the SPS Observer
Volume LIV, Issue 2
FALL 2020

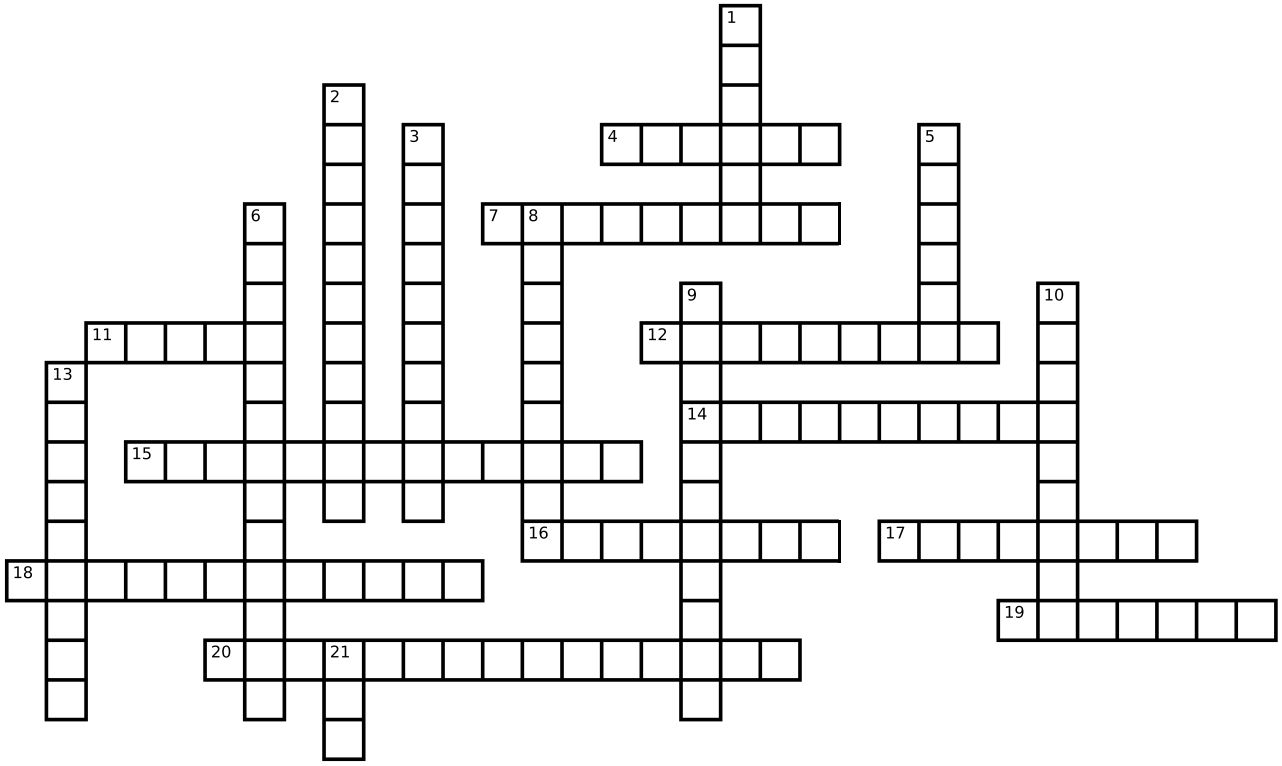
# Facing the CHALLENGES of 2020

+ Five Tips for Building Resilience During the Pandemic
+ Rethinking Lab Courses When the Labs Are Closed
+ SPS Outreach Adapts to Meet 2020 Challenges
+ SPS Statement on Racism and Protest
+ Using a Geophysics Lab to Advance the Testing and Cleaning of Face Masks

# Crossword Puzzle - Thermal Physics

**Put your thermal physics knowledge to the test with this crossword puzzle! Can you finish it first?**

by Samantha Creech, 2020 SPS Intern, *Physics Today*



### ACROSS

4. A Nobel prize–winning technique uses these to cool a gas close to absolute zero
7. No heat is lost in this kind of process
11. This is a cgs unit used for viscosity (and also a synonym for composure)
12. A type of free energy
14. A classic physical example of a two-state system
15. The theorem stating that the average energy is equal for each degree of freedom
16. The sum of the system's internal energy and the product of its pressure and volume
17. No, it's not avocado's number
18. At this temperature, entropy is minimized
19. This will always increase in an isolated system
20. *U-TS+PV*

### DOWN

1. The heat absorbed (or released) during a phase change
2. This type of statistics is used for systems of fermions
3. Describes the specific configuration of each element in a thermodynamic system
5. The most efficient cycle for an ideal engine
6. This type of statistics is used for systems of bosons
8. The type of equilibrium reached when chemical potential is equal
9. The inverse of (change in entropy / change in internal energy)
10. This Austrian physicist made great contributions to statistical mechanics
13. An ideal radiator that absorbs all incident light
21. A unit of pressure

**Submit a picture of your completed crossword puzzle to sps-programs@aip.org for a chance to win. If you are one of the first THREE to complete and submit the puzzle correctly, you will win a prize from SPS National, get a shoutout on our social media, and be mentioned in the next issue of the *SPS Observer*! Best of luck puzzling!**

**Congratulations to Genna Crom from the University of Iowa and Jenna Osborn from The George Washington University for completing the previous climate-themed crossword puzzle! Check out the previous crossword puzzle in the 2020 Spring issue of the *SPS Observer*.**

the SPS Observer

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# TABLE OF CONTENTS

FALL 2020 ▪ VOLUME LIV, ISSUE 2

## FEATURES

### Facing the Challenges of 2020



### Special Feature




**ON THE COVER**
APSU's Professional Mad Scientist, Bryan Gaither, safely uses 16 pounds of thermite to burn through a taxi cab on campus. Photo by Greyson Solomon-Crawford.

## DEPARTMENTS



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# 2020: A Focus on Community and Inclusion

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

**For many of us, SPS is our first way of connecting with other physicists and exploring what it means to be part of the community. Chapter pizza lunches and outreach events at local grade schools may not seem like they're anything extraordinary, but they are. These events set the tone and help us all experience what it means to be part of a community of physicists and astronomers. We organize complex events that could fail at any given moment by working as a team, work through very difficult problems by teaching each other, and succeed in conducting practically impossible modern physics experiments by collaborating as colleagues. These experiences help to form our physics identity and what we think it means to be a group of peers. While lots of physics is about individual understanding and effort, I would argue that most of physics is built on the idea that we succeed with each other, not in competition but in collaboration.**

The Society of Physics Students was formed with that key concept in mind. While the honor society ΣΠΣ honors excellence and promotes service, SPS is open to anyone with an interest in physics. It's intrinsically a different kind of interaction. At its core, SPS aims to bring everyone together as an inclusive community. This is a wide umbrella academically, as we know that undergraduate physics students go many different directions after graduation.[1] More importantly, this is an even wider umbrella socially. Being open and inclusive of everyone with an interest in physics means having a variety of options, events, and viewpoints within a chapter.[2] So, while it may not be obvious how having a Bad Physics Movie Night or an SPS-sponsored tutoring session[3] improves your collective sense, the building of community happens by having something for everyone, for every stage of their undergraduate careers, and by making sure everyone is included if they want to be.

ABOVE: Dr. Brad R. Conrad. Photo courtesy of Conrad.

Community is about people connecting as colleagues, friends, and classmates, and these connections last a lifetime. Forming a close-knit community isn't something that can be downloaded or bought—it's developed over time, trials, and triumph. Small moments in the SPS lounge can change perspectives and help people feel welcome.[4,5] Late-night homework sessions in the library encourage group work skills.[6] Physics demo shows give students the leadership experiences they will need in future careers and graduate programs. Attending department teatimes allows students to develop needed connections to faculty as colleagues. Many professionals look back on the late nights and department cookouts as defining moments in their concept of what it means to be a part of the physics and astronomy community. To help make each department welcoming and inclusive to the next class, SPS events must continue to happen, even if they look *really* different this year.

For many of you, this is not a normal beginning to an average school year. It's fair to expect a dynamic chapter environment that will make it much harder than usual, or simply impossible, to do many of the things we often do as SPS chapters and groups. Yet, as physicists and astronomers, we need to do what we always do when faced with a challenging problem: experiment, learn, and adapt to move forward. We will grow with the times, and we will do it by learning from each other's successes and bright ideas, with the help of the SPS and Sigma Pi Sigma National Council and SPS National Office. One of the main goals of the National Office and council this year is to help officers create an environment in which their chapter still does what we need it to do: build a community for everyone.

You might be asking, "What kind of events can we even do as a chapter this year?" since it might be impossible for you to meet in person. We've collected some great ideas from SPS leaders about activities and events that have worked for them and that you can try.[7] When you do something that works for your chapter, we want to add it to the list.[8] At SPS National we are also stepping up our game to make sure our members can find something that works for them. This year we are hosting a yearlong colloquium series,[9] regional zone meetings,[10] a virtual SPS lounge on Discord,[11] and member competitions over our far-from-serious social media platforms. All these can be found at spsnational.org. Yet, it's also important to remember that for many members, living situations will be different. In an environment where person-to-person interactions are limited or people have had to move back home, the people who most need a sense of belonging might be the least accessible or the most adversely affected. Not everyone will have access to the same resources and support networks. To achieve our mission of being welcoming and inclusive, we must ask you to *also* make an effort to reach out to folks who are not currently engaged, listen to fellow classmates, and make

accommodations so that everyone has the opportunity to participate. By supporting each other, we help to build the community that will define how we remember our time as undergraduates.

SPS should be whatever it needs to be to help students, but I want to make sure each chapter leader and advisor knows how important it is for us to maintain what makes SPS special in these dynamic times: a strong local identity and a supportive, inclusive community. We must, as a team, make sure that we still have vibrant and active SPS chapters but realize that things will look a little different. I ask that you help your chapter and its members find ways to connect to each other, come together, and make SPS events the highlight of the year (instead of just another video call). Please make everyone feel welcome and reach out to those that might be having a challenging time. SPS/Sigma Pi Sigma is a 99-year-old organization of members, and now, more than ever, we need to support each other. //

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7. www.spsnational.org/about/chapteractivities
8. Email us at sps@aip.org so we can share the idea.
9. www.spsnational.org/about/SPScolloquium
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11. discord.gg/Az3RMKZ


## EVENTS YOUR CHAPTER CAN DO VIRTUALLY:

- Physics Jeopardy
- Minute Physics talks
- Science-themed pumpkin carving competition
- Standing homework group sessions
- Virtual demo shows
- SPS-hosted virtual teatime
- Invite speakers from the SPS Alumni Engagement Program

# 2020 Individual Award and Scholarship Recipients

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

## SCHOLARSHIPS

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

### SPS Outstanding Leadership Scholarship

**Anshu Sharma**
*Randolph-Macon College*

**Tristen White**
*Juniata College*

### SPS Leadership Scholarships

**Abdullah Al Maruf**
*South Dakota State University*

**Kameron Goold**
*University of Utah*

**Matthew Macasadia**
*Texas Lutheran University*

**Chris Matsumura**
*University of Southern California*

**David Nguyen**
*University of Southern California*

**Ryan Pindale**
*University of Maryland, College Park*

**Tyler Price**
*University of Tulsa*

**Carol Stover**
*University of Central Arkansas*

**Georgia Votta**
*Augustana College*

### SPS Future Teacher Scholarship

**Carissa Giuliano**
*Adelphi University*

### Peggy Dixon Two-Year Scholarship

**Joseph Watson**
*McMurry University*

### Herbert Levy Memorial Scholarship

**Kirk Kleinsasser**
*Lycoming College*

### AWIS Kirsten R. Lorentzen Award

**Sophie Weiss**
*Coe College*

### Aysen Tunca Memorial Scholarship

**Amy Zingsheim**
*University of Wisconsin – River Falls*

### Science Systems and Applications, Inc. (SSAI) Academic Scholarship

**Sophie Roberts**
*University of Northern Iowa*

### Science Systems and Applications, Inc. (SSAI) Underrepresented Student Scholarship

**Anna Murphree**
*Rhodes College*

## SPS AWARD FOR OUTSTANDING UNDERGRADUATE RESEARCH

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

### Winners

**Kevin Fernando**
*University of Central Florida*

**Parsa Zareiesfandabadi**
*North Carolina State University*

## SPS EMERGENCY SCHOLARSHIP

**The SPS Emergency Scholarship was established by the Society of Physics Students, the American Institute of Physics (AIP), and donors to provide relief funding for students impacted negatively by the COVID-19 pandemic and effects thereof. Many undergraduate physics and astronomy students have been displaced, lost employment, had summer internship opportunities become unavailable, or need financial assistance to continue their studies. To help alleviate these potential hardships and ensure that undergraduate physics and astronomy students can continue their studies, SPS is awarding $100,000 in emergency financial support to students through the end of 2020.**

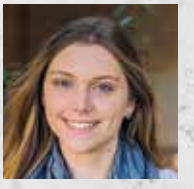
## 2020 SPS SUMMER INTERNS

**The SPS summer internship program offers 10-week positions for undergraduate physics students in science research, education, and policy with organizations in the greater Washington, DC, area. Students are placed in organizations that use the interns' energy and viewpoints to engage with the community and promote the advancement of physics and astronomy. Due to COVID-19, the 2020 internship program was virtual.**

**Abigail Ambrose**

*The College of Wooster*

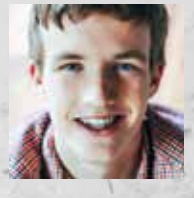
*AIP/Society of Rheology History Intern*



**Holly Fortener**

*Marquette University*

*SOCK (Science Outreach Catalyst Kit) Intern*



**Benjamin Petkie**

*Worcester Polytechnic Institute*

*AAPT Teacher Professional Development Intern*

**Kyle Blasinsky**

*John Carroll University*

*AIP Mather Policy Intern – Representative Bill Foster's Office (D-IL 11)*

**Paul McKinley**

*Pomona College*

*AIP Mather Policy Intern: US House Committee on Science, Space, and Technology*

**Abdul Qadeer Rehan**

*University of Richmond*

*NIST Research Intern*

**Billy "Trey" Cole**

*West Virginia University*

*NIST Research Intern*

**Alex Mikulich**

*Colorado School of Mines*

*NASA Goddard Space Center Intern*

**Maria Stokes**

*University of Utah*

*AIP Center for History of Physics Intern*

**Samantha Creech**

*University of North Carolina – Asheville*

*Physics Today Science Writing Intern*

**Jack Moody**

*University of Massachusetts – Amherst*

*APS Career Programs Intern*

**Hale Stolberg**

*American University*

*AIP FYI Science Policy Communications Intern*

**Joseph Dees**

*Henderson State University*

*APS Bridge Program Intern*

**Anna Murphree**

*Rhodes College*

*NASA Goddard Space Center Intern*

**Madison Swirtz**

*Colorado School of Mines*

*APS Education & Diversity Intern*

**Max Dornfest**

*University of California – Berkeley*

*AIP Mather Policy Intern – NIST*

**2021 SPS Internship applications open November 1. For more information, visit spsnational.org/programs/internships.**

# Making the Jump from Jurassic to Next-Gen:

## Facing the Challenges of the New Virtual Landscape in 2020


TOP: Michelle Starks, '22, happily greets our Jurassic partners in science.

MIDDLE AND BOTTOM: Little Scientist's intern Paige Edwards, '21, demonstrates how to make a cloud in a jar.

by Hailey Gilman, SPS Chapter President, Paige Edwards, SPS Chapter Vice President, and Joe Vazquez, Former SPS Chapter Vice President, Randolph College

**The Randolph College Science Festival was never intended to make the jump from physical to virtual event, but when it came to the festival's survival, our SPS chapter had to make a decision: Evolve—or become extinct.**

When the first-year students heard about the annual community outreach event known as SciFest, it sounded too good to be true. Randolph, a small liberal arts college in the mountains of central Virginia, has a student population of about 600. How could this event bring as many as 3,500 people to campus? The obvious answer: inflatable dinosaurs, baby chicks, non-Newtonian fluids, and a Pi Run followed by a lot of pie.

What began as a day event for children in 2005 happily expanded to a week of activities for everyone in 2009. Designed and coordinated by our SPS chapter, SciFest welcomes all participants for activities that educate and inspire future scientists and their parents. Events include a kick-off 3.14-mile Pi Run on March 14th, a keynote speaker (such as origamist and physicist Dr. Robert Lang in 2019), a Women in Science Panel (featuring Randolph alumni), a Scientist Goes to the Movies event, a kids' Poetry Jam Contest, a Jr. FIRST Lego League expo, and more. The Saturday of the festival, billed as Science Day and Science Day for Little Scientists, we invite 400 3rd to 6th graders and 300 3- to 7-year-olds to participate in science activities. The Sunday of the festival, we welcome our partner Vector Space (Lynchburg, Virginia's local makerspace) to host the Lynchburg Mini Maker Faire, featuring activities and exhibits for


TOP: Attendees enjoy the Newton's cradle, a past SPS project, during SciFest Sunday.

MIDDLE: SPS physics majors at PhysCon 2019 with advisor Dr. Peter Sheldon (right).

BOTTOM: The Randolph College SPS community after enjoying Science Jeopardy. Photos courtesy of Randolph SPS chapter.

all ages. Registration is on a first-come, first-served basis, and there is no charge, thanks to our sponsors.

During the first half of the 2020 Spring semester, our student interns and faculty volunteers worked hard to organize SciFest and plan engaging activities. Planning was nearly complete when the COVID-19 pandemic moved all academic and community activities from behind the Randolph Red Brick Wall to cyberspace. As students, we have had so much support from our science faculty that it was only natural to adapt as best as we could. That's how good science makes it from grant to practical application.

In this new virtual landscape, drawing in the middle- and high-school scientists has been more challenging. It's difficult to create activities that are engaging, age appropriate, and not susceptible to poor internet connectivity.

This year, college chickens hatched on a "chick cam" via live feed. Poetry Jam creations became their own live, virtual, interactive medium, with kids submitting videos of themselves reading their original, science-inspired poetry. Science Day's building challenge became a kitchen-table contest for which students built and submitted videos of their "amusement ride" creations. Science Day for Little Scientists activities were written up with detailed instructions in an activity booklet and demonstrated over several weeks of fun-sized episodes. All materials were posted on the official SciFest website.

We owe our success to the resiliency and adaptability of our students and our chapter advisor, Dr. Peter Sheldon. We've been grateful for the opportunities he has enabled for us, such as driving a group of us to the 2019 Physics Congress.

Brown University was the local host of the 2019 Physics Congress. One evening, they invited attendees to their Board Game Cafe, consisting of board games and hot chocolate, and prepared several talks for us. We really liked the idea of a social cafe to bridge the gap between physics- and nonphysics–related majors, and so we adapted it to feature our preferred medium of entertainment—video games. This was a hit in the early spring and transitioned surprisingly well to Zoom. An unexpected benefit is that we can also invite alumni and incoming first-year science students to socialize with us and broaden the SPS community.

It's been a year with more than a fair share of unexpected challenges, but 2020 has also proven just how resilient our SPS chapter can be. We never intended to give up our on-campus activities, especially SciFest, but we're working hard to make a new footprint with the knowledge that the only direction is forward. //

# Fizz-ics Propels Us Forward

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

*Puzzler: If a car was powered by using Mentos and Diet Coke for thrust, how many 2-L bottles would it take to go a kilometer?*

**What are we even talking about? Well, you are one brief internet search away from hundreds of thousands of related videos, some of which are super cool. The phenomenon of dropping candy Mentos into Diet Coke for an explosive foam geyser has been featured in MythBusters,[2] many YouTube science channels,[3] and even in music videos.[4] This goes beyond a simple internet meme; we're talking hard-core science about why Mentos, in particular, work so well at inciting a foam explosion[5]—surface roughness and a little chemistry are the main culprits—and there are even studies on the effects of altitude. At higher altitudes, you get more foam from the same reaction.[6]**

## THE EFFECT

We know that carbon dioxide is dissolved in the soda at high concentrations. When Mentos are dropped into the soda, the rough surface of the candy acts as many bubble nucleation sites for the carbon dioxide. Furthermore, surfactants in the candy (such as the gum Arabic) reduce the energy necessary to form bubbles, which speeds up bubble formation. The net result is that as the candy falls through the soda, carbon dioxide is released extremely quickly in the form of foam rushing out of the bottle, as seen in Fig. 1. If you add more Mentos, the effect is larger.

## THE PUZZLE

From watching some of the *many* Mentos and Diet Coke videos available online, I estimate that soda will spray at its farthest about 5 meters horizontally (if ~1 meter off the ground), or as high as 10 meters vertically,[7] at room temperature. From the published papers (yes, there are some!) I estimate at least 1.3 kg of mass loss from each 2-L bottle.[5]

As for Mentos propulsion, the logic goes that if the bottles can propel Diet Coke foam several meters in the air and power toy car rockets,[8,9] why couldn't we use

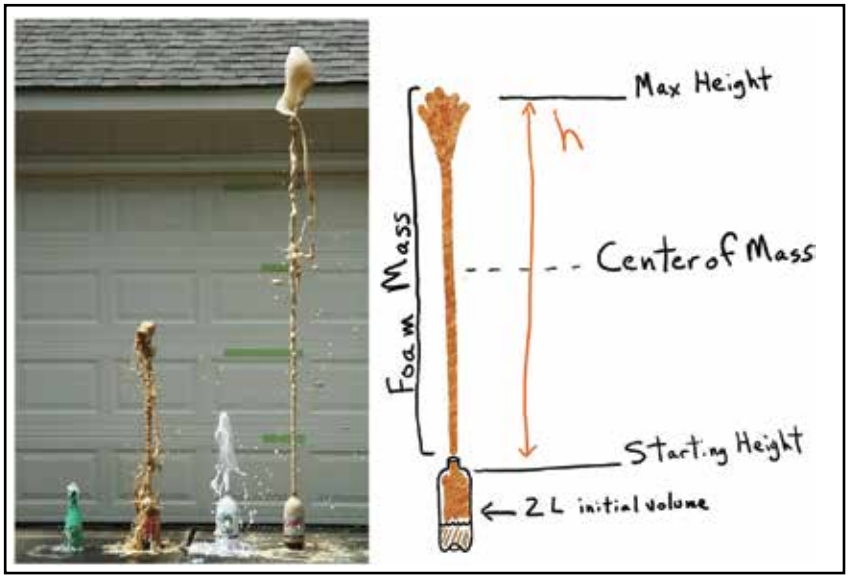



**Figure 1.** (Left) Image of Mentos-induced geysers with five plain Mentos. From left: carbonated water (Perrier), Classic Coke, Sprite, and Diet Coke. The background green marks denote 0.5 m of separation. Unaltered image by K. Shimada[1] (CC BY-SA 3.0). (Right) Sketch of foam center of mass and measurements.

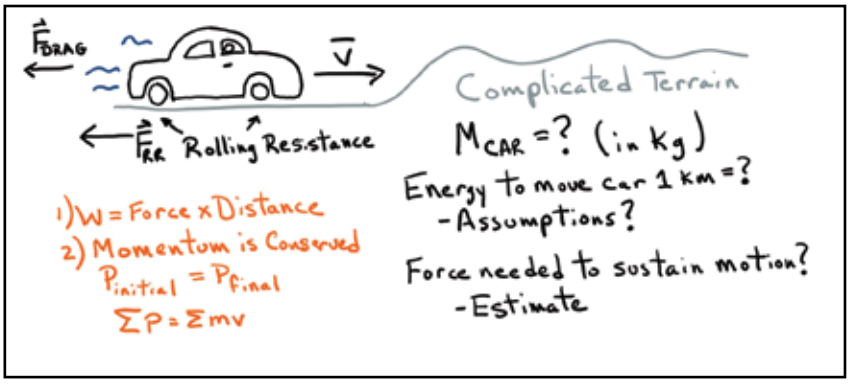



**Figure 2.** Sketch of starting information and equations.

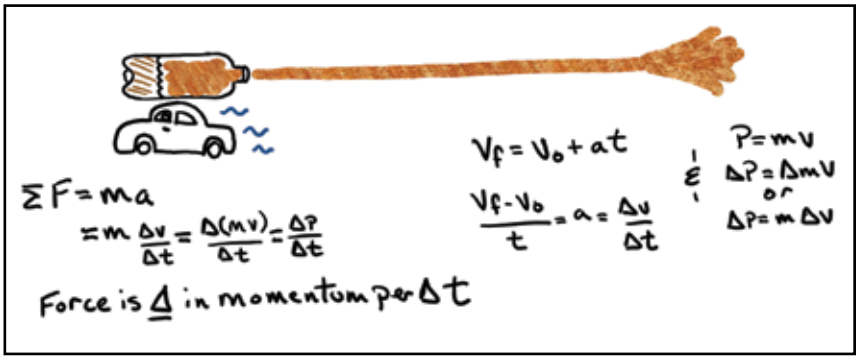



**Figure 3.** Notes on thrust and momentum. Images by Brad R. Conrad.

them to propel a real car forward? The question is, how can we figure out what it would take? I'll start you off with just enough physics to get going but let you puzzle out the answer yourself... (Fig. 2).

**Hint 1:** It turns out that for most problems I could sketch, the dynamics of a car moving are energetically complicated (duh): we have rolling resistance, air resistance, and even hills to deal with.

Is there some way of estimating the average force or total energy needed to move a car a kilometer?

**Hint 2:** We need to know the average thrust (which is a force) you can get out of a single 2-L bottle, which is definitely related to the total momentum of the foam spray (Fig. 3).

I now leave you with the puzzler for this issue: ***About how many bottles of Diet Coke (or Mentos) would it take to move a car a kilometer? What assumptions did you have to make?*** **Email us your answers at sps-programs@aip.org. //**

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**Check out our answer at spsnational.org/the-sps-observer.**

www.compadre.org/osp

# Hands-On Physics—Online

by Kendra Redmond, Editor

**Years before iPhones, Facebook, and broadband internet, two physics professors at Davidson College in North Carolina—Wolfgang Christian and Mario Belloni—were developing interactive, web-based physics simulations. Their Java applets let students change the parameters of a physical system and see the impact almost immediately. Anyone could access them with any browser.**

Operating systems, programming languages, and browsers evolved rapidly over the next 20 years, but so did the team of physicists and educators behind Open Source Physics (OSP). The OSP Collection now features more than 2,000 freely available simulations, tools, and curricular resources created by dozens of physicists and educators.

Last fall the American Physical Society awarded the 2020 Excellence in Physics Education Award to an 18-member OSP team led by Christian (the Principal Investigator) and Belloni in recognition of the team's sustained work on computational physics education.

## A TIMELY HONOR

The year 2020 turned out to be especially fitting for honoring OSP. Traffic to the website doubled in mid-March, when many in-person physics classes went online due to the COVID-19 pandemic. Use of the *Physlet Physics* resources, a key component of OSP, increased by a factor of 3 to 5 in the months following the transition.

"I will be teaching a class on waves and relativity in the fall and can't begin to imagine how I would teach it without interactive simulations," says Anne Cox, an OSP contributor and physics professor at Eckerd College. The concept of waves as a function of time and position is difficult to convey with a static image, but when students change the parameters and see the effect via simulation, "It makes all the difference," she says.

Along with ready-to-use simulations on topics from astronomy to quantum physics, the collection includes several computing tools. OSP Tracker, a popular image and video analysis package developed by physics professor Doug Brown at Cabrillo College, has over a million users worldwide. The Easy Java Simulations (EJS) authoring and modeling tool, created by math professor Francisco Esquembre at the University of Murcia in Spain, has tens of thousands of users and is behind many OSP simulations.

*Article continued on next page*

www.compadre.org/osp

## THE THIRD WAY OF DOING PHYSICS

Most of the OSP simulations are ready to run and don't require programming experience, although the source code is available under an open-source license. A subset of the collection is designed to help students dive deeper into the world of computational physics.

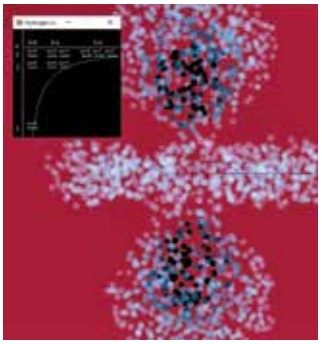
"To do physics nowadays you have to do computations," says Jan Tobochnik, a physics professor at Kalamazoo College. Thinking algorithmically, modeling problems, writing simulations, and evaluating their output are invaluable skills in physics. Simulations can't replace experiments or theory, says Harvey Gould, a physics professor at Clark University, but "They are a third way that's equally important."

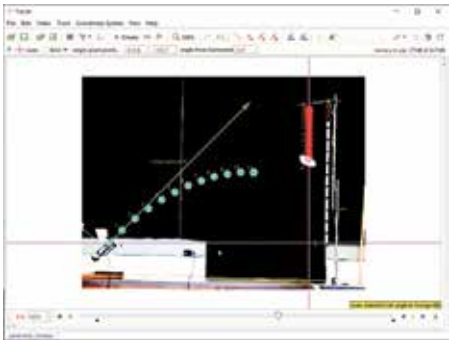
Gould and Tobochnik have collaborated on computational physics curriculum for more than 35 years. In the early 2000s, they realized their resources needed to be Java-based to stay relevant. They reached out to Christian and, before long, OSP became a natural home for their curriculum on computer simulation methods. Like all of the OSP resources, it's freely available online.

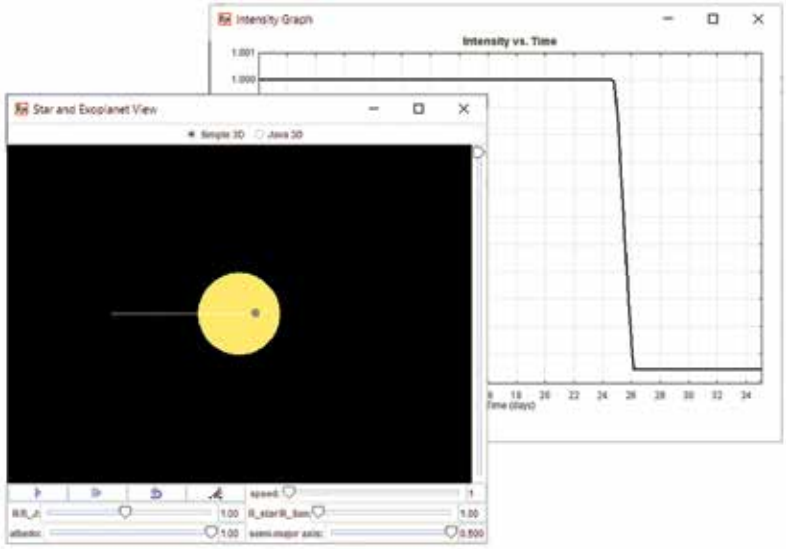
## ENGAGING THE HEAD, HANDS, AND HEART

Christian is retired from Davidson but still actively editing and developing OSP resources. He has created countless physics simulations, recreating many of them multiple times to keep up with changes in programming and browsers. By encouraging users to take and adapt what they need, Christian has enabled the collection to grow organically. He has welcomed new contributors while keeping the focus on engaging students and reducing barriers to access. And based on how he has seen the resources in use around the world, OSP is meeting a need.

Project-based computer programming involves a person's cognitive, psychomotor, and affective domains of learning, Christian explains. Put more succinctly, it involves "the head, the hands, and the heart," because students learn to think through problems by physically creating and manipulating code while working on a project they're excited about. "It's an ideal way to teach physics," he says. //








TOP LEFT: Screen capture from the simulation "3-D Hydrogen Atom Probability Densities," written by Jose Ignacio Fernández Palop.

TOP RIGHT: Screen capture from the Tracker project "Monkey with a Parachute," by students at Cabrillo College.

BOTTOM: Screen captures from the simulation "Exoplanet Detection: Transit Method," written by Mario Belloni. Images courtesy of Open Source Physics.

## GET THE DETAILS

**The OSP Collection is hosted by the AAPT ComPADRE Digital Library, a network of free online resource collections supporting faculty, students, and teachers in physics and astronomy education.**

**Browse the OSP Collection: compadre.org/osp.**

**Learn about the APS award: aps.org/programs/honors/prizes/education.cfm.**

# Bringing the Invisible to Light:
## An Artist Explores Our Hidden Universe

by Korena Di Roma Howley, Contributing Editor

**Most of what makes up our world is hidden from view, and it's these facets—the invisible light, the atoms and their building blocks, the relations between things—that inspire artist and teacher Geraldine Cox. With an eye toward nature and the physical universe, Geraldine[1] explores how patterns translate visually and echo each other in unexpected ways. The work that results may take form as a painting, a public art installation, a film, or even a class. "I'm interested in how we can express our understanding of the parts of the world that we can't directly experience," she says.**

Based at Imperial College London, where she was granted a Leverhulme Trust Artist in Residence Award in 2011, Geraldine regularly collaborates with scientists from Oxford, Durham, and other universities to craft workshops aimed at children ages 8 to 11. During the COVID-19 pandemic, the programs have moved online, and when not teaching, she paints, creates, and designs new ways of expressing and exploring knowledge from her home in west London.

Geraldine received her undergraduate degree in physics and later studied fine art with a focus on painting. Following her art degree, she returned to physics via popular science books and lectures and saw an opportunity to approach the subject from a different angle. "I thought, 'There's a real opportunity here,'" she says. "It felt like a really optimistic thing to do."

In her workshop, World of Atoms, Geraldine considers the role of the imagination in learning and creative expression. "A key factor is the imaginative and emotional involvement of the mind and sharing big ideas with children when they are at their most elastic," she says. The lessons use art projects, poetry, movement, experimentation, and discussion to explore advanced concepts in physics. A dance exercise, for instance, has each student imagine that they're an electron inside an atom, receiving and emitting light. Other activities include making collages inspired by the cutouts of Henri Matisse and mobiles influenced by Alexander Calder's hanging sculptures—projects that encourage a multilayered approach to artistic representation.

"I think of the workshops as artworks," Geraldine says. "I take the same care preparing and reviewing them as I do art." The children are finding their place in the universe, she says, and lessons often relate to what they know, such as fireworks or the aurora borealis. "I hope that there are aspects they'll always remember," she says. "They're imagining and creating impactful work that expresses what they've discovered."

In 2020, Geraldine was honored by the American Institute of Physics—the parent organization of SPS—with the annual Andrew Gemant Award recognizing individual contributions to the cultural, artistic, or humanistic dimensions of physics. The award's selection committee praised Geraldine's articulation of deep physics concepts through visual and performance art and other media, stating that she connects with "a remarkable range of people in innovative ways, and [shares] her passion for the expression of physical truths."

Reflecting on her unconventional path, Geraldine advises students to take a long perspective on their lives and points to the phenomenon of resonance. "If you follow what you're genuinely interested in," she says, "you can make contributions that are uniquely yours, because no one has been on the journey that you've been on." //

TOP: In Geraldine's short film "Resonance," a couple dancing while everyone sleeps is a suggested model for living.

BOTTOM: Geraldine Cox. Photos courtesy of Geraldine.

Notes

1. First name used by request.

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

### DISCOVER MORE

**To learn more about Geraldine's work, visit www.findingpatterns.info. To get more information and see examples of student work from the ongoing World of Atoms workshop, visit worldofatoms.com.**

# Using a Geophysics Lab to Advance the Testing and Cleaning of Face Masks

by Albert Nazeeri, Physics Undergraduate, California Institute of Technology

**For the first couple weeks of the shutdown, visiting professor Joe Kirschvink's geobiology lab was a welcome relief from Zoom meetings and catching up on papers. But there was a certain gloom when visiting campus. Almost all of the labs were shut down, and when I would check in on the Kirschvink lab, I would often be the only occupant of the GPS (Geology and Planetary Science) building. A bustling place only a few weeks ago, the GPS building now sat empty with its horde of scientific equipment unutilized.**

Prior to the COVID-19 pandemic, I had been working in Professor Kirschvink's lab, investigating how magnetotactic bacteria interact with radio waves. The project was engaging and it allowed me to hone my machining and electronics skills, but the experimental nature of the work meant that the shutdown was not kind to the project. I dragged some parts of the experiment to my apartment, but without access to Caltech's people and facilities, the pace of the project slowed considerably. In consolation for not having much work to do, Professor Kirschvink gave me the weekly task of checking in on the lab and ensuring that some of his long-term experiments were still running.

All of the now-idle lab equipment led me to consider whether any of it could be utilized for pandemic-specific research. After reading a preprint article out of a Stanford University lab on disinfecting face masks, I realized that the laser particle counter in the cleanroom could potentially be repurposed for measuring particle penetration through masks and respirators. When I shared the idea with Professor Kirschvink, he thought it was worth a shot. After a few emails, the project received division approval.

I gathered the parts I needed with a trip to the hardware store and some scavenging around the lab. After a couple weeks of tinkering and with the tele-help of Professor Kirschvink and Isaac Hilburn-the lab computer guru-I managed to build a working mask tester.

The motivation for the device was twofold: there is a clear need to test the efficiency of masks on the market, and I wanted to see if I could replicate the preliminary mask-cleaning results coming out of Stanford. I gathered a small collection of face masks and respirators through donations and by rummaging through the rock-cutting rooms of the GPS building. Using my tester, I quickly found that some of the N95-equivalent masks from China, known as KN95s, were not genuine. Through a collaboration with Huntington Hospital in Pasadena, California, I helped identify several counterfeit models in the masks they had procured.

TOP: The view inside of Nazeeri's experiment, showing a head model outfitted with an N95 mask. Photo by Albert Nazeeri.

MIDDLE LEFT: Undergraduate researcher Albert Nazeeri. Photo courtesy of Nazeeri.

MIDDLE RIGHT: Nazeeri's mask tester. Photo by Albert Nazeeri.

BOTTOM: Scanning electron microscopy image of an N95 mask. Image by Albert Nazeeri.

During this time I also tested several different cleaning methods on N95s. Previous reports stated that disinfecting N95 respirators with 70% ethanol devastates their filtration efficiency. However, through extensive drying of treated N95s via a vacuum, I was able to restore their filtration efficiency to within two percent of their initial value.

I further investigated this by varying the partial pressure of the vacuum the masks were exposed to and examining the correlation to particle penetration. These findings were replicated on two additional N95 models and a KN95 model. The results led to an ongoing collaboration with a group at Caltech led by Richard C. Flagan to build a mask tester that uses a calibrated aerosol to measure mask penetration and operates at a higher flow rate.

Meanwhile, Caltech was in the planning stages of reopening. Part of the plan included distributing reusable cloth masks to the community, but generally available cloth masks are unregulated and their efficiency can vary considerably from model to model. The facilities staff at Caltech procured many different masks, and with the assistance of fellow research assistant Kabir Mohammed, we measured tens of masks and wrote a report on our findings.

It is unfortunate that mask usage has been politicized during this pandemic, but this project highlighted the science-based benefits and limitations of commercially available cloth masks. Since they are not regulated, cloth masks are not a panacea or a silver bullet for this pandemic, but they are an important complement to the strategy of social distancing. //

**Editorial assistance provided by Samantha Creech, 2020 SPS Intern, *Physics Today*.**

# How Will HINDSIGHT Treat 2020?

by Korena Di Roma Howley, Contributing Editor

**When today's undergraduates look back on 2020, they may remember broadly the life-altering beginnings of the COVID-19 pandemic, the powerful and pivotal fight for social justice across the United States, and an unprecedented presidential campaign and election.**

But what details will surface from their personal memories? After all, big stories like these don't tell us about the students who struggled to find their place in a foreign country when colleges closed, or the ones who gathered friends and colleagues and showed up at hospitals with excess time and big ideas. They don't reveal the ingenuity of individual teachers and conference organizers or the successes and failures that followed new approaches to learning.

Like others in academia, during these extraordinary times, physics students and educators face a set of challenges unique to their field. In this issue we feature strong statements in support of the Black Lives Matter movement and the need for increased diversity, equity, inclusion, and justice in physics education. We highlight some of the ways SPS members applied their diverse skill sets to pandemic relief, and we look in on efforts to adapt to the changing academic landscape, including via virtual lab courses and a Minecraft graduation ceremony. For those in need of practical resources, we offer tips on building the resilience needed to navigate these uncharted waters and ways to sustain a healthy SPS chapter online.

When students look back on this year, and perhaps the ones to follow, maybe they'll also remember all the ways that they and their fellow physicists rose to the challenges of their time. To paraphrase one student who helped build the extensive virtual backdrop for UC Berkeley's 2020 graduation ceremony—if we can get through this, imagine what we can do in the future. //


ABOVE: The 2020–21 SPS National Council virtually kicked off the fall semester with ideas on community building and connecting with SPS chapters during these unprecedented times. Image courtesy of SPS National.

# A COVID-19 RESPONSE STORY –NEW MEXICO STYLE

by Joel Cannon, SPS Chapter President, New Mexico State University, and Juan Treto Jr., President, Society for Engineering and Physics National, New Mexico State University

**Our idea started as most do—with a problem and a question. We all understood the problem at hand, so a question was formulated: How can we use our time and skills to help during the COVID-19 pandemic?**

Juan Treto Jr. was sheltering in his home during New Mexico's first stage of quarantine in early March. His classes at New Mexico State University were temporarily cancelled until an online format could be established, and it was there that he found himself asking the aforementioned question. While searching the internet for inspiration, he came across a design for a protective intubation box called the CovidBox. During further research, he discovered that these boxes were not yet being used by medical professionals in New Mexico and wondered if his organization could manufacture the boxes and other protective equipment for hospitals. With this project, he thought, we could help healthcare workers on the front lines.

## Step 1: Recruit Volunteers

Treto, who is president of the Society for Engineering and Physics (SEPh) National, decided to initiate the first steps in bringing his idea to fruition by contacting some of his SEPh constituents for assistance.

Joel Cannon, speaker of the council for SEPh National and president of the Society of Physics Students at New Mexico State University (SPS-NMSU), answered Treto's call. Treto asked Cannon if NMSU-SPS would be interested in partnering with SEPh to make the idea a reality. Cannon's response: "Absolutely! When do we start?!"

With the partnership in place, production of a prototype CovidBox began. SEPh purchased a large acrylic sheet and, together with SPS-NMSU, cut and assembled the pieces into the first box—a small success. The group then began 3-D printing face shields, and SEPh National treasurer Elena Villasenor began sewing general-use cloth masks.

## Step 2: Fundraise

Our next success came when SPS-NMSU created a GoFundMe page to finance full-scale production of the protective equipment. Cannon contacted news outlets

LEFT: UV-C boxes for disinfection of commonly used items. Photo by Alejandro Soliz.

RIGHT: Joel Cannon, president of SPS-NMSU. Photo by Valeria Osollo.

all over New Mexico and El Paso, Texas, (just a 30-minute drive from our university) and participated in interviews. The news outlets ran the story, and our message was clearly broadcasted: "We need your help to manufacture personal protective equipment (PPE) for our hospitals and medical care workers."

The generosity of the public was put on full display when people from all walks of life donated their hard-earned money to our cause. We raised approximately $2,000, which allowed us to purchase all the materials and tools we needed. But the most challenging part of full-scale production was yet to come.

## Step 3: Full-Scale Production

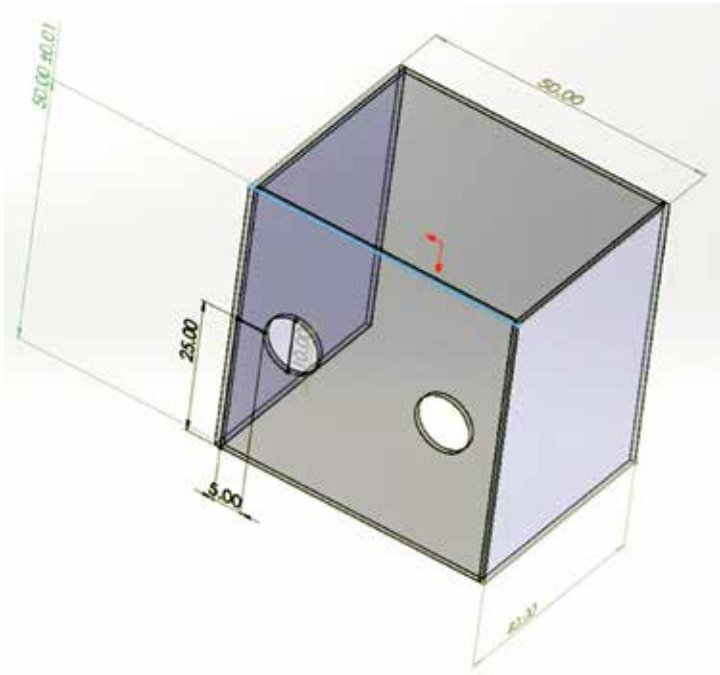
An obstacle arose. We needed to come together to perform the work required, but we needed to stay separate to prevent the spread of COVID-19. This is when Alejandro Solis, vice president of SEPh National, stepped up to the plate and volunteered to perform the labor. Solis, the project's head engineer, spearheaded the production of the boxes at home. He was stretched thin for time but nonetheless poured his efforts into constructing the boxes and other PPE.

We communicated through weekly remote video meetings and kept each other updated on our progress. We worked like a well-oiled machine, each person performing their own work and reporting their progress each week. During this time, Treto also led an effort to manufacture UV-C boxes that hospitals can use to disinfect commonly used items.

## Step 4: Carry On

After five months of production, we have donated 12 CovidBoxes (24 manufactured), 25 COVID keys, 7 UV-C boxes (12 manufactured), 150 face shields, 80 safety glasses, 200 pairs of disposable shoe booties, 84 ounces of isopropyl, 125 cloth masks, 2 face mask/shield hybrids, 25 three-ply earloop masks, and 400 swabs of alcohol strips, all to hospitals around New Mexico and El Paso. These numbers will increase with time and need.

This journey has been long and continues each day, but the work brings with it a sense of fulfillment. This project is teaching us many things, but if we had to choose one, it would be that the greatest thing about humans is that with effort and determination, we can adapt to our environment and take on the most difficult challenges on Earth. //




TOP LEFT: Juan Treto, president of SEPh National. Photo courtesy of Treto.

TOP RIGHT: Face masks sewn by Elena Villasenor, SEPh National treasurer. Photo by Alejandro Soliz.

BOTTOM: A CovidBox design by Dr. Hsien Young Lai, an anesthesiologist from Taiwan. Image courtesy of Hsien Young Lai.

FEATURE

# Berkeley Students Build an UNEXPECTED COMMUNITY, Block-by-Block

by Kendra Redmond, Editor

**In the spring of 2020, most of us were dreaming of an alternate reality featuring graduations and festivals instead of shutdowns and losses. Nick Pickett, a then-senior physics major at the University of California Berkeley, didn't just dream about it—he helped build one.**

The project started in March 2020, but the story begins almost ten years earlier. In 2011, the sandbox-style video game Minecraft was officially released by Mojang Studios. With broad appeal and endless opportunities to explore, create, and modify a virtual world with friends, Minecraft exploded in popularity. It's the top-selling video game of all time.

Many undergraduates have a special place in their hearts for Minecraft—the video game they grew up on, Pickett says. For him, playing is "borderline meditation," a relaxing reprieve from coursework. So when campus activities and social gatherings came to a screeching halt last March, it's no surprise that Minecraft was an appealing alternative to the real world.

When a friend made an offhand social media post along the lines of, "Wouldn't it be great if we could have graduation in Minecraft?" UC Berkeley student Biorn Lustic thought it sounded like a fun challenge. He reached out to a few friends from school and started a multiplayer Minecraft server. They decided to build a scale replica of Memorial Stadium, the football stadium used for graduation, and hold a mock ceremony for a few close friends.

News spread. Pickett heard about the stadium and took a virtual tour. He was a big fan, but he also noticed that a tunnel off the stadium, a behind-the-scenes area used by the marching band, wasn't quite right. He offered to fix the tunnel and became one of the project builders.

After completing the stadium, the group decided to build the practice field next door. And then, Pickett says, they just "went bananas." Why not make the whole campus and its 120 buildings? It was a tall order for a few short months. May 16 was the target date, the day that would have been graduation day at UC Berkeley, if not for the COVID-19 pandemic. "Blockeley University" was born.

A call went out, and ten volunteers turned into 100, then 300. Pickett became a building lead, keeping projects on schedule and doing quality control. Other students were builders, back-end programmers, public relations leads, and event planners preparing for a virtual graduation ceremony and a two-day music festival.

Hunter Hall, a senior astrophysics major, was friends with Lustic through rowing and involved in Blockeley from the start. The goal wasn't just to replicate campus but to do it in detail and to scale. In addition to building, Hall helped pull together campus maps, satellite maps, and school records for builders to reference.

One of Hall's specific tasks was the campus terrain. An astrophysics researcher, Hall started with high-resolution topographic data of the area collected by NASA's Shuttle Radar Topography Mission in 2000. He translated the data into a colormap of elevation and then correlated the map by pixel to Minecraft blocks. In Minecraft, each block equates to 1 $m^3$.

Building interiors—classrooms, offices, and labs—were brought to life by students intimately familiar with them. Along with fellow physics and astronomy classmates, Hall and Pickett filled the physics buildings, Le Conte Hall and Birge Hall, with nods to history and shared experiences.

Room 329 Le Conte features Hall's blocky depiction of the first cyclotron, built at Berkeley by Ernest Lawrence and his students in 1932. Avatars of J. Robert Oppenheimer and Enrico Fermi, two cyclotron pioneers, are hard at work in the room—Oppenheimer at a chalkboard that's still in room 329 today. Two infamous undergraduate lab spaces reflect more modern memories, brimming with references to inside jokes among current students and recent graduates. It's been a cathartic process for Pickett. "Especially in times like these, it's important to acknowledge memories and what we're missing out on," he says.

What started off as a casual activity quickly gained national media attention and piqued the interest of students, parents, prospective students, sponsors, musical talent, and the UC Berkeley administration. Everyone wanted to be involved. The university reached out to potential speakers. A production company, OS Studios, donated resources for a livestream. The wind ensemble put together an arrangement for the occasion, each person recording their part individually at home.

"It was definitely one of the strangest moments of my entire life," Pickett says of the unofficial graduation ceremony. He sat in his living room during the ceremony, manning two computers—one as an attendee, the other as ceremony director. His parents, logged into Minecraft accounts created just for the occasion, watched proudly on their own screens. One of the keynote speakers was Lydia Winters, a founding member of Mojang Studios.

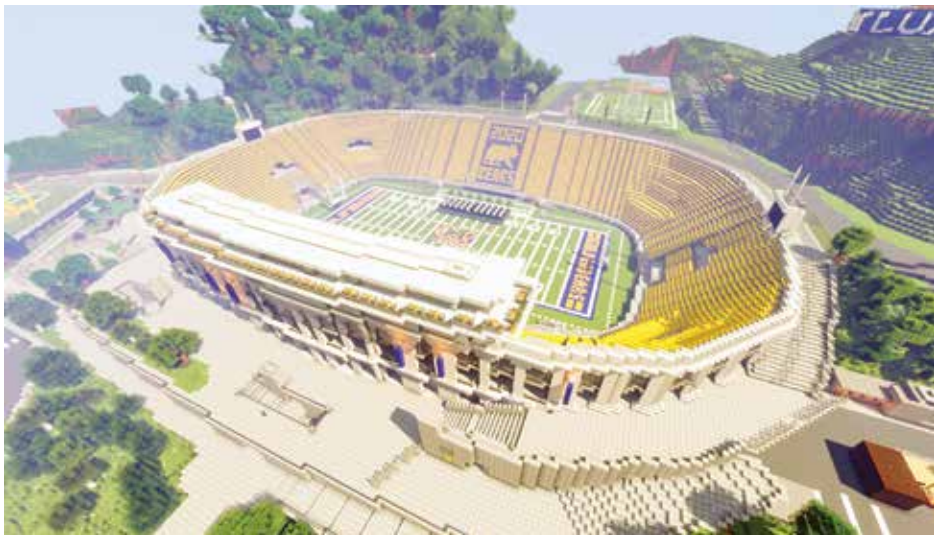
It all worked. On May 16, nearly 1,000 people attended the ceremony via the Blockeley Minecraft server and another 15,000 tuned in to the livestream. The ceremony was followed by an online celebration—a music festival featuring more than 60 acts, lasting two days.

The virtual campus is still open to visitors and still expanding. More than 300 students and alumni are active contributors, adding popular spots around campus and personal details: A Black Lives Matter protest. A van driving out to rowing practice. An inside joke in the band room. Blockeley University is a kind of time capsule. "It's a living monument of UC Berkeley and its students," Pickett says. "It's a place where we can express memory."

The Blockeley team is now working with UC Berkeley to officially archive this community-built Minecraft world. They're also partnering on a second world, replicating the campus as it appeared in 1893. The team has advised several schools interested in hosting similar events and are documenting their back-end processes to share with others.

Hall says the founders were just having fun. They had no idea their project would become a community center and a gathering place for thousands. They never expected that parents would cry watching the ceremony or that hundreds of builders would pour their hearts into creating spaces that defined their UC Berkeley experience. They didn't expect students who had never met in person to form new, lasting friendships in Minecraft. But the project took on a life of its own. Despite travel restrictions and quarantines, the community came together to build, celebrate, and process their collective experience through Blockeley University.

This whole endeavor illustrates that we now live in a time when large, collaborative, virtual communities can support one another even during a pandemic, says Hall. "This is where the internet and technology are now…If we, or anyone, can do this in Minecraft, imagine what could be in the future." //




**Visit Blockeley:**
Blockeley.com

**Server IP address:**
mc.blockeley.com

TOP: Blockeley University's Memorial Stadium. Image courtesy of Blockeley University.

ABOVE MIDDLE: Blockeley's recreation of Berkeley University's physics and astronomy complex, which includes Campbell Hall, Le Conte Hall, and Birge Hall. Image courtesy of Blockeley University.

ABOVE LEFT: Nick Pickett's Minecraft avatar celebrates graduation. Image courtesy of Nick Pickett/Blockeley University.

BOTTOM: J. Robert Oppenheimer writes on a chalkboard near a cyclotron as Enrico Fermi looks on. Image courtesy of Blockeley University.

FEATURE

# Rethinking LAB COURSES When the Labs Are Closed

by Heather J. Lewandowski, Physics Professor and Associate Chair, Department of Physics, University of Colorado Boulder, and Fellow of JILA

**As universities and colleges across the United States switched to remote instruction in March 2020, many instructors were asking questions about how to structure physics courses to support students and promote continued learning. There were questions about synchronous vs. asynchronous lectures, flexibility in deadlines for assignments, administering exams, and access to technology for students, as well as concerns about the physical and mental health of students and instructors. These important issues were relevant for all physics courses, but lab courses raised many additional questions that needed answers.**

A core component of many lab classes is students working together to design and construct an apparatus with equipment or to use an existing apparatus to take measurements. How do instructors transition these activities to a remote modality in a way that preserves at least some of the benefits of laboratory course work?

At the same time that institutions were transitioning to fully remote classes, our physics education research group at the University of Colorado Boulder wondered what solutions instructors would come up with to move their lab courses online. Over the last decade, we have conducted research on teaching and learning in physics lab classes, partnering with—and learning from—a large number of lab instructors across the United States. We were interested to see what creative strategies they would develop and the challenges they and their students would face in this new environment. We wanted to capture what was happening in lab classes across the country, from both student and instructor perspectives, with the hope of learning which strategies were particularly productive. We sought to document this unprecedented and challenging time in physics education, as well as to identify areas where we need to better support students learning experimental physics.

In order to collect and analyze this information from a large number of students and instructors involved in undergraduate physics labs, we proposed a project to the National Science Foundation's RAPID program. We were awarded a grant to collect responses to both open- and closed-form survey questions posed to students and instructors. Over 2,200 students and 106 instructors responded to the surveys. We have since followed up with in-depth interviews with some students and instructors to get a more complete picture of lab classes in Spring 2020.

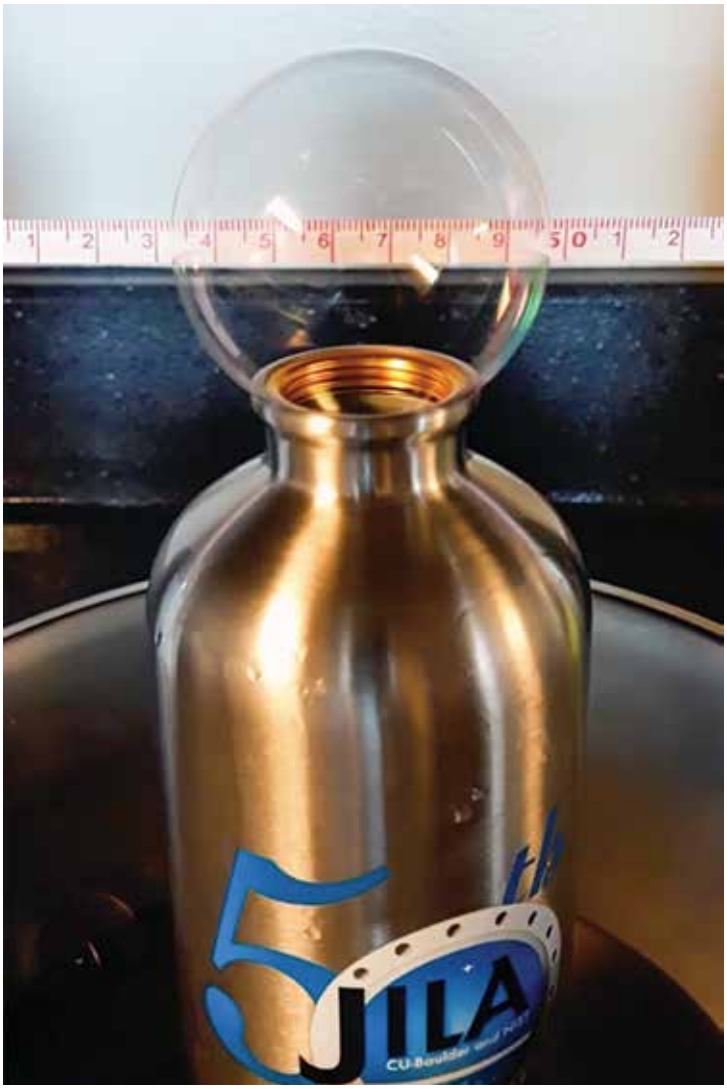
## SPRING 2020 OBSERVATIONS

There are many things we learned from an initial analysis of some of the data.[1] From the instructor perspective, some of the largest challenges involved providing students with a similar experience to the in-person lab under significant time and technological constraints. These results were not unexpected, as the switch to emergency remote teaching happened rapidly and often with insufficient access to technology. Perhaps because of these challenges and limited student access to equipment, many instructors shifted their class goals, focusing more on reinforcing physics concepts than developing lab skills. Courses also shifted more toward individual work instead of group work. There are many possible reasons for this, such as limited student access to a fast, reliable internet connection or intentional flexibility to account for the hardships students and instructors were facing.

Through the stressful process of creating a remote version of their lab courses, instructors often found themselves asking, What is the most important thing students should learn in this course? And then, How can I achieve that learning objective given the new constraints?

In one case, an instructor had always wanted to develop a more student-driven, open-inquiry version of his course. In the transition to remote labs, he was able to try out this idea, and it worked very well—so well, in fact, that he plans to continue this more open-ended version of the course even when classes return to normal in-person learning. This focus on defining learning goals and trying new ways to reach them may be one positive outcome from all of this going forward.

While, predictably, most students reported preferring in-person labs for multiple reasons (e.g., being able to work with equipment and having a group to help with the lab), there were some aspects of remote labs that students viewed positively. They noted that remote labs were generally better than in-person labs at enabling them to work at their own pace and control their learning. Perhaps the flexibility built into the remote course allowed students to have more agency in their lab learning.




ABOVE: Using household equipment, data can be collected by students at home. For example, a water bottle, some soapy water, a bowl of hot water, a tape measure, and a smartphone camera allow students to make quantitative measurements of thermodynamic quantities at the kitchen table. Photo by M. F. J. Fox.

However, just as in experimental measurements, there was a distribution of responses from students, indicating that there clearly isn't a one-size-fits-all approach.

Many other issues came up that instructors should consider going forward. For example, they shouldn't assume all students have access to smart phones, household materials, and fast, reliable internet connection. Second, when deciding on which materials or technological tools to utilize in a remote class, instructors need to consider their accessibility for students with cognitive or physical disabilities. Third, the flexibility provided by open-ended projects, if managed successfully, works well in the remote environment. Finally, synchronous, short meetings with small groups anecdotally work better to foster collaboration than longer meetings with larger groups.

## MAKING THE BEST OF YOUR LAB EXPERIENCE

As a student taking a physics lab class, there is a lot you can't control, such as the modality of the course or the types of activities you will be doing. However, there are things you can do to get the most out of the class as it is designed.

- Consider that the process of experimental physics is so much more than just working with equipment. The full experimental process includes reading the existing scientific literature, defining a research question, developing a proposal for answering the question, designing the experiment, constructing the apparatus, troubleshooting the equipment, making measurements, doing data analysis and modeling, drawing conclusions based on the data and models, making iterative improvements (including to apparatus, data taking, and models), and presenting results to peers. You may not get to take part in all of these aspects, but you may also get the opportunity to focus more deeply on some of these components than in a traditional in-person course.
- Engage in collaboration with your classmates, TAs, and instructors. Experimental physics is not a solitary endeavor. Progress in science is made by teams of people working collectively toward a common goal. Remote or physically distanced collaboration may require some different skills than working in normal times and use different tools (Zoom, Slack, etc.). However, this type of collaboration is actually very common. International research teams and people in different cities and countries collaborate remotely as a standard practice.

  Employers of STEM graduates often note one of the skills many new employees lack is the ability to work productively on interdisciplinary teams.2 Lab classes, in-person and online, offer opportunities to learn how to be a productive team member, how to play different roles on the team, how to help guide the team, and how to overcome obstacles as a group. These are invaluable skills no matter what career path you take.
- Finally, remember this is still a new, and not ideal, situation for you, your classmates, and your instructors. Some empathy for, and patience with, yourself and others will go a long way toward helping you have a productive learning experience in a physics lab course during the coming year. //

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2. Leak, A. E., Santos, Z., Reiter, E., Zwickl, B. M., and Martin, K. N. (2018). Hidden factors that influence success in the optics workforce. Phys. Rev. Phys. Educ. Res., 14(1), 010136.

# SPS Outreach ADAPTS TO MEET 2020 Challenges

Last spring's transition to virtual learning and consideration of social distancing precautions required many SPS chapters to reconsider their typical outreach efforts. Here are a few inspiring examples of how chapters took their situations in stride and adapted their plans to make a difference in their communities.


TOP: 2018 DU WISHES program field trip at NASA.

ABOVE: Screenshot of 2020 DU WISHES online summer program. There were 35 online participants using a Zoom platform for daily meetings.

BELOW: Closing ceremony for 2019 DU WISHES program. Images courtesy of DU SPS chapter.

## Summer WiSHES Takes Hands-On Learning Virtual

by Jamaya Wilson, SPS Chapter President, and Eboni Collins, SPS Chapter President-Elect, Dillard University

**During a typical year of the DU WISHES program, Dillard University's Women in STEM High School Experience in Summer program, high school students from nearby areas come to campus for an interactive, 14-day STEM experience. Geared toward Black women in 7th–12th grade, DU WISHES is run by physics professor Abdalla Darwish and is funded by an Air Force Office of Scientific Research STEM grant. SPS plays a major role, performing many of the experiments side by side with faculty.**

SPS students also promote hands-on activities to ensure that the cohort of female students from underrepresented communities have hands-on-training and learn critical-thinking techniques important for college and the workforce. We use inquiry-based activities with hands-on, minds-on training and exploration to inspire the participants.

When COVID-19 caused many of the wheels of society to stop turning and the majority of outreach programs to be cancelled, we oriented the wheel in a new direction. It wasn't an easy decision to take DU WISHES online, since the themes of the program are hands-on training, doing science, observing the wow factor, and reasoning through the results. But after a long discussion with the faculty team, a new plan was set.

We came up with experiments that can be done at home, chose an online platform (Zoom), and purchased tablets and materials for participants (whom we call scholars). We also provided free internet access as needed. The teaching team and the program director reworked the program to focus on the participant experience and safety. Despite the challenges, the program was a great success, and the participating scholars made history while staying home. //

# A New App for a New Need

by Ujwal Kumar, SPS Chapter President, George Washington University

**The world as it stands in 2020 differs drastically from what we have been familiar with for most of our lives. The COVID-19 pandemic affected nearly all facets of our lives, but we are learning to work with it and past it.**

The George Washington University (GW) SPS chapter typically conducts outreach events through our Life Pieces to Masterpieces program, in which we conduct science experiments, lessons, and activities with a nearby elementary school in Washington, DC. However, due to the pandemic, we had to suspend our outreach activities. Instead, we turned our attention to how we could help the world around us in a new way.

Members of GW SPS and GW's Innovation Lab club brainstormed ideas such as 3D printing personal protective equipment (which was soon done by our Innovation Lab club lead, Sylvain Guiriec) and creating an interface that allowed users to share symptoms with COVID testing sites before arrival.

We chose to focus our efforts on developing a COVID-19 testing site app that enabled users to find the nearest testing sites and drive times. Our outreach chair, Addy Irankunda, led development of the app and spoke to healthcare workers in DC to find out how to help ease the stress on hospitals and healthcare workers. Addy heard that patients typically flood one particular testing site, so we added a wait time feature to our app to alleviate overcrowding at any one testing site.

By way of Zoom calls, we discussed features the app needed, how the user interface should look, and more. Addy coded the app and, by the end, we had a fully developed UI app that was ready for launch to the Apple Store. Our SPS treasurer, Caden Gobat, coded the app for other application stores.

During the initial phase of quarantine, we quickly realized how many of the planned SPS activities could no longer take place. Our goal was to help the society around us during a rather unpredictable and unprecedented time. While this new activity was in line with SPS values, it fell most in line with our personal ethics, and as SPS students, we are proud to have worked together on this useful tool. //

# School Supply Drive Goes Virtual

by Shannon Brindle, Margaret Gregory, William H. Mills, and Drake Richmond, SPS Members, University of Mary Washington

**In March 2020, a member of UMW's SPS and OSA chapters started a school supplies drive in which donations of supplies were solicited to benefit an underserved elementary school in Galax, Virginia.**

Galax, Virginia, is a hardworking town that has been severely affected by COVID-19; the pandemic has not just threatened the health of its citizens, but unemployment in Galax peaked at 17% during April, compared to 10% unemployment for the entire state during the same period. Inspired by Christmas gift drives hosted by her church in the past, SPS member and president of our Optical Society chapter, Shannon Brindle, decided to hold a school supplies drive to support an elementary school in need. Raised in a small town herself, Brindle has a special place in her heart for families in blue collar communities. Upon investigating Title I schools in Virginia, she reached out to a school in Galax. Serendipitously, she learned the school was preparing to seek donations from their local community.

Brindle's plans were already in the works before the COVID-19 pandemic. Following the outbreak, the traditional tabling component of the drive was cancelled and the operations were shifted to an entirely virtual platform. SPS has been actively marketing the drive online, promoting it to the community and on social media, and setting up an Amazon Wish List for direct supply purchases.

Now, more than ever, outreach efforts from the STEM community can make an impact on already underserved areas. The need for help is greater, as each child needs their own set of supplies—sharing classroom materials poses increased health risks. The need never truly goes away, the drive has no official end, but we are pushing for the bulk of donations to be made prior to the start of the school year. //


ABOVE: University of Mary Washington SPS members at a fundraiser.

LEFT: Current and past members of The George Washington University SPS chapter with SPS Director Brad Conrad. Photos courtesy of SPS National.

FEATURE


by Brittney Hauke, Penn State University, Deval Mehta, Columbia University, and Mikayla Cleaver, SPS Programs Coordinator

**On June 1, 2020, the parent organization of SPS, the American Institute of Physics (AIP), released the following statement in solidarity with those protesting against systemic injustices endemic to our nation, not the least of which stem from racial and ethnic biases.**

## AIP Statement on Racism and Protests

> The American Institute of Physics (AIP) stands in solidarity with the victims of police brutality, their families, and those who are protesting racism in the wake of the brutal killings of George Floyd, Breonna Taylor, Ahmaud Arbery, and countless others. AIP also acknowledges that these events are additional examples of a larger system of social, economic, and academic injustice that marginalizes and dehumanizes our fellow citizens.
>
> As we, the AIP leadership and staff, witness the pain, anger, and unrest across the country, we are determined to channel our shared feelings of outrage and grief toward a renewed commitment to elevate the voices of those silenced in our community and do our part in calling out and addressing the inequities experienced by African Americans in the physical sciences.
>
> At AIP, we will continue to do our best to expose and address injustice and discrimination within our society and the physical sciences community.

## SPS echoes this statement. On June 5, 2020, the Society of Physics Students released the following statement:

> The SPS National Office echoes the AIP Statement on Racism and Protests: We support our Black students, stand with those who are victims of police brutality and racism, and support those who are protesting for change. As a professional association of students, we collectively have a duty to call out injustice when we see it and be active elements of change. To the Black students of our community, we see you, we are here for you, we will listen to you, and we stand with you. Only together can we end racism in our classrooms, institutions, and community, and we commit to work toward this end.

Some of our colleagues may question why we, as physicists, should directly address issues many consider to be in the realm of politics. After all, they might argue, science is impartial and nonpolitical—it does not care for our feelings. Indeed, science governs the world without regard for our emotions, but our quest to observe and understand its workings are certainly influenced by our actions and emotions both today and throughout history and by our humanity.

The pursuit of science, by its very nature, relies on a diversity of thought as a means of generating novel ideas in research, and we would be remiss to assume that such diversity arises only as a facet of something like genius. Our experiences contribute to our ideas as well; thus science progresses further and faster through the inclusion of people from varying circumstances and backgrounds. But even this scientific argument shouldn't be our driving factor.

In "How Long Should We Wait," an open letter from Fermilab physicist Brian Nord to his colleagues, Nord asks,

> *Why is innovation the motivation to support diversity and inclusion? Is this the principle that the astronomy community wants to "uphold?" Why isn't my humanity enough? Why isn't my existence as the sole Black American male Principal Investigator in my major astronomical collaborations (that I know of) enough to motivate you to welcome more Black people? Where are the Black women and nonbinary people who have had to be educated and come of age under the conditions of Black life in America?*
>
> *Why is productivity the motivation for supporting diversity or for maintaining a high-quality work environment? Why isn't our humanity enough?*

## THE TIME IS NOW: RESULTS OF THE TEAM-UP PROJECT

In January of 2020, the AIP National Task Force to Elevate African American Representation in Undergraduate Physics & Astronomy (TEAM-UP) released a report on a two-year study investigating the reasons for the persistent underrepresentation of African Americans in physics. The task force team of physicists, astronomers, and social scientists, many of whom are Black, conducted student surveys, department-chair surveys, and interviews with African American students, and made site visits to five high-performing physics departments.

The researchers identified two primary causes for underrepresentation: "the lack of a supportive environment for these students in many departments" and "the enormous financial challenges facing them and the programs that have consistently demonstrated the best practices in supporting their success."

As the report highlights, African American physics students face multiple systemic barriers in their academic pursuits and otherwise. The TEAM-UP report outlines a number of research findings and as many specific recommendations for how the physics and astronomy community can address the ways in which we have failed Black physics students. We encourage all SPS students, advisors, and physics departments to read TEAM-UP and begin implementing their recommendations.

The recent wave of protests, though triggered by the killing of George Floyd at the hands of those who were meant to protect him, are at their core a response to this widespread inequality stemming from historical injustices and systemic biases. We must realize the role that scientists and academia have played in the propagation of such injustice and undo the damage that our community has done, starting with implementing the recommendations outlined in the TEAM-UP report, assessing their outcomes, and taking further steps to break down the barriers that have hindered our fellow human beings.

**TEAM-UP Report and Recommendations**
aip.org/diversity-initiatives/team-up-task-force


LEFT: Cover of the TEAM-UP report.

Image courtesy of AIP.

## SPS CHAPTERS AT WORK

To enact any real change we must both act and reflect on those actions, and we are proud to say that many SPS chapters around the country are working toward fostering a more inclusive physics community. A few have also issued public statements in light of recent events.

The University of North Carolina at Chapel Hill SPS chapter released a statement on June 8, 2020, in the wake of protests following George Floyd's killing. In the statement they outline their support for the Black Lives Matter movement, list planned actions for the coming semesters, and provide resources about the movement to their members. They write,

> " Our goal as members of this community is to educate ourselves to become effective allies and extend this education to our peers. Some actions that we all can take to create a more inclusive environment are recognizing our implicit biases and privilege, fostering a safe environment within the SPS/ViP room, calling out injustices, and being open to the tough conversations that are needed to enact change. . . . The only way to address racial injustice is to actively recognize systemic racism and work to dismantle it. We can create this change by having tough conversations, voting, signing petitions, donating, and more."

The SPS chapter at the University of Rochester in New York released a statement emphasizing their "goal of increasing diversity in physics" and developing "a more welcoming and encouraging community for [B]lack students." The chapter plans to move their outreach events to Rochester City schools, where the students are majority Black, rather than requiring that students come to campus; this eliminates the potential barrier of transportation. Additionally, they plan to discuss the lack of diversity among students in the physics major with department leadership and work on making the physics community at their school more inclusive. Lastly, SPS at the University of Rochester states that they " . . . recognize and embrace the fact that Black Lives Matter and similar campaigns constitute a fundamentally [B]lack led movement. Accordingly, we would like to collaborate with the [B]lack student organizations on campus."

ABOVE: University of North Carolina at Chapel Hill group picture from the 2019 Southeastern Section APS conference. Photo courtesy of the University of North Carolina at Chapel Hill SPS chapter.

These SPS chapters and others are helping to create lasting change in the physics community.

## MOVING FORWARD

We would also like to feature the National Society of Black Physicists (NSBP), an organization that promotes the "professional well-being of African American physicists and physics students within the international scientific community and within society at large." They have many opportunities for students and professionals alike, offering a variety of scholarships, internships, conferences, and seminars. We encourage you to donate to the organization, purchase their merchandise, or collaborate with your local chapter to show support.

The fight against inequality does not end at the protests, nor in legislative houses. Systemic injustice will persist unless we are all actively standing against it. As such, we must all continue to educate ourselves on these issues, understand the impact that we have made and will continue to make, and amplify voices within the Black community. We encourage all SPS chapters to use the resources from this article as a starting point for your own actions moving forward. As physicists we excel at learning and changing course, so let's get to work. //

**National Society for Black Physicists**
nsbp.org

**Shut Down STEM**
shutdownstem.com

**Particles for Justice**
particlesforjustice.org

**Black Lives Matter, Ways You Can Help**
blacklivesmatters.carrd.co

**AIP Statement on Racism and Protests**
publishing.aip.org/about/news/aip-statement-on-racism-and-protests

**SPS and ΣΠΣ Statement on Diversity, Inclusion, Ethics, and Responsibility**
spsnational.org/about/governance/statements

# University of Rochester SPS Chapter RESPONDS TO BLACK LIVES MATTER: How We Need to Change

by Molly Griston, SPS Chapter President, and Amanda Wasserman, Former SPS Chapter President, University of Rochester


LEFT: SPS members at the University of Rochester chapter's annual Spooky Science Day outreach event in 2019. Photo by Benjamin Nussbaum.

**The recent surge in antiracism protests and demonstrations prompted us to examine the impact of race in the physics community. We felt it was necessary to release a statement in firm support of these demonstrations and, more specifically, to emphasize the concrete changes our club can make to create a more welcoming environment for Black and Indigenous students. It's easy to stand in solidarity, but we cannot expect any progress if we don't recognize our own problems and fix them. We are working closely with our department to hold each other accountable and ensure that constructive discussions are continued and changes are actually implemented.**

Our chapter is adjusting our outreach focus by going to Rochester City schools, where the classes are majority Black students, rather than planning outreach events that bring students to us. We recognize that our previous methods of outreach have helped to reinforce systemic disadvantages faced by underprivileged students while favoring students with the time and ability to travel to campus. We planned past outreach programs based on convenience, and we intend to change our emphasis. While social distancing restrictions will make planning outreach events challenging this year, we are looking into virtual outreach events and will not let these obstacles deter our efforts.

We recognize and embrace the fact that Black Lives Matter and similar campaigns constitute a fundamentally Black-led movement. Accordingly, we would like to collaborate with the Black student organizations on campus. We have begun educating our own members by sending them specific resources, and we also plan to hold more events that are dedicated to discussing diversity and representation in physics. Obviously, we cannot place the burden to educate us on the Black community, but we also cannot pretend to make an environment more welcoming for Black students without taking the time to not only hear these students but to also amplify their voices in the physics community.

In addition to the aforementioned items that our chapter will be focusing on, we have also been involved in discussions led by graduate students about changes at the department level. The discussion topics have included hiring, admissions, mentoring, the APS Bridge Program, climate and retention surveys, colloquia speakers, journal groups, and more. We are especially proud of and encouraged by the fact that these discussions have already had positive impacts, such as the assignment of a Bridge Program faculty advisor, and that an infrastructure has been created to ensure that these discussions are ongoing. Additionally, the department has created significant documentation—including a list of short-, medium-, and long-term goals—and we are in the process of defining methods to evaluate whether these goals have been met.

We are excited about the trajectory of change that our chapter of SPS and our department have been moving toward, but we also know that this is only a first step. We recognize the hurt and discomfort felt by students of color in our department, as well as in the physics community as a whole, and realize it is past time to rectify this. //

SPECIAL FEATURE

# Five Tips for Building Resilience during the Pandemic

by Ann Marie Roepke, PhD

**Ann Marie Roepke, PhD, is a clinical psychologist and organizational consultant at Evoke Training and Consulting, PLLC. She hosts the podcast *Psychological Resilience in the Time of Coronavirus*.**

For many of us, these are hard times. The outbreak of COVID-19 has impacted daily life in profound ways. Simultaneously, we're grappling with issues of long-standing systemic racism and facing an economic recession. These circumstances can breed uncertainty and lack of control—setting us up for fear, stress, and depression. Given all this, it may be quite normal to feel not normal.

More than ever, we need the skills and the relationships that help us to be resilient: to make it through challenging times with the least suffering and the greatest well-being possible. Here are five tips that may help you boost your own resilience:

**1. Find and follow your values.** What matters most to you? When we clarify and connect with our values, we can use them like true north on a compass to point our way through the storm. Whether we care about social justice, professional development, showing love for our family and friends, spiritual growth, or something else, our values are a powerful resource for guiding our actions during tough times.

**2. Be kind to yourself.** We often talk to ourselves in a harsh, critical, judgmental way—a way that we would never talk to our loved ones. Notice when you're doing this and ask, "How would I talk to a close friend or a scared child?" Tap into that compassion for yourself.

**3. Take back control.** When so many things are out of our control, it can be helpful to identify parts of our life where we have more influence. Write out two lists: things I cannot control and things I can influence. Then take action on the latter!

ABOVE: Ann Marie Roepke. Photo courtesy of Ali Heller.

**4. Do boring self-care.** Taking care of ourselves isn't always about treating ourselves; it's also about the mundane tasks of sleeping enough, moving our bodies, eating well, and giving ourselves a daily routine (which can restore a sense of normalcy).

**5. Connect (creatively).** We need other people. When in-person hangouts are unsafe and you're getting "Zoom fatigue," find creative ways to connect, whether via phone, text, email, gaming, or something else. Aim to make this connection active, rather than passively scrolling through social media (which can make some of us feel worse rather than better).

Coping flexibility might be more important than any single coping tool. It's about having the right tool for the right job, not about getting really good at always using a hammer. Think of resilience-building as an experimental endeavor; try manipulating different variables (like the ones above) and informally gather data on what works for you. Use that data for new hypotheses and new experimental tests about how to boost your own resilience and well-being. //

**This article is offered for informational purposes only and is not intended as medical advice.**
**If you have questions about what's right for you, check with your healthcare provider.**

# How to Virtually Maintain a Healthy SPS Chapter

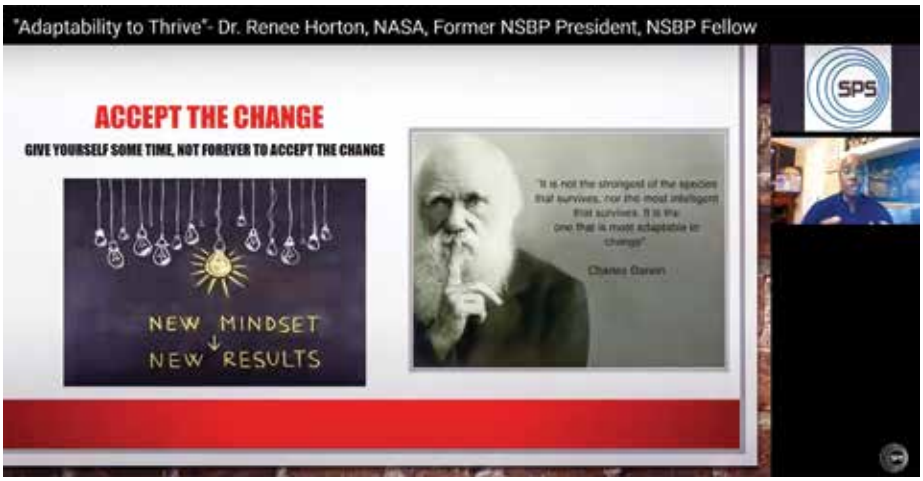
by Anthony Kuchera, Molly McDonough, and Nicole Gugliucci, SPS National Council

**SPS chapters face many of the same challenges that make classes, work, and socializing difficult in every other facet of life during the coronavirus pandemic. How can you build community when you're not allowed within six feet of each other? What do you do if your membership is scattered geographically? How can you support each other through this incredibly unusual time?**

The lack of face-to-face interaction and reduced opportunities to gather are significant challenges that require a new way of thinking about getting together. In addition, the switch to virtual meetings has left many of us with computer-screen and Zoom fatigue. All of this can lead to a lack of motivation to plan yet more virtual events.

Further disconnecting ourselves, however, isn't likely to make our situations any better. Scientists thrive on collaboration, and the mutual support networks built through SPS can help. See suggestions below:

- ***Asynchronous communication*** through a platform such as GroupMe, Signal, or Discord allows your members to interact whenever they want and still feel part of the community. In fact, SPS National has a Discord server for all members with a range of topics in physics and a rather active "meme" channel (to join, please visit https://discord.gg/Az3RMKZ). Chapters can also make space for a voice channel or video conference room to serve as an SPS "lounge" where members can collaborate on problem sets or just chat.
- ***Rethink professional development opportunities*** by hosting an online poster session, or start a journal club where members suggest papers to read each week and discuss as a group. Host a speaker that you'd never be able to get in person! One advantage of virtual meetings is that they erase the distance between us. Invite an alum from your chapter, a colleague, or a member of the Alumni Engagement Program to give a colloquium talk via videoconferencing; they can make it just as easily from another state or across the country. You can also get together with your chapter and watch the virtual colloquium talks hosted by SPS National. Don't forget that you can also hold your Sigma Pi Sigma inductions virtually! The National Office has resources for online inductions available at sigmapisigma.org/sigmapisigma/virtual_inductions and is always happy to help.
- ***Social events*** have already helped some chapters stay connected. Have an online game night with a sharing platform such as skribbl.io, or host a virtual movie night so members can watch a film together using a separate text chat for discussion. In addition to the usual streaming platforms, chapters can find old science fiction classics for free on YouTube. If you're missing astronomy outreach, join a virtual star party, such as those hosted by the McDonald Observatory or Universe Today, that feature live telescope views.
- It's most important to ***remember that this pandemic is affecting everyone differently***. Not everyone will have the mental bandwidth for more virtual meetings, and that's okay. Consider setting aside at least an hour each day for doing an activity away from the computer—exercise, yoga, reading, art—anything to reduce screen fatigue. Now more than ever, mental health and self-care are incredibly important.




ABOVE: Dr. Renee Horton, NASA, former president of the National Society of Black Physicists (NSBP) and NSBP fellow, gives a virtual colloquium to the SPS community discussing the "Adaptability to Thrive." Image courtesy of SPS National.

It's easy to feel isolated, but your SPS chapter and SPS National are here for you! Be patient with yourself and the people around you. You might not be as productive as you usually are or as you'd like to be, and that's to be expected. Anxiety may be high, and that's okay. Remember, physicists are people first! So take care, and keep in touch. //

# Savannah Thais

BA, Physics and Mathematics, University of Chicago

## What she does

I'm a postdoc at Princeton University, where I primarily work on physics-informed machine learning (ML). Right now I'm developing accelerated ML-based reconstruction algorithms for the High-Luminosity Large Hadron Collider (LHC). I'm really interested in understanding the underlying scientific theory of machine learning, why certain algorithms work best for certain problems, and how the constraints of physical systems can help us answer these questions. I also work on some AI for social good projects, right now focusing on public health advocacy in at-risk communities.

## How she got there

I received my undergraduate degree in math and physics at the University of Chicago and always dreamed of working at the LHC. I got my first research position there working for Young-Kee Kim, chair of the physics department at UChicago, who was a huge inspiration for me; she does incredible work in experimental particle physics and accelerator physics and is indefatigable.

I kind of stumbled into ML during my PhD at Yale, and it became my passion. I enjoyed my "service task" for the ATLAS experiment—building an electron identification algorithm—much more than my physics analysis work and realized that that was the area I wanted to focus on. My two advisors during grad school, Keith Baker and Sarah Demers, were instrumental in my success. They supported my ideas and helped me become a researcher I was proud of. I also am incredibly grateful to my dear friend and "academic big sister," Michela Paganini, who went out of her way to include me in ML discussions and introduce me to key players. As I got more involved in the ML space, I started to see more how this technology can be misused and can actually harm communities, and that became an additional focus of my work and advocacy. Generally, I'm inspired by folks who are motivated by good science *and* societal good.

## Responding to the COVID-19 pandemic

We started Science Responds quite early in the pandemic. I had already been following a few researchers who were talking about ways to use data science to encourage good public health practices, support communities, and better understand the pandemic. My boss, Peter Elmer, reached out to me and some of our colleagues to see if we'd be interested in forming a collaboration to enable scientific researchers to best use their technical skills to combat the pandemic, and Science Responds was born. Within Science Responds I have primarily focused on data science and ML projects. We provide a central hub where interested volunteers can find projects to join and resources to support existing projects. We've also hosted various meetings and discussions to share best practices for reopening labs, hosting virtual conferences, collaborating remotely, and more. Through Science Responds I started COVID Community Vulnerability Index, which provides governments and nonprofits with a science-backed, multi-axis, quantitative community-needs assessment tool that incorporates COVID-specific information and effects. I have a great team working on this project now, and we're beginning to develop direct partnerships with national nonprofits and other research organizations.

## The importance of science education and outreach

Science and technology affect nearly every aspect of our daily lives, and I believe we have a duty as scientists to ensure everyone is able to make informed decisions about these issues. Science education and outreach is a form of empowerment and something we should all invest in. Additionally, education and outreach help make science accessible; allowing folks to see themselves as scientists and become invested in the process fosters diversity and vibrancy in science!

## Advice to physics students

My advice is to take every opportunity you can and pursue your passions! There is so much more to being a good scientist, and especially a good science educator, than laboratory or data skills (although these things are very important as well!). Don't limit yourself or let others dictate what is useful for you to spend your time on. Some of the experiences that have served me best in my career so far have come from being active in student government, my college sorority, and other program management opportunities. Most importantly, if you want to do effective education and outreach, you must invest in and understand the communities you're trying to serve.

I hope we as a field keep redefining what it means to be a scientist. We have to support diversity and inclusion efforts across all axes: gender, race, disability, mental health, origins, etc. Doing good in the world and doing good science don't have to be incompatible goals. //

## GET INVOLVED

**Science Responds is an evolving community of scientists exploring ways to contribute to the COVID-19 response through physics-related applications, data analytics, machine learning, simulation, software, computing, and hardware development. The group is also examining how research activities can be adapted during the pandemic and developing ideas for new approaches based on lessons learned. The website (science-responds.org/) provides a collection of useful resources—including datasets, articles, and papers—plus a database of existing projects. Anyone can request the addition of a project via the email link on the home page.**

**To get involved in the conversation, join the Science Responds discussion on Slack (link on the home page, under "Join Us"). You can contribute resources directly to the website via GitHub. Instructions and a list of specific resources requested (such as project ideas, links, and primers) are available here: science-responds.org/about/contribute/.**

# E-Lexus Thornton

BS, Physics, Indiana University South Bend

## What he does

As a sixth-grade math teacher in South Bend, Indiana, E-Lexus Thornton taught students about ratios, equations, and how to find the area of a polygon. But that's not all. "I taught them stuff they wanted to learn," he explains. "How to save money, what bills were, what credit was, their history." His lessons often included five-minute sessions on cultural topics relevant to the Latino and Black students who composed his classes.

"When I started [in the fall of 2019], I was told that it was going to be hard," he explains. "Some kids were coming into middle school without knowing how to add and multiply, without knowing how to read well or even write their name." Thornton sought all the advice he could and eventually found his stride, talking to kids about football, video games, and musicians—anything to keep them engaged.

The first year of teaching can be rough under normal circumstances, but 2020 brought extraordinary challenges. In March, the COVID-19 pandemic closed school buildings across the United States and forced teachers to take their classes online. Then, in May, racial tensions escalated dramatically when George Floyd, a Black man, was killed by a White Minneapolis police officer who is currently being charged with second-degree murder. As a teacher and an activist in the South Bend chapter of Black Lives Matter, Thornton was in the middle of it all.

## How he got into physics

Thornton didn't set out to become a physics major, math teacher, or activist, roles that now define him. Inspired by science fiction, his plan was to become an engineer and work in the space industry. But the summer before he was supposed to start college, reality hit. Having received no guidance on navigating financial aid or scholarships, tuition for the school he planned to attend was simply out of reach.

With September approaching, Thornton started calling schools. Indiana University South Bend was affordable, nearby, and still accepting applications. They didn't have an engineering bachelor's program, so he went with physics. Once he got past the introductory courses, he was hooked. "I was doing computations all night," he recalls. "That's really where the love [of physics and math] began."

## Navigating a double life

Around the same time, Thornton met Jordon Giger, a local activist and eventual mentor. The two became early members of Black Lives Matter South Bend, which Giger now leads. From this platform they brought local and national attention to injustices in education, home ownership, economics, and policing.

During his senior year, Thornton was president of the Black Student Union and treasurer of SPS while juggling upper-level physics coursework and activism—giving speeches, attending community events, organizing marches, and challenging norms in South Bend. The demands were high. He was exhausted. His grades were suffering. But Thornton says the activism was non-negotiable. He couldn't ignore the racism, injustice, and brutality being experienced by the Black community. "It got to a point where I was like, 'I gotta do something because nobody else is.'"

After graduating, Thornton received an unexpected job offer to teach sixth-grade math from an activist colleague and middle school principal with whom he had worked to address the city's school-to-prison pipeline. He enjoyed teaching and had planned to continue, but instead followed another bend in the road. This fall, Thornton started a PhD program in mechanical engineering at the University of Kentucky, aiming directly for that career in aerospace engineering.

## Advice to physics students

To physics students, Thornton offers these words: Network. Develop skills. Ask for help. Stay vigilant. Stay consistent. Work hard. Take an ethics course on another culture. And stay current. Know what's going on, know how people are feeling right now. //

TOP: E-Lexus Thornton as a first-year graduate student at the University of Kentucky. Photo courtesy of Thornton.

MIDDLE: Thornton speaks at a vigil for Eric Logan, a Black man who was fatally shot by a White South Bend police officer on June 16, 2019. A special prosecutor determined the shooting was justified, but activists cite many problematic discrepancies in that narrative. The incident increased already-high racial tensions in the city, especially between Black residents and the police. Photo courtesy of Thornton.

BOTTOM: Thornton presents his undergraduate physics research at the Conference Experience for Undergrads (CEU) in 2017. Photo courtesy of S. R. Lesher, uwlax.edu/ceu/.

# Words of Advice on Applying to Physics PhD Programs

Q&A with Professor Robert Riehn, Associate Director of Graduate Programs, Department of Physics, North Carolina State University

ABOVE: Robert Riehn. Photo courtesy of Riehn.

*Responses have been edited for length and clarity.*

## HOW DO YOU WRITE A GOOD ESSAY OR COVER LETTER?

The biggest recommendation I give students is to show us (the graduate committee) your strengths through a narrative. Many students have a wide variety of strengths, and it is hard to provide such a diverse group with a prompt that effectively encompasses this range of strengths.

Good letters provide a compelling narrative and highlight the applicant in a unique way. Students have diverse interests when applying to graduate school, and so you have to explain to us why you believe you will be a good researcher and why you are well suited for a challenging program. Many students provide a narrative of how they decided to go to graduate school. If you do this, know that we are looking for the ability to present this as a path with reasoned steps.

The strongest essays prove that the applicant is a suitable student, a good researcher, and that our school is a good fit for them. It's important to state why you're interested in our institution and relate your interests to our program. From the cover letter we can also judge how well you write, which is very important to us since writing is a large part of completing a PhD.

## IF STUDENTS HAVE DONE RESEARCH, SHOULD THEY DISCUSS THAT?

Research is a very important part of being a graduate student. If a student has a research background, we look for an explanation of that research, the findings, and the student's contribution to the field of research. We expect that all strong applicants identify who they would want to work with within the program, why they want to work with those specific groups, and why they believe they are specifically suited to that work. Make sure that your letter has this piece and that it fits into the broader narrative. Additionally, if you have overcome significant hurdles in your life, provide a description of how you approached and overcame these hurdles. How people overcome hurdles tells the committee a lot about how they will address challenges as a researcher.

## HOW DOES A STUDENT STAND OUT AS AN APPLICANT?

Achievements. Students often lower the impact of their application by writing about things they did but not identifying why their contribution to the field is unique and why their work is significant. When you write your story, your narrative, in terms of achievements and with context, that is the strongest indication that you can write and that you are aware of where you stand in the world.

## WHAT'S CHANGED FROM LAST YEAR TO THIS YEAR, IN A PANDEMIC RESEARCH WORLD?

I am speculating, as we are beginning the process now, but there is increased uncertainty in the level of preparation. When a committee examines applications, they are looking at two different things:

1) Proven successes – Using completed courses and research experience, the committee looks to see if the student will be able to complete the class work, join a research group, and complete the work required to graduate.

2) Potential to excel – Using the student's research experience, time management skills, resilience, and demonstrated planning skills, we try to judge whether someone will succeed in research and make outstanding contributions to their field. There are many things that go into being a researcher, and the committee will look for students who put their heart into a project or an activity that mattered to them. Many of the best graduate students didn't have access to the best academic resources as undergraduates. We seek to identify such applicants and give them the opportunity to develop their full potential.

Because of the uncertainty in how courses were conducted this spring, the grades of applicants will be harder to interpret. This means that committees will have to look at other measures of students' potential for graduate study. I am afraid that some schools may weigh the reputation of the undergraduate institution or their experience with previous students from that school more heavily. We will look for students that will put their hearts into their programs and who have excelled given the current environment. At the end of the day, we want students who are self-motivated, have a passion for their research, and will succeed in the program—even if their last semesters were challenging because of the pandemic.

## IN THEIR APPLICATIONS, HOW CAN STUDENTS ADDRESS THEIR ACADEMIC PREPARATION DURING THE PANDEMIC?

If asked, I recommend that you briefly explain how courses were conducted in the spring and fall of 2020. Was the transition smooth or rough? Where you can, highlight achievements that continued through the spring and beyond. Students can also comment on how

they transitioned to computational or more theoretical work over the past year, if applicable. Explaining how the pandemic shaped choices in research direction and opportunities may be important when you discuss your target research area, since many students that wanted to do experimental research were forced to change their short-term plans when labs closed. If you were involved in other activities and leadership opportunities, we want to know about that too.

### HOW MANY LABS SHOULD A STUDENT MENTION THEY WANT TO WORK WITH IN THEIR APPLICATION?

I suggest mentioning three people. Research groups are often 3–5 students per faculty member, but in many fields there are multiple professors and researchers working on overlapping projects. It's totally possible that a specific group does not have space for you in a given year but that there is space in a different group in the field that collaborates with your first choice. If you identify three faculty members, you usually can find a research home, even if it is not with the one person you identified first in your application. Interestingly, about 50% of students decide to join a PhD adviser they didn't foresee working with when they started the program. This typically happens when students arrive on campus, take classes, and discover a new field of research that lights a fire for them. I recommend listing not too many potential advisers, and if you can't decide on who to list, it's best to be honest about it. Authenticity is an important aspect of an application—write what you mean.

### WHAT IF A STUDENT IS HESITANT TO APPLY BECAUSE THEY CAN'T VISIT THE SCHOOL IN PERSON?

Apply! We waive the application fee for domestic students so that there is no financial barrier, and I believe there is a growing number of departments that take the same path. Without a fee, an application is only a few extra hours of effort. Learn as much as you can online, and see if the research at that school excites you. In your essay, be as specific as you can about your interests and why the school is a good fit for you. If a school is interested in your application, they will give you all the information that you request to convince you to join them.

### IS THERE ANY ADVICE YOU THINK ALL STUDENTS SHOULD HAVE?

Contact the graduate program if you have any questions at all. If you are not clear on something—required grades, tests, or groups you could work with—contact the program. If you don't have all of the required preparation, some schools will work with you on a way of completing the coursework necessary to succeed. If you have a transcript from a well-known school, admissions staff will be able to judge your transcript easily. If your transcript is from a less well-known school, ask the graduate program if there is anything that they are interested in seeing, such as a textbook list or syllabi. If you are a mathematician or a computer scientist or an engineer and you discovered your passion for physics late, departments can still work with you. If you are worried about your application, ask the program what they would like to know about you. Programs want applications that help them understand you at a deep level.

Many professors are willing to start a conversation with you before applying. They may be able to tell you the kinds of skills that they are currently looking for and whether you may be a good match. You could find a research adviser even before joining the graduate program. Be sure you do your homework before writing that first email—the more you know, the better your email, the more likely you are to engage the professor in a conversation. //



# How to Make the Most of a Virtual Physics Conference

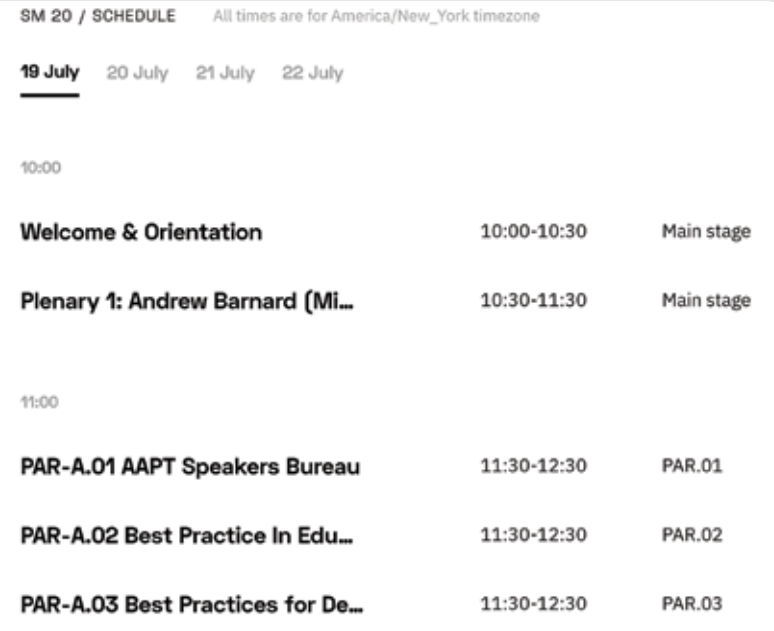
by Ben Petkie, 2020 SPS Intern, American Association of Physics Teachers

**I am nervous. With only a few minutes left until my presentation begins, my mind is racing about how well I'll be able to present online. And then… my Wi-Fi dies. I can't present, let alone be nervous about it!**

This summer I worked with the American Association of Physics Teachers (AAPT), which aims to spread physics knowledge and pedagogy around the country, and STEP UP, a movement that provides resources for high school teachers to encourage young women to study physics and increases awareness of inequality in the physics community. I was lucky enough to work on both the AAPT conference and the STEP UP Summit, both of which were virtual. Based on these experiences, I'd like to share some thoughts on attending and running a virtual conference.

AAPT's Virtual Summer Meeting was hosted with Underline.io, which is easy to navigate and allows participants to view all of the talks via a master list. This is one benefit of the virtual platform—you have a lot more control over what to watch or participate in because it's easy to plan. You can also create "ads" for the conference (one of which I made) to promote certain talks. These help attendees because they can get a lot of information from one small ad on the page.

During a virtual conference, anxiety is way down for attendees. Not only can they avoid travel, but they also have complete control over their experience. This isn't necessarily true for those hosting. Nobody at AAPT or STEP UP had ever designed an online conference. Communication with the hosting service





can be time consuming, and online communication and meetings don't allow for the same level of understanding as in-person gatherings.

As the meeting approached, so did a big decision: Do we ask speakers to present live or present a recording and have a live Q&As? When preparing for a virtual presentation, speakers need to ensure quality internet connection. If one were to get disconnected during a plenary, it would leave a few hundred people sitting at home looking at a blank screen. The AAPT meeting took advantage of the ability to have plenary speakers record their talks and paired them with live Q&As to really make it feel like you were engaged with the speaker.

There were also "virtual conference rooms" using Gather.town, where attendee avatars could walk around the room to mingle with others. It was a great place to take a break, and it also made the experience feel a lot more like an in-person conference. So, when attending a large virtual meeting, try to take advantage of the increased planning ability and comfort, and treat it like you would an in-person conference by visiting those virtual rooms!

But how do people interact virtually? And how do hosts run breakout rooms? Both conferences made use of having designated roles for participants in each talk or breakout room, including tech support, note taking, and watching for raised hands. It's obviously easy to just turn off your webcam and get distracted. To increase group interaction, you might try having attendees contribute their thoughts to a shared note page instead of having one person taking notes. This is easy to do virtually: Just share a Google doc!

After a lot of hard work, the meeting was all set up—but how to get the word out? This was extremely important, as we expected attendance would be lower for a virtual meeting. Social media, therefore, was an important tool to drive attendance. We designed posts, videos, and emails to send out to those planning to attend. We attempted to show attendees what to expect in order to lower anxiety and boost attendance.

This isn't the way we usually plan for conferences, but we learned that the virtual platform had both drawbacks and benefits. In the end, it's important to take advantage of what virtual meetings have to offer. Because of how well they can be run, I wouldn't be surprised to see them continue even after the COVID-19 pandemic has passed. //

TOP: Screenshot of the AAPT Day One schedule, visible to attendees using the Underline.io platform for the conference.

BOTTOM: Ad designed by Petkie for the AAPT K12 teacher lounge. Images courtesy of Ben Petkie.

# Fostering Engagement in Physics during a Pandemic

## 2020 AAPT Summer Meeting

by Sarah Anderson, SPS Member, Wake Forest University

**Educational institutions across the United States have been driven to completely restructure and transform a variety of learning programs in response to the COVID-19 outbreak this past spring. As students were forced to return home, not everyone faced ideal circumstances.**

The virus presented a challenging new obstacle for physics teachers as well. The transition to remote instruction was difficult for students to navigate, and engaging students became even harder in a remote learning space. This issue was discussed extensively at the 2020 AAPT Virtual Summer Meeting.

I attended sessions that discussed remote learning and diversity and equity issues. After learning remotely for half a semester and doing a summer internship unexpectedly online, I wanted to understand the implication of this transition on national physics departments and to better understand the reasoning behind new learning practices implemented by teachers. Furthermore, being one of few female physics majors at Wake Forest University, I had a particular interest in the equity and inclusion aspects of the conference.

A talk by Dr. Andrew Barnard was one of the most interesting. Discussing a new model for interdisciplinary teaching in physics, he first broke physics down into two main components: physical laws and mathematics, and application. Instruction tends to begin in the former, whereas comprehension often starts in the latter, leading to a disconnect for students. As a result, Barnard believes that teachers should use applications to first build excitement and curiosity so that students will be motivated to pursue the higher-level and more difficult content. As an associate professor of mechanical engineering, Barnard implements this technique by teaching physical phenomena through various application spaces.

Another presentation that I found particularly interesting was given by Zahra Hazari on the second day of the conference. Her talk focused specifically on gender differences. A leader of STEP UP, a social movement to promote cultural change in physics, Hazari first explained the "box" of physics. She defined this box as inclusive of everything meaningful to the physics community, and naturally, it was created by physicists. Because the history of physics predominantly includes White men such as Einstein, this group of physicists is not very diverse. As a result, this box leads to a "figured world of physics," a place where there is limited participation from diverse groups and certain characters are deemed most important.



TOP: A slide from Dr. Andrew Barnard's presentation on the first day of the conference.

MIDDLE: An image from Zahra Hazari's talk.

BOTTOM: The panel of five women discussing the voice of women in physics. Photos courtesy of Sarah Anderson.

On the final day, I listened in on a discussion of the voice of women in physics, led by a panel of five women. Each person discussed her personal goals and professional career path as a woman in physics. Interestingly, they all agreed that seeing students grow and succeed was the most rewarding experience for them. They also discussed the importance of mentorship, especially for women pursuing a career path in physics. Even though mentoring relationships may be difficult to establish, the panelists described how valuable they can be. They also shared stories about the hardships of being a female in the physics community. In the words of Dr. Chandralekha Singh, women "have to work really hard to dismantle these systems of power."

Student engagement emerged as an overall theme of the conference. Many teachers are trying to foster greater engagement in physics among their students, including among women and students from other underrepresented groups. Especially during this time, I think it is extremely important that teachers discuss such issues because they play a fundamental role in student growth and development. I largely credit my teachers in both high school and college with stimulating and maintaining my interest in physics. I believe that a teacher can completely change a student's perspective on a subject and play a significant role in their chosen academic path. Overall, I found the conference to be very insightful, and I am very grateful for the experience! //

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# Society of Physics Students

# 2020 APPLICATION DEADLINES!

The Society of Physics Students provides scholarships, research and travel grants, and outreach awards for both individuals and chapters.

## Fall Deadline: November 15

Future Faces of Physics Award
Marsh W. White Award
SPS Chapter Research Award
Sigma Pi Sigma Chapter Project Award

## Winter Deadline: January 15

SPS Summer Internship

## Spring Deadline: March 15

SPS Scholarships
Outstanding Research Award
Outstanding Chapter Advisor Nominations
Journal of Undergraduate Reports in Physics (JURP)

## Summer Deadline: June 15

SPS Chapter Reports, including the Blake Lilly Prize

## Ongoing Opportunities

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