one point we were kind of stuck … [Here's a very specific thing I did that seemed to help a lot.] In the end it was wonderful to see this incredibly complex thing come to completion and to know that I was a part of it."

These are the basic steps of writing your story. The things that make you unique help you tell an exciting and archetypal story about yourself. Now go out there and be creative!

Good luck, young Padawan! //



A Day of Awesome Physics

by Kendra Redmond, Contributing Editor

On a Tuesday last May, more than 300 fourth-grade students took the Department of Physics and Astronomy at the University of North Carolina at Chapel Hill (UNC) by storm. They came by bus and foot from three schools to participate in Science Is Awesome Outreach Day.

Students rotated through a demo show, a hands-on Rube Goldberg machine activity, and a reverse science fair—an engaging event during which they listened to UNC faculty research talks and voted for the coolest science and best presentation.

More than 20 volunteers participated, several from the local SPS chapter. SPS member Cameron Kass helped with the Rube Goldberg activity. "I will always remember my third and final group," he says. The group designed a roller coaster–like contraption in which a golf ball rolled down a ramp and released a car that knocked down a bunch of dominoes. "Ultimately, the contraption failed, but it was an excellent teaching opportunity to let them know that failure is one of the most important parts of the scientific process and that they might make great scientists one day," he says.

For SPS vice president and volunteer Margie Bruff, the highlight was an overheard conversation during the demo show. After a particularly awe-inspiring demo, she heard a student exclaim, "It's magic," and a classmate respond, "It's not magic, it's science. He's gonna tell us how it [works]." Says Bruff, "It was great to hear this interaction because one of the purposes of the event was to demonstrate that anyone can do physics; anyone can be inquisitive, think critically, and gain a better understanding of the world around them."

Science Is Awesome also aimed to introduce kids to a range of physics topics and encourage them to consider STEM careers, says physics teaching assistant professor and organizer Jennifer Weinberg-Wolf. The program aligned with a fourth-grade curriculum but went further, including topics like fluid dynamics, extrasolar planets, and engineering organizational structures—topics UNC faculty are studying.

The event grew out of a personal connection between Weinberg-Wolf and the local schools. After getting to know her own children's teachers by volunteering to help with science activities, she started bringing classes on field trips to the department. Eventually, she brought whole grades from a nearby school one at a time. This inspired UNC physics department chair Christian Iliadis to ask, "Why don't we make this bigger and better? Why can't we help more kids and get them excited about science?" And so, plans were set in motion. Weinberg-Wolf took the lead on planning, and the Stirling Foundation provided financial support.

Although this is one of its biggest undertakings, the UNC physics department often participates in community events, facilitated by an outreach group composed of faculty members, postdocs, grad students, and undergrads. The group handles requests for science fair judges, speakers, and other volunteers that come in to the department from community organizations. The department also hosts a big demo show on campus each year.

If you are thinking about hosting an outreach event in your community, Weinberg-Wolf has a few recommendations. Recruit lots of enthusiastic volunteers, she says, and build in time on the day of the event for volunteers to have informal conversation with participants. Also, try to recruit volunteers from a diverse range of backgrounds, fields, and levels of experience. This increases the odds that participants will see a bit of themselves reflected in the role models. It's also good for the volunteers.

"For many SPS students, there was something that inspired us to pursue physics. Outreach events allow us to share that excitement and inspiration with others and sometimes even to rediscover it for ourselves," says Bruff. //

LEFT: No awesome day would be complete without liquid nitrogen ice cream. Image courtesy of UNC–Chapel Hill.

ABOVE: Dr. Duane Deardorff engages students during the demo show. Image courtesy of UNC–Chapel Hill.

RIGHT: Busy students work on their Rube Goldberg machines as a volunteer looks on. Image courtesy of UNC–Chapel Hill.

HOST YOUR OWN REVERSE SCIENCE FAIR

It's one thing to explain your physics research to peers; try explaining it to a group of 10-year-old students!

In a fun event that was eye-opening for all involved, Science Is Awesome featured four 10-minute faculty research talks. These talks were judged by the fourth graders—each student submitted a ballot after the session, voting for "Coolest Research" and "Best Presentation." Dr. Nicholas Law took home first place in both categories for his talk on the search for exoplanets and life on other planets. The students were also very enthusiastic about Dr. Daphne Klotsa's research on organizational structures—or how penguins stay warm.

To make sure the talks didn't get too technical, Weinberg-Wolf encouraged faculty presenters to consider the interests of a typical fourth grader and put their day-to-day research in that context.

Not only is this a good way to challenge researchers and engage visitors, it's also a great way to introduce them to current areas of research—to some of the physics beyond rolling balls down ramps and calculating the density of objects.

If you like this idea but need help funding an outreach event, apply for an SPS Chapter Outreach Award! Applications are due November 15.

www.spsnational.org/awards/chapter-awards

FEATURE

The Shape of an **Education**

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

> "One never notices what has been done; one can only see what remains to be done."
> –Marie Skłodowska Curie

Dr. Curie was a brilliant physicist who won two Nobel Prizes, one in physics and one in chemistry. With her husband, Pierre, she discovered two elements, radium and polonium, yet she was not satisfied. Knowing that it wasn't easy, she was always looking ahead to the next scientific challenge. This quote is an excellent reminder to me about how hard it is to see how far you've come in the middle of a journey. An education is no different: It's about the journey, not the destination. The feature pieces in this issue touch on different facets of this concept: grit, mental maintenance, and resilience.

Few of us correctly predict our educational journeys at the beginning, even if it seems at the moment like everyone else has it all figured out. We are all people, with the associated limitations and required maintenance. We will stumble, fall, and sometimes make poor decisions. Sometimes we won't know what the next step should be. But it's through these experiences that we grow and advance, and an education is no different. We are not defined by a single course or homework set, but we are shaped by these experiences, stumbles and all.

A sense of perspective on our educational journey is a very hard thing to achieve. We embark on our studies with not only a set of expectations placed on us, but also those we set on ourselves. It's so easy to focus on the tasks we have not yet completed that we can forget to celebrate what we've accomplished. Sometimes we assign more value to other people's expectations than we do to our own. Yet, the only person one ultimately needs to answer to is oneself. One of the hardest lessons for me to learn as an undergraduate was that I need to control the shape of my education, and if I'm not taking care of myself, it's hard for me to take care of anything else, including my academic progress. Resilience, perseverance, and grit are vital to making it through the difficult times (and there are difficult times), but knowing when to rest and reset is just as important as knowing when to keep at it.

Director of SPS and Sigma Pi Sigma Brad R. Conrad hiking in Acadia National Park. Photos by Brad R. Conrad.

And just as every journey requires both perseverance and rest, so too does an education. The goal is to not rush through as many things as possible but to appreciate the stops along the way. If, on vacation, you raced from city to city without ever appreciating the local culture or taking time to rest, you've cheated yourself and are not really accomplishing the goal anymore. And unlike a vacation, you may not end up back where you started; it's okay if your goals change mid-experience. The purpose of an education is to challenge and change you, so pause from time to time to evaluate the shape and path of your education. You may not even recognize yourself at the end of it. //

> "I was taught that the way of progress was neither swift nor easy." –Marie Skłodowska Curie

FEATURE

Paths to Resilience and Success

by Soonhee Lee, PhD, Interim Counseling Center Assistant Director/Training, University of Maryland, Baltimore County; Susan Han, PhD, Counseling Center Associate Director for Outreach, Johns Hopkins University; and Bruce Herman, PhD, Director of Health & Counseling, University of Maryland, Baltimore County

A new academic year has begun, and for many college students, it's a time of academic, personal, and social development. You may experience a wide range of emotions, including excitement, nervousness, sadness, or happiness. In addition, about 70 percent of successful people experience impostor syndrome (feeling like a fake or fraud), and it is not uncommon to feel intimidated by seemingly smarter peers and professors.

This is all normal. But knowing that these emotional ups and downs are normal doesn't necessarily make them easier to deal with. But there are ways to cope throughout college. **Resilience**, in particular, has been shown to be positively related to mental well-being, academic success, and retention (Eisenberg et al., 2016). Here are some specific resilience-building strategies that you can practice throughout your college experience.

1. **Get involved with friends and organizations.** First-year students' sense of social belonging was found to predict their academic and health-related outcomes over three years (Walton & Cohen, 2011). It takes time to develop close relationships, so be patient! Also, remember that participation in clubs and organizations, leadership positions, and immersion into the community all contribute to a sense of belonging in your college life.
2. **Accept that no one is perfect.** Rigid and too-high standards can take an emotional toll on students, leading to feelings of guilt, shame, or anxiety. And while it can seem motivating to compare yourself to someone who does better than you, it may also dampen your spirit or sense of hope. Keep in mind all of the things you already do well, accept that it is okay to be human, and don't be afraid to make mistakes.
3. **Embrace your anxiety. Anxiety is a part of life and necessary for survival.** Anxiety's effect on you is a bell curve. We do best when we experience a moderate level of anxiety. There are different strategies that can help you reduce anxiety when it is too high, but you should also try to motivate yourself when your anxiety is too low. Embrace your anxiety, rather than fight or suppress it. Then, study techniques such as mindfulness, cognitive flexibility, or relaxation to help you cope with the range of anxiety.
4. **Nurture your body.** Our minds and our bodies are intricately connected, and wellness encompasses a holistic view of health. Healthy eating habits, regular exercise, and restful sleep are just as important as self-care and study breaks. For academic success, nurture your mind and your body.
5. **Ask for help and guidance.** Whenever you face a new opportunity or challenge, don't be afraid to ask questions, get advice, and learn from others' experiences. Colleges provide a wealth of services and resources that are intended to guide you, and don't feel embarrassed to ask for help whenever you need it. Taking steps early on can prevent problems in the future!
6. **Get to know the mental health resources on campus.** It can be helpful to talk to a mental health professional before, during, and after your stress or anxiety levels start to impact your academic, social, or personal functioning. Many colleges have a counseling center or offer various mental health services, including individual or group counseling, skills-based workshops, or psychiatric care. The staff are trained to work with college students and can help you develop a plan for the future. In addition, many schools offer crisis services or referrals for students who are in need of more immediate care. Make sure you are aware of these resources, for yourself or for your friends and peers who may be in need.

The above strategies can help you as you navigate your way through college. As you practice resiliency-building skills, you may find yourself feeling better able to face new challenges and persist despite barriers. The staff and faculty of your school are also on your side and want to see you thrive. Make the most of the resources that are provided to you and enjoy the college experience! //

Eisenberg, D., Lipson, S. K., & Posselt, J. (2016). Promoting resilience, retention, and mental health. *College Student Mental Health, 156,* 87–95.

Walton, G. M., & Cohen, G. L. (2011). A brief social-belonging intervention improves academic and health outcomes of minority students. *Science, 331,* 1447–1451.

FEATURE

When the Going Gets Tough, **the Gritty Get Going**

by Rachel Kaufman, Editor

Albert Einstein had it. Michael Faraday had it. So did Marie Curie. Maybe you have it.

"It" is grit, a personality trait that is increasingly considered one of the most important factors that predict your success—in college and in life. Grit has been defined by psychologist Angela Duckworth as a combination of "perseverance and passion," and colleges and employers are increasingly recognizing that people with grit are more than they may appear "on paper."

At first glance, this sounds obvious—especially to physics students used to pulling all-nighters and spending evenings and weekends in the lab. The message boils down to this: You might not be immediately good at something, but if you're passionate about it and work hard at getting better, progress will follow.

This message is making its way into academia, as admissions programs are beginning to consider factors beyond grades and test scores, such as grit.

Since 2004, Fisk University and Vanderbilt University have offered a master's-to-PhD bridge program to help students from backgrounds underrepresented in physics and astronomy successfully transition into a PhD program. During the application process, the admissions committee looks for students with a good GPA and strong letters of recommendation, but it also looks for "fire in the belly and sparkle in the eye," says Arnold Burger, codirector of the program. "What we mean by it is what [do you] do when you encounter difficulties? How do you go about solving problems?"

Unlike many graduate programs, the Fisk–Vanderbilt bridge program doesn't have a GRE floor for admissions. That's partly because the GRE doesn't predict success in a PhD program. The test's own creators, Educational Testing Service, say as much, noting that the GRE can only predict success in first-year graduate courses. (It's a much better predictor of sex and skin color than of ability.)

Also, like many successful physicists, the students applying for the Fisk–Vanderbilt bridge program don't necessarily have top GRE scores.

If you are a student with a less-than-stellar GRE score, take heart: A 2014 essay by bridge program administrators, published in *Nature*, found that if admissions officers had used a 700-point GRE score as the minimum floor for candidates, 85 percent of the bridge students would have been rejected. But that doesn't mean that 85 percent of the student body should have pursued another career. On the contrary, 80–90 percent of enrollees finish their PhD within 8 years, and all PhD holders who have gone through the program hold STEM jobs in academia or industry. (Nationally and across disciplines, only 54.7 percent of people who start a doctoral program have finished it 10 years later, according to the Council of Graduate Schools.)

> "Grit may not be sufficient for success, but it sure is necessary…"

That's why the admissions office for the Fisk–Vanderbilt bridge program makes sure to place emphasis on the student's letters of recommendation, as well as their answers in a long interview. In that interview, admissions officers try to tease out a potential student's perseverance or response to adversity.

Both Burger and Dina Stroud, executive director of the bridge program, emphasize that grit and perseverance are only part of the success story. The bridge program also works because it provides resources like tutoring and mentoring to help students make up any academic deficiencies. That said, of course, it takes perseverance and grit to keep showing up at the tutoring sessions week after week; having resources available isn't the same as taking full advantage of them.

Neither Burger nor Stroud uses the term "grit" to describe the program's students. There are a few reasons for this. For one, emphasizing "grit" and self-control places the onus for success or failure on an individual student and "ignores systemic racism and other systemic discrimination," says Stroud.

Grit doubters point out that intelligence, not perseverance, explains at least half of people's differences in "performance in academic and work settings," according to a meta-analysis of grit studies published in 2016.

Others say "grit" is synonymous with "conscientiousness" —a similar personality trait that psychologists have known about for decades.

Duckworth, the psychologist, for what it's worth, argues that grit is related to conscientiousness but is not the same. She also addressed the question of structural barriers, writing in a FAQ on her website, that "Grit may not be sufficient for success, but it sure is necessary…. [T]he question is not whether we should concern ourselves with grit or structural barriers to achievement. In the most profound sense, both are important, and more than that, they are intertwined."

It's hard to study grit, and it's hard to self-assess whether you have it, because you can only judge yourself in context with other people. If you're surrounded by hard-working physics students, you may feel like you're less "gritty" than everyone around you. If your roommate spends all day browsing social media, you may feel like you are more hard-working than the average person.

The jury is out on whether you can "train" yourself to be grittier. Scientists are still researching this question, but grit may be something you're born with—or not. But good news: Even if you might not be able to become grittier, you might be able to start acting grittier—which is apparently just as good when it comes to academic success. A literature review from the University of Chicago Consortium on School Research found that "students are more likely to display academic perseverance when they have positive academic mindsets or strategies to successfully manage tasks," even though it also noted that "grit is fairly stable as an individual trait."

That said, it's OK to step back every now and then and take a breather. Duckworth, the psychologist, writes on her website that she doesn't "have any data that suggests there are drawbacks to being extremely gritty," but adds that it's possible to be "too stubborn about mid-level and low-level goals." In other words, mental maintenance can be just as important as persistence.

The idea of admitting students based on grit or perseverance is gaining traction. The American Astronomical Society adopted a policy in 2016 recommending graduate programs eliminate the GRE requirement or make the test optional, and stop using cutoff scores. But it's true that many schools still care about test scores—flawed though they may be—if only because interviewing properly can be time consuming and difficult for many admissions offices. So if your goal is graduate school, having grit in the absence of other qualities "on paper" may not yet improve your admissions chances. But having grit, or learning to act "gritty," will serve you well in all other aspects of your physics career, giving you strategies to cope with setbacks, to work hard even when the goal seems far off, and to hold steadfastly to whatever your goal is.

In other words, to butcher a phrase, when the going gets tough, the gritty get going. //

Are you gritty?
Find out at **https://angeladuckworth.com/grit-scale/**

FEATURE

Mental Health Matters–Normalizing the Conversation

by Kendra Redmond, Contributing Editor

At the Science Museum of Minnesota, you can run a virtual race against a T. rex, create a tornado out of water mist, and visit a real Egyptian mummy. You can also shred your worries.

The Worry Shredder sits at the center of a new exhibit, *Mental Health: Mind Matters,* that aims to create a safe space for discussions about mental illness. Visitors can write their worries on a piece of paper, insert it into the machine, and then watch their worries be shredded into oblivion. It's not your typical science museum exhibit.

"We wanted to raise awareness—in a safe, comfortable manner—about mental health," says Cari Dwyer, director of exhibit project management at the Minnesota Science Center and project lead on the new exhibit. "Mental health is a part of our overall health. And, like physical illness, mental illnesses are not a 'choice' or a personal flaw but medical conditions that require care," she said.

The stigma attached to mental health issues may be receding in general, but that doesn't mean the struggles are easy to talk about—especially when they are personal. Unfortunately, the climate and expectations in many physics departments make conversations about post-traumatic stress disorder, depression, anxiety, eating disorders, addiction, and other personal challenges difficult. This can leave already struggling people feeling even more isolated.

With this in mind, we asked some physics majors to visit the new exhibit and then to bring us, the SPS community, into the conversation about mental health by sharing their reflections here.

You can add your voice to the conversation by using the hashtag #MakeItOK on Twitter, as part of a campaign promoted by a Minnesota healthcare provider, or by emailing your thoughts to sps@aip.org, with the subject line "Mental Health Matters."

"It's Okay"

Greta Helmel, SPS Member, Macalester College

As I shredded a paper with the words "Will there be a job for me?" written on it, I wondered what I would have written as an elementary schooler with undiagnosed severe social anxiety. Would visiting this exhibit at that time have changed how my mental illness developed, or the ways I learned to cope? Would I have talked about my anxiety with my mom if we'd been there together?

We live in a society where experience is in high demand, and it seems like you can never be too overqualified. In physics and astronomy, you can never have too much research experience, take too many advanced courses, or know too many programming languages. Over the years, I've felt increasing pressure to make sure I'm doing everything I can to make myself competitive for whatever lies next, to the point where I've felt close to burning out on multiple occasions.

Many students face this pressure while also juggling a mental illness—often one like depression or anxiety—that can bully the mind into thinking "I'm never going to be able to do enough," or, "If I don't do more, I'll never be employed in my field."

I have lived with high-functioning anxiety ever since I can remember and was not surprised to learn that one in five Americans live with an anxiety disorder. I didn't openly talk to my parents about my anxiety until I was in college. Part of me never felt like it was bad enough to warrant bringing it up. In addition, my anxiety drove me to be competitive and do well academically. To remove a driving force of that success felt like it would change who I was.

As with many mental health disorders, anxiety is often invisible—especially if you choose not to see it. But silence is one of the most dangerous things you can do with a mental health disorder. The good news is that talking about mental health issues seems to be increasingly acceptable. As institutions like the Science Museum of Minnesota provide safe places for people to explore and learn, it becomes easier for people who do not live with these disorders to empathize, sympathize, and understand these issues. It also provides the vocabulary to do so, for those new to the conversation.

I am lucky enough to attend an institution that has accommodations for mental health issues; not everyone has access to that privilege or is in a place where they feel comfortable obtaining help. In many instances, stigma—societal, self-imposed, or otherwise—can be a huge hindrance to recognizing or managing a mental health disorder. Continuing to normalize the subject is a step in the right direction.

This is more important than ever in places where it is easy to withdraw—like in the sciences, where coding behind a computer screen or hiding amidst a problem set is a common excuse for cutting oneself off from others. We need to talk about mental health disorders and how to balance them as physics majors, research assistants, and aspiring astronomers. The Minnesota exhibit provides a good outline for that conversation: listen, learn, engage with the subject, and most importantly, "make it okay."

Bringing Hidden Symptoms into the Light

Zoe Kearney, SPS Member, University of Massachusetts, Amherst

When I first walked into the exhibit, I saw a large screen showing a short video, surrounded by faces of people who each have a story to tell. This was a striking reminder that people who struggle with mental illness are normal people, and that their illness is not a defining label. One man in the video, who struggled with depression, said it this way: "I have a mental illness, but mental illness does not have me."

In one of the most memorable activities, I sat in a chair across from another person and had a small speaker near my ear. As I tried to talk to the person sitting across from me, a woman's voice yelled into my ear from the speaker, saying phrases like "Why are you laughing?" and "Keep your eyes DOWN." The voice was so distracting that it was hard to answer easy questions like "What day is it today?" This was a simple but powerful demonstration of the unseen challenges people struggling with schizophrenia or bipolar disorder may have to manage.

As I moved through *Mental Health: Mind Matters*, I became a bit overwhelmed. It took me the rest of the night to really digest what I was seeing. The exhibit reminded me that mental illnesses can take very different forms, and some people may hide symptoms instead of getting the treatment they need and deserve. We can all help each other by watching out for the signs and symptoms in ourselves and those around us, encouraging people who are struggling to get help.

TOP LEFT: Exhibit visitors try to hold a conversation as nearby speakers play distracting voices. Image courtesy of the Science Museum of Minnesota.

TOP RIGHT: Exhibit visitors watch real people talk about living with mental illnesses. Image courtesy of the Science Museum of Minnesota.

BOTTOM: An exhibit visitor puts the Worry Shredder to work. Image courtesy of the Science Museum of Minnesota. Photo by Aria Kovalovich.

Making Personal Connections

Meg Foster, SPS Member, University of Minnesota

Sometimes, their stark descriptions make mental illnesses sound scary or make you believe that a normal life could never be possible.

One *Mental Health: Mind Matters* station played interviews of people describing their experience living with a particular mental illness. This approach made learning about mental illnesses much more meaningful to me. Hearing their voices helped me understand, on a more personal level, the struggle (or ease) of living with a mental illness. After visiting this station, I felt less intimidated by mental illnesses that were unfamiliar to me, like schizophrenia and dissociative identity disorders, and I felt much more capable of connecting with someone that has a mental illness.

There are people very close to me who have experienced anxiety and depression, some who have expressed thoughts of suicide. It is unsettling to imagine the pain and frustration associated with these conditions, but normalizing mental illnesses by talking about them, sharing experiences, and being there for others when help is needed will benefit everyone. Living with a mental disorder does not make someone any less passionate or capable. It shouldn't stop anyone from achieving their goals—in physics or beyond. //

Mental Maintenance and Inner Unity

When physics and life get hard, what gets you through?

by Dwight E. Neuenschwander, Professor of Physics, Southern Nazarene University

Content warning: This article contains some sensitive content, including graphic language describing suicide. If you or anyone else needs help finding support or crisis resources, please visit https://suicidepreventionlifeline.org.

Every semester, usually between midterms and finals, one or more discouraged students comes into my office, anxiously wanting to talk. Their course work is not going well; they are behind in everything and feel overwhelmed, inadequate, trapped, and discouraged. They want to drop a course and may hint at changing majors or quitting university life. Perhaps they are so burned out that they are tempted to just disappear … what a relief if everything would just go away.

I can empathize with these students. I was one of them myself, more than once, as an undergraduate and in graduate school. When I look in the distressed student's eyes, I remember …

… A student furiously rides his bicycle around and around in a large empty parking lot, like a caged wild animal, lap after mindless lap—at four o'clock in the morning. Trapped for weeks in a downward spiral, frustrated at being unable to work, he feels guilty about trying to relax. He is exhausted but unable to sleep. This cannot go on. Maybe a change of venue would help.

A few months later he transfers to another university. But he brings along the same person he was before. Within six months the solitary student finds himself, late one Friday night, sitting under the stars on a seemingly deserted campus, as everyone else whoops it up at the cafés and bars across the street. The student hears the laughter and music but cannot bring himself to join in. To leave tasks undone makes him feel irresponsible, but if he returns to them he steps back into a prison. So there he sits, pulled between opposite poles of duty and frivolity, trapped in a wearisome pattern grown too familiar. Although he has been in school a long time, somehow he missed the lesson on mental maintenance. Maintenance requires occasional downtime. For a motorcycle to keep on going for the long term, its engine's oil must be periodically changed. But you can't change the oil while the engine runs at 3000 RPM.

This student soon leaves the new university too and goes home, the place where, as Robert Frost described, "When you have to go there, they have to take you in."[1] No one at the university seemed surprised by his sudden departure.

He reads *A Christmas Carol* by Charles Dickens.[2] Ebenezer Scrooge's behavior hits close to home. Dickens writes: "Scrooge took his melancholy dinner in his usual melancholy tavern; and having read all the newspapers, and beguiled the rest of the evening with his banker's book, went home to bed. He lived in chambers which had once belonged to his deceased partner. They were a gloomy suite of rooms."[2]

When the Ghosts of Christmas Past and Present help Scrooge step outside of himself, Scrooge sees other possibilities:

> When this strain of music sounded, all the things that Ghost had shown him came upon his mind; he softened more and more; and thought that if he could have listened to it often, years ago, he might have cultivated the kindnesses of life for his own happiness with his own hands, without resorting to the sexton's spade that buried Jacob Marley.

Some of us have to learn things the hard way. In university life our most important lessons have nothing to do with courses and majors. The greatest lessons are about ourselves and about life.

Physics never came easy for me; I had to work hard at it. When I was an undergraduate, the hard work paid off in predictable ways. In graduate school the stakes were higher, the topics deeper, and the pace faster. I assumed success would come through maximizing time spent in the office. That assumption, combined with my high motivation, lack of natural talent, and excess of stubborn persistence, led to a perfect storm of downward spiral and burnout. The world closed in, a painful form of self-centeredness. Extreme motivation and persistence can be admirable. But doing physics with competence also requires peace of mind. Peace of mind requires mental maintenance. Mental maintenance depends on deliberately taking time to enjoy life, which includes periodically giving the work a rest.[3]

Although I would not want to go through those days again, I am grateful for them now. When each despondent student looks into my office and asks if we can talk, I can say, "I've been there." Most discouraged students are not suicidal, but I don't take that for granted. I have been a faculty member in a building where a student took his own life by diving down an eight-story stairwell one beautiful Thursday

---

1. Robert Frost, "The Death of the Hired Man," *Complete Poems of Robert Frost* (Henry Hold & Co., New York, 1949); reprinted in *Adventures in American Literature*, John Gehlmann and Mary Rives Bowman, eds. (Harcourt, Brace, & Co., New York, 1958), pp. 263–267.

2. Charles Dickens, *A Christmas Carol* (first published 1843), published in 1957 by Nelson Doubleday, Garden City, NY, as the first of three Dickens Christmas stories, under the title *Christmas Stories*, illustrated by Walter Seaton. This excellent volume was part of an extensive book club set called "Junior Deluxe Editions." One of the best things my parents did for me at a young age was to sign me up in that book club. Titles by Dickens, Robert Louis Stevenson, Mark Twain, Howard Pyle, and many others came each month, and it helped make a reader out of me.

3. Of course, some students have the opposite problem; they never get around to getting the problems started, or they do them carelessly. I am not talking about those students here.

The author is shown sitting behind a 1964 Volkswagen bus in Sevier Lake (a salt flat) in western Utah, during a summer in his graduate school years. Out here peace of mind could be found. Why he did not do this more often back then he does not understand now. Photo by Douglas Strickland.

afternoon. That student, we learned, had withdrawn from the university earlier in the week. The previous Monday a student had come to my office and asked me to sign a withdrawal form. I signed, he left, and I turned back to my desk.

Today, if you come to my office to withdraw, you and I are going to have a long conversation, and not just about the course. If you jump ship from my course or the university, that's fine; but I must know where you're jumping to. Not, I pray, down a stairwell. That is never the answer, even if you see no other way out at that moment.

I would like to offer a few suggestions:

#1.

Never, never, never make an irreversible decision based on how you feel at the moment. Every year, about a dozen university students out of every 100,000 commit suicide.[4] Before you dive down a stairwell, for once in your life decide to let that dilemma go. Go ride a bike, go dancing, go to a concert, go TP your professor's house . . . get out of yourself and do something fun. Have coffee with a friend and share your struggles. If you are in a no-way-out crisis and have to act now, call a suicide hotline, go to an ER—tell yourself you can always dive tomorrow, but not today. When the immediate crisis has abated, pack your car and take a spontaneous road trip, even if you have to drop out of school (as I did—sometimes being temporarily irresponsible is the most responsible thing you can do). You may end up as a coffee shop barista at Lake Tahoe or a guide for a Grand Canyon river trip company, interesting experiences that will give you time to renormalize your mind. If you decide to go back to school, you can always make the necessary apologies (as I have had to do). At least there will be pieces that can be put back together, and your story will keep going. As a professor, I will gladly work with you on putting the pieces back together whenever you return—that beats reading your obituary.

#2.

Do not get so obsessed with the goal of tomorrow that you overlook the joys of being alive today. Henry David Thoreau observed that, "The cost of a thing is the amount of what I call life which is required to be exchanged for it."[5] The only reality we genuinely have is this present moment. However pressing the task at hand, take a look—really look—at that gorgeous sunset. We must work for the future and remember the past, but the living takes place right now.

4. D. E. Neuenschwander, "Sometimes I Feel Like Quitting," "Some Facts About Student Depression and Suicide," and "The Longer View," *SPS Observer* (Fall 2004), pp. 1–7.
5. Henry David Thoreau, *Walden* (first published 1854), Sherman Paul, ed. (Houghton Mifflin Co., Boston, MA, 1960).

#3.

Keep things in perspective. Life and physics are too important to be taken too seriously. If your self-worth depends on grades and accolades, that's a self-serving dead end. No matter how good you are, there is always someone better. The only comparison I should be making is against myself: Am I giving it my best, so that I won't be a hack?[6] Being another Richard Feynman is not the measure of success; we already have Feynman. But we need you to be you. You have a unique set of experiences and passions and skills to offer. Brilliance is nice, but quality is what counts. And if we never had any difficulties, where would our most colorful stories come from?

#4.

Setting aside periodic downtime is not goofing off—it's maintenance. Albert Einstein did not have his "miraculous year"[7] in 1905 through relentless nonstop work. He knew how to enjoy life. In 1902, while in graduate school and shortly before he got a job in the Swiss Patent Office, he met two fellows who became lifelong friends: Maurice Solovine and Conrad Habicht. The three comrades began meeting regularly over frugal dinners of sausage and cheese in their apartments to discuss physics and philosophy. Sometimes they took mountain hikes together. They called their three-member society the "Olympia Academy," poking fun at the pomposity of learned societies. Rather than delaying Einstein's immortal work, those sessions of relaxed conversation, with friends at a table or while sitting on a mountain awaiting the sunrise, helped his creativity bloom.[8]

When I look back on it now, I wonder what was so dreadfully important in the office that I could not give it a rest for a couple of hours once or twice a week. (My father used to ask me, when I was stressed out about something, "Will it matter 10 years from now?" That's a great question.) Had I done so, I would have returned

6. In a radio interview, photographer David Plowden describes how, when he decided to become a photographer, he told himself, "Plowden, don't be a hack. Do it right." David Plowden interview titled "Disappearing America," from "The Story," North Carolina Public Radio, broadcast on National Public Radio, Dec. 7, 2007.
7. *Einstein's Miraculous Year: Five Papers That Changed the Face of Physics,* John Stachel, ed. (Princeton University Press, Princeton, NJ, 1998).
8. Walter Isaacson, *Einstein: His Life and Universe* (Simon & Schuster, New York, 2007), pp. 79–84.

RIGHT: "Life is like riding a bicycle. To keep your balance, you must keep moving."—Albert Einstein. Image by Mark Hom.

refreshed to the tasks waiting there, and completed them with effectiveness and genuine joy. I know that to be so because that's what I do now.

#5.

Nurture your hidden inner selves. Inside every physicist there also lives a musician or an artist, a hiker, or a cyclist. To be a whole, interesting, authentic person, those other selves need space to grow, along with the physicist. Those inner selves teach one another. Samuel Crothers wrote, "As civilization advances and work becomes more specialized … what then becomes of the other selves? The answer must be that playgrounds must be provided for them outside the confines of daily business.… If one has only a little free time at his disposal, he must use that time for the refreshment of his hidden selves. If he cannot have a sabbath rest of 24 hours, he must learn to sanctify little sabbaths, it may be of ten minutes' length. In them he shall do no manner of work."[9]

#6.

Strive for excellence, not perfection. When I was a TA, each week I gave a 10-point quiz. One student who I shall call Elisabeth got 10/10 every week—except one week, when the score was only 9. After class the student argued with me for 20 minutes about that one point. The irony of the situation was that I dropped the two lowest quizzes anyway, but for the persistent student, this argument was not about the quiz average—the student's ego demanded nothing less than perfect scores across the board. That's a crushing burden to carry around—and is counterproductive too.

9. Samuel Crothers, "Every Man's Natural Desire to Be Somebody Else," reprinted in *Exploring Life Through Literature* (Scott Foresman and Co., Chicago, IL, 1964), pp. 413–420.

#7.

Notice that most of our difficulties are self-inflicted.
When I walked out of graduate school, my professors were not telling me to leave. When I returned after a year of reflection, I decided that two things would change: First, I was going to enter the lives of people around me, on and off campus; and second, when I left the final time, it would be either because I graduated or because my professors had thrown me out, but I was not going to *take myself out.*

A wise friend once told me, "The important ingredients for the wholeness of life are easy to state but can take a lifetime to master." Practice maintenance. Be competent. Nurture relationships. To experience our place in the world with equanimity, the inner life and the outer life must be of a piece. The poet Rainer Maria Rilke eloquently expressed this yearning for wholeness:[10]

Ah, not to be cut off,
not through the slightest partition
shut out from the law of the stars.
The inner—what is it?
if not intensified sky,
hurled through with birds and deep
with the winds of homecoming.

//

Acknowledgments

Thanks to Brad Conrad, Rachel Kaufman, and Kendra Redmond for insightful suggestions about this article. Gratitude to my students who come into my office and ask "Can we talk?" and to the mentors and encouragers who were there for me.

10. *Ahead of All Parting: The Selected Poetry and Prose of Rainer Maria Rilke*, translated and edited by Stephen Mitchell (Modern Library, New York, 1995), p. 191.

About the Author

Dwight E. ("Ed") Neuenschwander was born in New Mexico, grew up in Kansas and Colorado, and graduated from the University of Southern Colorado in Pueblo in 1976 with a degree in physics and math. He did some graduate work at Kansas State University in Manhattan and eventually finished a PhD in physics at Arizona State University (ASU) in Tempe in 1983. Dwight taught at ASU and Northern Michigan University in Marquette, and has been a professor of physics at Southern Nazarene University (near Oklahoma City) for 30 years.

A former director of SPS and Sigma Pi Sigma (1995–97), he edited SPS publications for 15 years and continues writing the "Elegant Connections in Physics" column for *The SPS Observer* and *Radiations,* the official publication of Sigma Pi Sigma. He served on the SPS Council 1991–2016, coached the US Physics Team that competes in the International Physics Olympiad, and authored books for undergraduate physicists, including titles on Noether's theorem (2017, Johns Hopkins University Press) and tensor calculus (2015, Johns Hopkins University Press).

Dwight enjoys mountain and desert solitude and starry nights; motorcycle trips and old cars; the Beatles' *Abbey Road* and Samuel Barber's *Adagio for Strings*; books, art museums, and trying to operate an alto sax. He and his wife, Rhonda, have two sons and five wonderful grandchildren. He is pictured above during a workshop at the 2012 Quadrennial Physics Congress of Sigma Pi Sigma (PhysCon), held in Orlando, Florida. Photo by Ken Cole.

SPECIAL FEATURE

Physics in the News

by Rachel Kaufman, Editor

Noodling on a Spaghetti Mystery

It is practically impossible to break a dry spaghetti noodle into exactly two pieces. Try it—odds are good that you'll end up with three or even four fragments.

Even Richard Feynman spent time noodling over the conundrum. Inventor Danny Hillis wrote in a 1994 Feynman biography that he and the famed physicist spent "hours coming up with crazy theories.... We ended up with broken spaghetti all over the kitchen and no real good theory about why spaghetti breaks in three." French physicists solved the answer of why in 2005, earning themselves an Ig Nobel prize for describing the "snap-back" wave that fractures the spaghetti into multiple pieces.

But the story doesn't end there; in 2015, two MIT students wanted to see if it really was possible to break spaghetti into exactly two pieces. They eventually built a mechanical device to reliably bend and twist hundreds of spaghetti noodles.

The trick? If you twist spaghetti nearly 360 degrees, then slowly bend it, it will snap exactly in two. The work was reinforced by a mathematical model developed by another MIT student and the French scientists who developed the original spaghetti theory. The model found that as the spaghetti unwinds from the twist, it creates a twist wave that travels faster than the snap-back wave, dissipating extra energy.

"It will be interesting to see whether and how twist could similarly be used to control the fracture dynamics of two-dimensional and three-dimensional materials," co-author Jörn Dunkel, associate professor of physical applied mathematics at MIT, said in a statement. "In any case, this has been a fun interdisciplinary project started and carried out by two brilliant and persistent students—who probably don't want to see, break, or eat spaghetti for a while."

DOI: 10.1073/pnas.1802831115

IceCube Hits Pay Dirt

Scientists have, for the first time, traced a neutrino back to its source.

In July, physicists working with data taken at the IceCube Neutrino Observatory in Antarctica reported in *Science* that they had detected a single neutrino and figured out exactly where it came from: a blazar, a giant galaxy with a black hole at its core, 4 billion light-years away.

Physicists have been hoping to find the sources of neutrinos for decades, because they're related to cosmic rays, with one key difference. Cosmic rays, being charged particles, change their trajectory as they zip through the galaxy at insanely high energies. (The highest-energy cosmic-ray particle ever recorded was two million times as energetic as the protons accelerated at the Large Hadron Collider.) Neutrinos are essentially inert, so they travel in a straight line. That means when we detect one, we can theoretically trace it back to where it came from.

That happened for the first time when a single neutrino hit IceCube in September 2017 from somewhere in the direction of Orion. Researchers trained their observatories around the constellation to find a more precise source, and the *Fermi Gamma-Ray Space Telescope* delivered: It detected a jump in energy coming from a blazar known as TXS 0506+056.

The discovery opens up a new branch of so-called multimessenger astronomy. Just as LIGO's detection of gravitational waves two years ago allowed astrophysicists to begin studying the skies by looking at not just light but light and gravity, now scientists can add neutrinos—and their sources—to the list of observations we can make. //

DOI: 10.1126/science.aat2890 and 10.1126/science.aat1378

To the Sun!

The *Parker Solar Probe* successfully launched August 12 on a Delta IV Heavy rocket. It will spend the next seven years gracefully pirouetting closer and closer to the Sun, until its closest approach, under 9 solar radii (about 6.2 million km) from the photosphere, the closest any human-made probe has ever been to our nearest star.

This places it solidly within the corona, or outer atmosphere, of the Sun. Scientists hope to learn more about how and why the corona is so hot (about 1 million kelvin) compared to the Sun's surface (about 5800 K). They're also hoping to study in depth the Sun's magnetic field, which creates and accelerates the solar wind.

The probe is named for astrophysicist Eugene Parker, who coined the term "solar wind." It's also the first NASA spacecraft named after a living person.

Learn more about *Parker* at: https://www.nasa.gov/content/goddard/parker-solar-probe.

At Cape Canaveral Air Force Station's Space Launch Complex 37, the Delta IV Heavy rocket with NASA's ***Parker Solar probe***, lifts off at 3:31 a.m. EDT on Sunday, Aug. 12, 2018. The spacecraft was built by the Applied Physics Laboratory of Johns Hopkins University in Laurel, Maryland. The mission will perform the closest-ever observations of a star when the probe travels through the Sun's atmosphere, called the corona. The probe will rely on measurements and imaging to revolutionize our understanding of the corona and the Sun–Earth connection. Photo credit: NASA/Kim Shiflett

David Kaplan's Curious Path to Physics and *Particle Fever*

by Kendra Redmond, Contributing Editor

It wasn't until his second physics postdoc that David Kaplan could actually see himself as a physicist. In a fitting turn of events, his 2013 documentary *Particle Fever* has inspired many young students to envision themselves as physicists.

"I always thought the people around me were much more accurate and rigorous in their abilities to do a calculation," Kaplan explains. "Even as a postdoc, when I was doing research, I was still not sure I was supposed to be a physicist," he says.

Everything changed when he met Savas Dimopoulos, a faculty member at Stanford University. Dimopoulos was rigorous in other ways, explains Kaplan. Rigorous in his choice of research projects, in questioning the direction of a project, in applying physical intuition, and in reducing an idea to its bare bones. Kaplan says, "Once I understood that he could be a great physicist, I thought I had a chance, too."

Empowered to tackle important physics questions from this critical, "big picture" approach, Kaplan fell in love with physics. He joined the faculty of Johns Hopkins University in 2002, and his contributions to physics research populate an impressive CV.

Particle Fever grew out of his constant questioning. Like other theoretical particle physicists, most of Kaplan's research focused on questions that could be answered by the Large Hadron Collider (LHC). Despite his scientific predictions, as the world's largest particle collider neared completion in the mid-2000s, Kaplan couldn't shake the thought that the field was at a turning point. "Are we missing something?" he wondered.

Either the LHC would find something and confirm that particle physicists were on the right track, or it would find nothing. If it found nothing, then what? Because the theoretical particle-physics community was so narrowly focused on ideas that could be tested by the LHC, Kaplan worried that the entire field might crumble if it came up empty.

Whether the LHC saw something or nothing, Kaplan realized, the story would be significant and dramatic. He wanted to capture and share the human side of this drama—the scientists who, above all else, were committed to the pursuit of truth regardless of whether it supported their scientific predictions. In Kaplan's words, "What we discover belongs to all of humanity."

The result is a documentary that follows Kaplan and a handful of other physicists on a journey from nervous anticipation to new scientific results, from the LHC's first run to its first monumental discovery. The film dispels the notion that being a physicist is all about calculational ability, highlighting the intense passion, curiosity, and humanity of the scientists that worked on the project. It was coproduced by Kaplan and Mark Levinson.

The response to *Particle Fever* has been overwhelmingly positive, and the film has received numerous awards. Earlier this year the parent organization of SPS, the American Institute of Physics, honored Kaplan with the 2018 Andrew Gemant Award, which recognizes contributions to the cultural, artistic, and human dimensions of physics.

Since the film's release, Kaplan has been most moved by the response of young students, like a 13-year-old girl who asked for advice on becoming a particle physicist after watching the documentary. To her and the many others that ask the same question, Kaplan advises, "When you have a choice, try to get the best teachers you can."

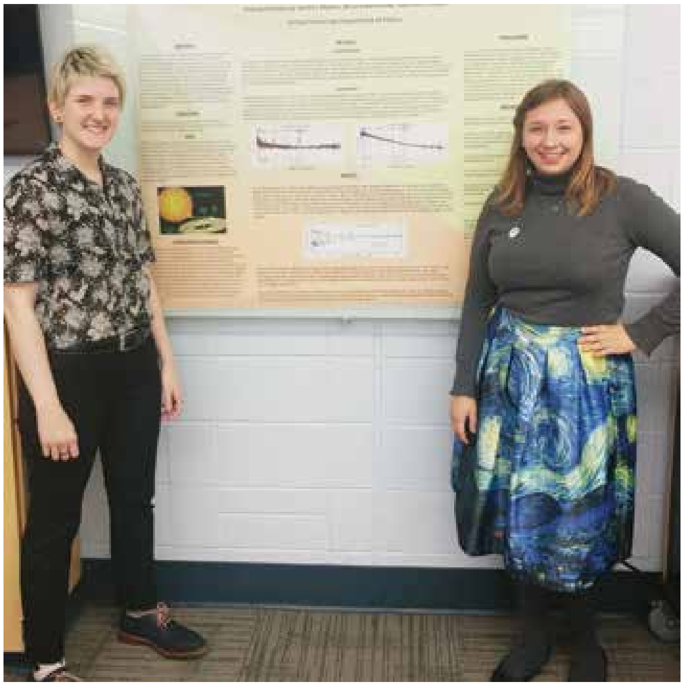
Reflecting on his physics journey, Kaplan seems amused at where he is now. He clearly enjoys his research, seeking to extend the standard model of physics and cosmology and develop experimental strategies to probe his theoretical predictions. He loves his colleagues and relishes the freedom to consider risky ideas and pursue interesting projects—like a Broadway musical loosely based on *Particle Fever*. For someone that had a hard time seeing himself as a physicist, he seems right where he should be. "Physics is so much fun," he says. "If you can do it, I recommend it." //

For more information about the Andrew Gemant Award visit:
www.aip.org/aip/awards/gemant-award

A Joint Success: Zones 9 and 11 Combine Spring Meetings

by Kendra Redmond, Contributing Editor

The highlight of the zone meeting was a Demo-Off—each chapter brought their favorite physics demo, and chapters competed for laser-cut championship plaques.



"I feel like as scientists we often forget to be amazed by the world around us, and this demo competition allowed each of us to be genuinely curious and excited about the world around us," says Tori Eng, the 2017–18 associate zone councilor (AZC) for Zone 11. "Personally, I felt that this moment captured everything that is great about SPS, both the love of physics and connecting to others through that love," she says.

Last year, Eng and Samantha Pedek, then AZC for Zone 9, teamed up to bring together students from across the upper Midwest for the joint zone meeting. The meeting kicked off with an interactive tower-building competition and included zone breakout sessions, a trivia contest, tours of the labs at the host institution (the University of Wisconsin–River Falls), a poster session, research talks, and more.

Hosted on the border between the two zones, the meeting facilitated interactions between nearby chapters that might otherwise travel in opposite directions for zone meetings. "Many chapters decided to hold meetups with nearby chapters and overall increase their connection with SPS both locally and nationally after this meeting," says Eng. Another benefit of a joint meeting—twice the zones mean the possibility of twice the funding. This gave Eng and Pedek a larger budget to work with.

Joint meetings can be a lot of fun, says Eng, but they come with extra challenges, too. She recommends that meeting planners be overly organized and communicate frequently. A website and online registration can be helpful tools once you've established the type of zone meeting you'd like to hold. For a thorough guide to planning a zone meeting, visit the SPS website at www.spsnational.org/meetings/zone-meetings. To receive funding support for your zone meeting, visit the SPS website at www.spsnational.org/meetings/zone-meetings/funding. //

LEFT: Meeting attendees pose during the poster session. Photo by Sam Pedek.

RIGHT: A group of students compete in a tower-building competition during the joint meeting. Photo by Sam Pedek.

International Peers and Where to Find Them: My Experiences at 2018 ICPS

by Samuel Borer, 2017–18 AZC Representative, University of Maine

Walking around the room, I begin to start counting the languages I hear being spoken: Finnish, Norwegian, German, Swedish, Greek, English, French—and the number keeps growing. Through the cacophony of voices, I can make out some common physics words: "quantum," "atomic," "quark." The shared thread intertwining through the hundreds of people in the room is that everyone is a physics student, either undergraduate, master's, or doctoral. We are all here to take part in an international convention of physics students, to break the borders and share in experiences together. We are the International Association of Physics Students (IAPS), and if you are a member of SPS, then you are also a member of this amazing international organization. In this article, I hope to share with you why you should take advantage of it.

The first International Conference of Physics Students (ICPS) was held in Budapest in the summer of 1986, when a small group of Hungarian physics students wanted to organize a conference to meet other physics students from around the world. Shortly thereafter, the International Association of Physics Students was founded to encourage mutual cooperation and unity between physics students.

Today, IAPS is run by students from all over the world, with its headquarters in Mulhouse, France, with the European Physical Society.

ABOVE: Map showcasing all the countries represented in IAPS. Courtesy of Sam Borer.

BELOW: ICPS 2018 Attendees—Helsinki, Finland. Photo by Miika Kosloff.

Besides offering some amazing grants and activities, the two defining IAPS events are ICPS and PLANCKS. ICPS serves as the Annual General Meeting (AGM) for the IAPS Executive Committee and the delegates from each member organization. Outside of the AGM, it serves as a multinational assembly of students from around the world to come and socialize together. The Physics League Across Numerous Countries for Kick-Ass Students (PLANCKS) is a newer event, first started in 2014 in the Netherlands, which brings together teams of physics students for a three-day theoretical physics competition. Ideally, each member organization of IAPS has a chance to submit their top team of 3–4 bachelor's or master's students.

As your delegate to IAPS, I attended the 2018 ICPS in Helsinki, Finland. It was nine days filled to the brim with social events, five keynote speakers, excursions, general assembly meetings, laboratory tours, research talks and posters, and Finnish cultural events.

During the research symposium, I was given the opportunity to give a talk about the particle-physics work I had done for my undergraduate thesis. Having the symposium placed a few days into the conference was a brilliant idea, because I had developed close friendships with a small group of delegates and we were able to go around to each of our talks and cheer each other on.

I have been very fortunate throughout my undergraduate career to attend a few conferences, but nothing has ever come close to this experience. I was able to make friends from all over the world and discuss what it is like to study physics, or just live, in many other countries. We also were able to explore Finland together and take part in some truly amazing cultural activities, such as a Finnish *sitsit* (a traditional three-course feast) and a sauna night. I took a cruise around the archipelagos of Helsinki, while others hiked into Nuuksio National Park, took a ferry to the Helsinki Observatory, or visited the Korkeasaari Zoo. On the last day, I was able to take a ferry across the Baltic Sea to Tallinn, the capital of Estonia. The trip was filled with memories I cherish, with people I will not easily forget.

Next August, everyone will come together in Cologne, Germany, for 2019 ICPS. If you have the means and the interest, I recommend you consider attending. If you are an SPS member, you are eligible to attend. I can promise you that it will be an experience of a lifetime.

If you have any questions about participating in IAPS or ICPS 2019, please feel free to reach out to Megan Anderson at nc-usa@iaps.info. //

2018 Sagan Exoplanet Summer Workshop: An Out-of-This-World Conference

by Mark Giovinazzi, SPS Member, Drexel University and PhD Candidate, University of Pennsylvania

Within minutes of accepting an offer to attend graduate school at the University of Pennsylvania, I was told, "You need to go to this conference. And by the way, it's across the country, you've got to find your own funding, it's three months away, and you'll want to present some research you've done." A grad student's gotta do what a grad student's gotta do. So I made it work.

The Sagan Exoplanet Summer Workshop provides opportunities for students, postdocs, and researchers to learn about the exoplanet-related techniques used in NASA's Exoplanet Exploration Program. Held at the California Institute of Technology (CalTech), the 2018 Sagan Workshop hosted more than 150 exoplanet scientists from 18 countries.

The first four days focused on a different exoplanet detection method: transits (Monday), radial velocities (Tuesday), direct imaging (Wednesday), … microlensing (Thursday). The final day was dedicated to the future of the field. The days included POP talks (brief, two-minute talks given mostly by students to highlight research results), poster sessions, lunches with the speakers, and group projects.

I have been to numerous physics conferences, but I have never seen anything quite like the POP talks—they were great. People who did not yet have concrete results could quickly highlight the direction of their research, and people who were not enthusiastic about public speaking could give a more relaxed talk. In addition, most of the POP talks occurred before the poster sessions, so those who were also presenting posters could encourage interested listeners to stop by for a more in-depth discussion.

As always, I enjoyed the poster sessions and the chance to hear about interesting research. These poster sessions were held outside—evidently in Southern California you don't have to worry about rain. Also held outside were lunches with the day's speakers. I met with an array of exoplaneteers over lunch, from those who do what I hope to do in graduate school (detect and characterize exoplanets using the radial velocity method) to those working on the opposite side of exoplanet research (by using the microlensing method, for example).

The final segment of the workshop was an ongoing group project. Attendees had split into teams of five to ten participants at the start of the workshop and worked on projects using one of two exoplanet data-fitting software programs. My group used the program EXOFASTv2 to sift through data and demonstrate that in order to properly constrain measurements of exoplanets, it is imperative to collect multiple observations from multiple techniques. We worked on our projects a little each day and then gave 10-minute presentations during the closing session. The best part of this, aside from collaborating with the authors of the programs we were using, was getting to work in CalTech's beautiful new astronomy building.

When I attended the workshop, I had been working at the University of Pennsylvania (and in the field of exoplanets, for that matter) for only about a month. It was an incredible opportunity to immerse myself in the exoplanet community and learn what it takes to succeed in the ever-growing field of exoplanets. I cannot wait to apply my newfound knowledge, and I look forward to presenting new work at next year's Sagan Exoplanet Summer Workshop! //

the SPS Observer
American Institute of Physics
1 Physics Ellipse
College Park, MD 20740-3841

physcon
2019 Physics Congress

Making Waves & Breaking Boundaries

Featuring

Dame Susan Jocelyn Bell Burnell
PhysCon Honorary Chair
Professor of Astrophysics,
University of Oxford
Winner of 2018
Breakthrough Prize

Sandeep Giri
Manager, Advanced
Technology
Engineering, Google X

Dr. John C. Mather
Nobel Laureate
Senior Astrophysicist
at NASA Goddard Space Flight
Center
**Photo Courtesy of Christopher Michael*

Dr. Jami Valentine Miller
Primary Examiner, U.S. Patent and
Trademark Office
Founder, African American Women in
Physics (AAWIP)

Dr. Ellen D. Williams
Distinguished University Professor,
Department of Physics and Institute for Physical
Science & Technology,
University of Maryland

SPS ΣΠΣ ΣΟΦΙΑ

November 14 – 16, 2019
Downtown Providence, RI

AIP American Institute of Physics