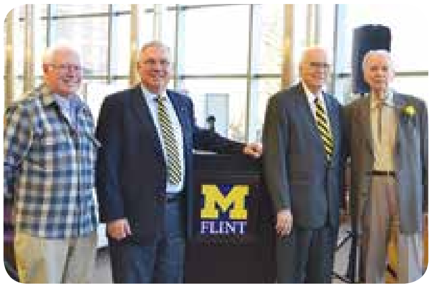
Radiations

FALL
2017

The official publication of Sigma Pi Sigma

Today's Physics *Education*

The Hindenburg Disaster as a Teaching Tool
Bringing Astronomy Research into the Classroom
Updating the Careers Toolbox



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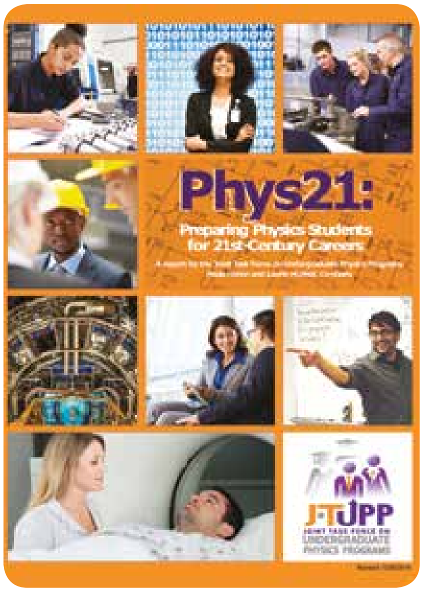

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ON THE COVER
SPS Member and former SPS Intern, Samantha Spytek. Samantha graduated from Virginia Tech in 2017 with a BA in Physics. She is continuing in Virginia Tech's Secondary Science Education Program with plans to earn an M.Ed. with licensure in Physics. Samantha is excited to begin her career teaching high school physics.

Photo credit: Susan Haymore.

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Radiations

Fall 2017
Volume 23, Issue 2

Radiations (ISSN 2160-1119) is the official publication of Sigma Pi Sigma, the physics honor society, published twice per year by the American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3841. Printed in the USA. Standard postage paid at Columbus, OH. POSTMASTER: Send address changes to: Radiations Magazine, Sigma Pi Sigma, 1 Physics Ellipse, College Park, MD 20740-3841.

Sigma Pi Sigma is an organization of the American Institute of Physics. It was founded at Davidson College, Davidson, NC, December 11, 1921. Member, Association of College Honor Societies. Contact us at sigmapisigma@aip.org; telephone: (301) 209-3007; fax: (301) 209-3082.

Sharing Physics

by Brad R. Conrad, PhD
Director, Sigma Pi Sigma and Society of Physics Students

Each issue of *Radiations* focuses on a different facet of who we are as a community. This edition homes in on how we acquire knowledge and what it means to use knowledge. To paraphrase Michio Kaku, all humans are naturally scientists. Physicists and astronomers in particular focus on the *why* questions: Why are the equations of this form? Why must the wavefunction go to zero at infinity? Why do stars have the spectrum they do? We never stop questioning, growing, and expanding what we know. The universe is our laboratory. What more could we ask for?

Many students have asked me why a physics degree is so useful, and I usually reply that it enables me to not only formulate questions but make sense of the complicated world around me. The world is messy, but that's half the fun. This issue focuses on the idea that education and discovery happen everywhere, and an undergraduate physics education is changing to embrace this reality. Physics is deeply seated in experimentation, and part of its beauty is that we can apply the principles learned in the laboratory to the real world: by carefully examining distant starlight, by investigating the Hindenberg explosion, and by incorporating experimental or computational activities in almost any course.

Throughout my education, the most important lesson I have learned is that physics is not just scribbles on a chalkboard but something that happens every day, all the time. As trained scientists, it is our task to share what we learn and help others see the beauty in physics and sunrises. I hope this issue helps. ●

"Humans are natural born scientists. When we're born, we want to know why the stars shine. We want to know why the sun rises."

— Michio Kaku

Image Credit: NASA Earth Observatory images by Joshua Stevens, using Suomi NPP VIIRS data from Miguel Román, NASA's Goddard Space Flight Center.

Introducing Some of the Newest Sigma Pi Sigma Chapters

by Kendra Redmond, Contributing Writer

Berry College

After a decade of inactivity, Berry College recently resurrected its SPS chapter. "Our students were interested in strengthening our physics/engineering community and saw SPS as a chance to do that," says advisor Shawn Hilbert. Two years in, they added Sigma Pi Sigma. "Sigma Pi Sigma is a great way to come together as a community to collectively say thank you to our student leaders both inside and outside the classroom."

Members of the Berry College SPS and Sigma Pi Sigma chapters show off science demonstrations at the science magic show. Photo by Andrew Lockhart.

The department graduates an average of four physics majors a year and supports about 80 physics/dual degree engineering majors at any given time. The faculty strongly emphasize active learning with techniques grounded in physics education research, encouraging technical reading, strong problem solving, self-learning, and research.

The SPS and Sigma Pi Sigma chapters at Berry College host an annual physics magic show for their local community of Mount Berry, Georgia. They also host star parties at the campus observatory, giving community members the opportunity to explore the cosmos. In the future, the chapters plan to host a monthly science café series.

University of the Sciences

Roberto Ramos, advisor of the new chapter at University of the Sciences, describes the physics department as small and very tight-knit. SPS students participate in several outreach events in the Philadelphia area each year, developing leadership and teaching skills early in their education. With Sigma Pi Sigma, Ramos aims to honor outstanding scholarship and connect students to the broader community of physicists.

SPS director Brad Conrad presents the Sigma Pi Sigma charter to professor Elia Eschenazi, department chair at the University of the Sciences, as university president Professor Paul Katz and SPS president Katee O'Malley watch. Photo courtesy of Brad Conrad.

The chapter's inaugural induction ceremony included talks by three physics professionals—a food scientist, medical physicist, and high school physics teacher. "These speakers from different walks of life gave personal testimonies of excellence as they practiced physics in their respective spheres of influence," said Ramos.

Moving forward, the chapter plans to continue inviting professionals from diverse fields to be part of their induction ceremony. "Through this process, we want to facilitate the connection between students, faculty, administration, and these professionals—and even stimulate collaborations," says Ramos. They also plan to invite local K-12 students who are impacted by SPS physics outreach activities.

University of Washington Bothell

This is an exciting time for physics at the University of Washington Bothell. "We have a new physics degree program, with the first students declaring their physics major in 2016 and graduating in 2017," said Joey Shapiro Key, Sigma Pi Sigma advisor of the new chapter. There are currently about 35 physics majors.

The Sigma Pi Sigma chapter was founded by Holly Gummelt, the first student to declare a physics major on campus. "Our physics department is very new and small, but we have a wonderful group of dedicated professors who are incredibly involved in our education, both in and out of the classroom," she says.

Gummelt was inspired to start SPS and Sigma Pi Sigma as another way "to create a fuller experience for the students and commend them on the enormous amount of effort they put into their schoolwork." This past spring, she was among the first group of students inducted into the chapter and one of the first to graduate with a physics degree from the university. ●

Left: Holly Gummelt during the University of Washington Bothell graduation, proudly wearing her Sigma Pi Sigma honor cords. Photo by Warren Buck.

Right: Katherine Reyes signs her name in the red book during the University of Washington Bothell inaugural Sigma Pi Sigma induction. Photo by Marc Studer.

West Virginia Wesleyan

"With about 100 physics majors, we have the largest undergraduate physics program in West Virginia," says Albert Popson, Sigma Pi Sigma co-advisor of the chapter recently established at West Virginia Wesleyan in Buckhannon. The physics program emphasizes a hands-on approach with several advanced labs and research opportunities.

The department is also home to a space club and a science public outreach team. Popson hopes that the addition of Sigma Pi Sigma will help students become contributing members of the professional community of physicists by engaging in service, building professional skills, and presenting scholarly work at professional meetings and in journals. Chapter highlights so far include colloquia on topics ranging from NASA's planned mission to Mars to medical physics, bridge design, and gravitational waves. Several students have given research talks at recent conferences, and many chapter members participated in SPACE Day, a public outreach event that included student presentations and competitions on drone flying, cryptography, and designing paper airplanes and hydrofoils. ●

Summer research students pose with their faculty advisors at West Virginia Wesleyan. Photo by Mark Loudin.

For chapter induction resources, visit

http://www.sigmapisigma.org/sigmapisigma/induction-center

Sigma Pi Sigma Sharing Science

Don Lincoln honored with AIP's 2017 Gemant Award

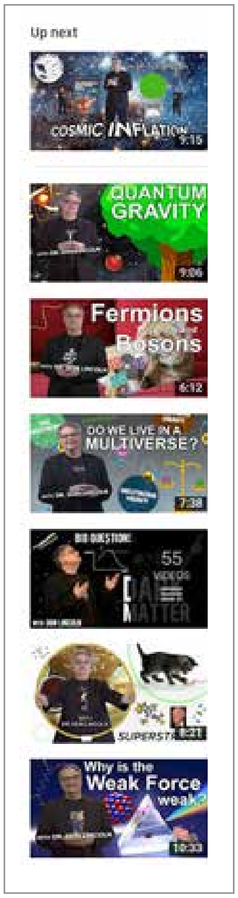
by Rachel Kaufman, Editor

Photo by Fermilab/R. Hahn

It's fitting that one of Don Lincoln's favorite science communication videos involves him blowing up a house.

Lincoln (Sigma Pi Sigma '85), a senior scientist at Fermi National Accelerator Laboratory in Chicago, is a particle physicist. He smashes small things into each other on the regular. So why not also blow up a house?

Okay, so Lincoln didn't push the plunger, but in one of his science communication videos (he's created dozens) the physicist uses a recently demolished house (with permission from the local bomb squad) as a metaphor to explain how particle accelerators work.[1] In another video he makes the compelling case that particle physicists led to cat videos,[2] and in a third a Charlie Chaplin gag reel explains gravity.[3]



It was for these videos, as well as his Great Courses lectures, numerous articles in popular media, and a TED Talk—among other scientific communication achievements—that Lincoln was awarded the 2017 Gemant Award from the American Institute of Physics.

The Gemant Award is an annual prize recognizing "significant contributions to the cultural, artistic, or humanistic dimension of physics" and comes with a $5,000 grant and an invitation to give a public lecture.

Winning the award "means a great deal," Lincoln says. "Outreach is… something I did, sort of not greatly encouraged by academia," he says. "Nonetheless, I personally think it's important, and the fact that people have looked at it and said, 'He's doing it well,' is something."

Lincoln didn't grow up in an academic family, but even early on, he had "theological questions" about the world. "Questions like, 'How did the universe come into existence? Does it have to be the way it is? Could it be a different way? Could there be a universe where we don't exist?' These are questions that have bothered classical thinkers for thousands of years," he says, and as a kid, they bothered him, too. He tacked onto his physics major minors in both philosophy and religion, but realized that only science held quantifiable answers. While conducting research at Fermi National Accelerator Laboratory (Fermilab) as a graduate student, he began "learning how to talk to people" by leading tour groups of visiting high school students. Soon he began writing for Fermilab's website, then writing articles, hosting videos, and writing books.

Lincoln has also had a successful research career—he helped discover the Higgs boson at CERN, with "six thousand of my closest friends," as he jokes in a TED Talk.[4] But it's with outreach that he has made his broadest impact.

"The fact of the matter is that we as scientists… we make measurements, make insights, make discoveries, and understand the world around us. However, we also live in an environment in which a lot of science funding is handled by the public. We are not independent of the community. I think it's imperative that we share the things we discover," he says.

Further, science isn't going away just because someone might want it to, he says. "We live in a highly technically advanced society. Cell phones work because of scientific principles that have been discovered. Vaccines keep people alive—babies used to [regularly] die before they were 2. Scientific phenomena are all around us." Now, however, science is under attack, he says. "There are people who have not only skepticism but a hostility to the idea that there really are answers. So I think it's extremely important that we as scientifically minded people push back against what I see as a fierce undercurrent of anti-intellectualism."

Ultimately, Lincoln hopes that the physics knowledge he shares in books, articles, and videos reaches more than "science likers." "Somebody who stumbles upon one of my videos on YouTube could have no clue they like science," but after watching a 5 or 10 minute video, could be converted. "That's great," he says. "That's the [outcome] I'm most proud of." ●

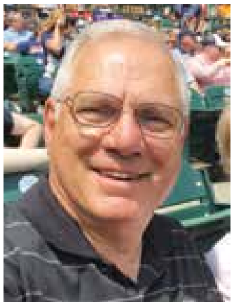
A sample of Don Lincoln's videos available on YouTube.

1. "Subatomic Bomb Squad," https://www.youtube.com/watch?v=-d6sKfPfYTU.
2. "Because CERN Invented the World Wide Web, of course," https://www.youtube.com/watch?v=sTt27A8W4eY.
3. https://www.youtube.com/watch?v=9LGBo7dLgYk.
4. https://www.youtube.com/watch?v=7DbFZKdeBaQ.

Paying It Forward

A Physics Alumnus Connects with the Next Generation

by Mariann Salisbury, Development Director, American Institute of Physics



David Zick
University of Michigan-Flint class of 1973, inducted into Sigma Pi Sigma in 1996.

David Zick is a philanthropist whose motivations for giving have deep roots in his undergraduate years at the University of Michigan-Flint. In the 1970s, he studied physics and education, earning a bachelor's degree from UM-Flint and a master's degree in the same fields from Michigan State University. From his master's degree he went on to teach high school physics for four years. The friendships he made with faculty and classmates in those years are the bedrock of his professional foundation.

Zick left teaching and went into business for himself, but never lost his passion for physics or his gratitude for the scholarships that made his undergraduate education possible. To this day, he values how studying physics in small collaborative teams shaped his thinking and informs his business. He considers his giving a way to ensure the opportunities that were available to him as a student in need will remain available to others.

"The clarity that science teaches is essential for problem solving," Zick says. "The value of my undergraduate experience is that I learned to simplify issues, identify problems while not being distracted by tangential issues, and work collaboratively with others to find solutions."

Zick was inducted into Sigma Pi Sigma in 1996, long after he graduated, as there wasn't a chapter at University of Michigan-Flint in 1973. Zick became involved with Sigma Pi Sigma after he initiated a giving program to UM-Flint to support the undergraduate physics department. He has funded many scholarships to help young people finish their degrees, meeting with students and mentoring them. He has supported lectureships on campus. And in 2012, he set an example by funding the building of an innovative lab/lecture learning center for physics and engineering. Most recently, in 2016, Zick honored Dr. Donald DeGraaf, his physics professor (who is now 93), by funding a second lab/lecture learning center hall in his professor's name.

Through his philanthropy, Zick has advanced opportunities for undergraduates in physics and has kept in touch with some of the students as they move through undergraduate and graduate programs and to the professions of teaching, research, and business. In addition to supporting SPS financially since 1996, he has also donated his time to several SPS committees: working to inspire local chapters to reach out to their communities, invite speakers to share their scientific research and breakthroughs, and to encourage young people to study the physical sciences.

Zick believes that his decisions in the business world had their earliest underpinnings in the undergraduate physics classroom where he learned to identify problems, process solutions, and work carefully and collaboratively in teams to learn from the process. He has found that these lessons continue to apply in his professional life and have profoundly shaped how he approaches his work.

> "The skills I acquired working on problem solving with other physics undergraduates followed me into the business world."

Through his unwavering support, Zick has inspired others to get involved in SPS at the local and national levels. As you reflect on your own experience, we hope you will consider making a gift to SPS in honor of your favorite professor or mentor. For more information, contact Mariann Salisbury, AIP Director of Development, **msalisbury@aip.org,** or **call 301-209-3098**. ●

(From L to R): Dr. Donald Boys, David Zick, Dr. Donald DeGraaf, and Dr. Frank Rose at the dedication ceremony for the DeGraaf Learning Center. Photo courtesy of David Zick.

2016–17 Award Recipients

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

2017 SPS Summer Interns

SPS internships are awarded on the basis of collegiate record, potential for future success, SPS participation, and relevant experience. Interns are placed in a variety of organizations and work on research, policy, or education projects. See the interns' profiles and blogs at https://www.spsnational.org/programs/internships/interns/2017.

Justine Boecker
Bethel University

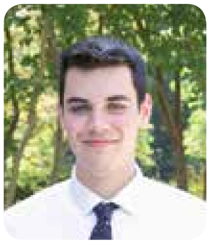
AAPT/PTRA Teacher Professional Development Intern

Designed and revised resources for AAPT's high school teacher professional development programs.

Victoria (Tori) Eng
Coe College

AIP Center for History of Physics Intern

Worked with staff to create a museum-style exhibit to highlight the human side of physics.



Michael Forkner
Oregon State University

The Optical Society Intern

Supported the development and update of OSA's Optics for Kids programs.

Eleanor Hook
Rhodes College

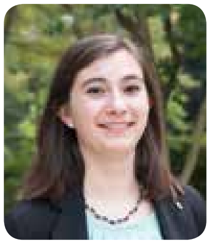
AIP Mather Policy Intern

Worked for the House Science Committee Democratic staff.

Lisa McDonald
Coe College

AIP FYI Science Policy Communications Intern

Worked with AIP staff to research and write FYI Bulletins.



Mary Ann Mort
California State University, Sacramento

APS Career Programs Intern

Researched and created content for the APS Careers website and the "Physics InSight" slideshow.

Zakary Noel
Lamar University

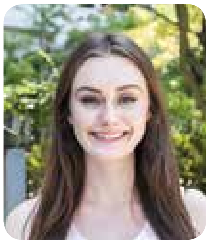
SPS SOCK & NIST Summer Institute Intern

Created and tested a set of outreach activities for SPS chapters and the NIST Middle School Teacher's Institute.

Samantha Pedek
University of Wisconsin - River Falls

NASA Goddard Space Center Intern

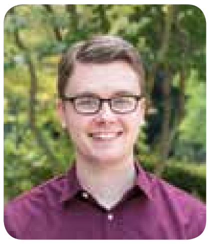
Collaborated with a team to further the detector and modulator development.



Lexxi Reddington
University of Denver

AIP Center for History of Physics Intern

Created a social media outreach plan to promote the exhibit on various outlets, including a newsletter, blog, Facebook, and Twitter.



Jacob Robertson
Austin Peay State University

SPS SOCK Intern

Created and tested a set of core activities for this year's SOCK and writing instructions for lessons and demonstrations.

Francisco Ayala Rodriguez
University of Texas - El Paso

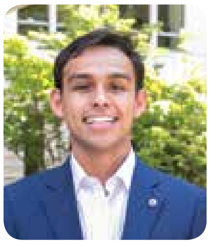
APS Public Outreach Intern

Developed and implemented a new informational education effort alongside the APS public outreach team.

Kristine Romich
California State University - Northridge

NASA Goddard Space Center Intern

Researched the basics of time series analysis and image processing by contributing to two research projects.



Luis Royo Romero
High Point University

NIST Research Intern

Worked with the National Institute for Standards and Technology (NIST) to support their development of new characterization techniques, physics-based models, and data analysis methods.

Riley Troyer
University of Alaska - Fairbanks

AIP Mather Policy Intern

Worked for the Senate Energy and Natural Resources Committee Republican staff.

Photos by Hyun-Joo Kim and Liz Dart Caron.

SPS Award for Outstanding Undergraduate Research

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

Winners

Matthew Huber
Rhodes College

Kathryn Regan
University of San Diego

Runner-Up
Brittney Hauke
Coe College

Honorable Mention

Luciano Manfredi
Loyola Marymount University

Jeremiah Wells
University of Minnesota - Twin Cities

Collin Wilkinson
Coe College

Outstanding Chapter Advisor Nominees

The Outstanding Chapter Advisor Award is the most prestigious recognition given each year by SPS. The following SPS chapter advisors were nominated by their students, colleagues, and departments in recognition of their dedication to furthering the mission of SPS. The winner will be announced at the Winter 2018 AAPT Meeting in San Diego, California.

Michael Dowding
South Dakota School of Mines and Technology

Alina Gearba-Sell
United States Air Force Academy

Edwin Greco
Georgia Institute of Technology

Craig Group
University of Virginia

Donna Hammer
University of Maryland - College Park

Shawn Hilbert
Berry College

Jose Lopez
Seton Hall University

Walerian Majewski
Northern Virginia Community College

David Peak
Utah State University

Jessie Petricka
Gustavus Adolphus College

Roberto Ramos
University of the Sciences

Michael Rogers
Ithaca College

Ryan Sayko
Allegheny College

Peter Sheldon
Randolph College

William V. Slaton
University of Central Arkansas

Gary White
George Washington University

Matthew Wright
Adelphi University

Scholarships

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

SPS Leadership Scholarship

Vanessa Chambers
Utah State University

Emily Churchman
Texas Lutheran University

Niyousha (Ni) Davachi
University of Texas at Arlington

Cody Jordan
University of Central Florida

Luciano Manfredi
Loyola Marymount University

Elijah Meyer
University of Oregon

Spencer Peters
University of Washington

Francesco Sessa
Florida International University

Hannah Simons
California Polytechnic San Luis Obispo

Alexandria Skinner
Berry College

SPS Outstanding Leadership Scholarship

Shannon Armstrong
Grove City College

Matthew Huber
Rhodes College

Aysen Tunca Memorial Scholarship

Elizabeth Pham
California State University, Chico

Future Teacher Scholarship

Shannon Armstrong
Grove City College

Herbert Levy Memorial Scholarship

Scott Sacharcyzk
Portland Community College/Portland State University

AWIS Kirsten R. Lorentzen Award Scholarship

Elizabeth (Cady) Van Assendelft
Yale University

Science Systems and Applications, Inc., Underrepresented Student Scholarship

Kassie Marble
Tarleton State University

Science Systems and Applications, Inc., Academic Scholarship

Steven Stetzler
University of Virginia

The Hindenburg Disaster Is a Physics Teaching Opportunity

by Gregory A. DiLisi, Associate Professor, John Carroll University

This May marked the 80th anniversary of the Hindenburg disaster. On May 6, 1937, the German passenger zeppelin *Hindenburg,* hovering 300 feet in the air and held aloft by seven million cubic feet of hydrogen gas, burst into flames while preparing to dock at the Naval Air Station in Lakehurst, NJ. The ensuing fire consumed the massive airship in only 35 seconds.

We present the *Hindenburg* disaster as a case study in the flammability of fabrics. Our goal is to examine the ship's outer covering and decide whether or not it was the fire's initial source of fuel. To accomplish this, we piloted a basic vertical flame test with students in an introductory-level undergraduate laboratory. Our test is patterned after the protocol set forth by the American Society for Testing and Materials (ASTM) for determining the flammability of textiles. The case study provides several unique teaching opportunities.

First, we observe the anniversary of this tragedy by bringing it to the attention of a new generation of students, namely, those currently enrolled in our courses. Reexamining a major historical event is a powerful means of piquing students' interest. Next, we introduce the topic of physics flammability at a level of rigor appropriate for introductory students or more advanced students. Finally, we use this case study to emphasize that scientists no longer adopt a strictly passive approach to history. Instead, scientists now take a forensic approach, bringing sophisticated analytical tools to scrutinize why certain events unfolded. Far from being a set of agreed-upon immutable facts, the historical record is open to reexamination and reinterpretation.

"Reexamining a major historical event is a powerful means of piquing students' interest."

"THIS GREAT FLOATING PALACE"

The zeppelin LZ 129 *Hindenburg* (Luftschiff Zeppelin #129) was launched in 1936 as the premier passenger aircraft of the world's first airline, the German Airship Transportation Corporation.

The ship was classified as a rigid airship because of its steel frame. Within the steel structure were 16 large gas cells (or bladders) made of gelatinized latex, designed to hold hydrogen gas. The steel structure was covered by panels of cotton cloth doped with various compounds. The flammability of this outer covering plays a pivotal role in the debate surrounding the ship's destruction.

As the ship approached New Jersey on May 6, 1937, it encountered a storm before reaching the Lakehurst Naval Air Station. After a number of maneuvers designed to get the ship into position at the airfield, the forward grounding lines were dropped. A light rain began to fall. The metal frame was now electrically grounded by the landing lines.

"IT'S BURST INTO FLAMES!"

> It's burst into flames! … and it's crashing! It's crashing terrible! Oh, my! …. It's smoke, and it's in flames now; and the frame is crashing to the ground, not quite to the mooring mast. Oh, the humanity!

The first sign of trouble appears to have been at the top, rear of the ship, just in front of the vertical fin. Two crew members testified that they noticed a fluttering of the ship's outer cover at this location—suggesting hydrogen was leaking.[1] By 7:25 p.m., a yellow flame appeared on the outside of the ship at this spot. Within seconds, the tail section was engulfed in flames.

Most eyewitnesses described the *Hindenburg* as burning from the inside out. Within 30 seconds, the entire ship crashed to the ground. In general, passengers and crew in the promenade or public areas of the ship were able to jump to safety while those deeper inside the ship were not. Some family members lived or died based merely on a few feet of separation.

THEORIES

Subsequent investigations by the United States and Germany were inconclusive in determining the cause of the fire. Was it sabotage? No evidence of sabotage was ever found. Was it a lightning strike? Unlikely—the outer covering of the ship had several burn holes, some as large as five centimeters in diameter, proving the ship had survived in-flight lightning strikes during its first year of service.[2]

Today, a reexamination of the evidence leaves us with two competing theories. Here is what they agree on: As the *Hindenburg* passed through the storm off the New Jersey coast, it became electrically charged. When the landing lines touched the ground prior to docking, they "earthed" the *Hindenburg*'s steel frame but not every panel of the ship's fabric covering. A spark between the charged panel of fabric and the grounded steel frame ignited some source of fuel. The difference between the two theories lies in identifying that source of fuel.

The most likely explanation of events is that the electrostatic discharge ignited leaking hydrogen gas. However, in 1997, engineer Addison Bain put forth the idea that at least early in the fire, the ship's outer covering itself was the primary source of fuel for the fire.[3] The cotton cloth that covered the ship was doped with different mixtures based on cellulose acetate butyrate (CAB), the base resin for what are commonly called lacquers. These coatings were used to keep the

1. Bureau of Air Commerce, Air Commerce Bulletin of August 15, 1937, Vol. 9, No. 2 (United States Department of Commerce, Washington, DC, 1937), pp. 28–29.

2. R. Archbold, *Hindenburg*: An Illustrated History (Warner Books, New York, 1994).

3. A. Bain, "Colorless, nonradiant, blameless: A Hindenburg disaster study," Gasbag J./Aerostation 39 (March 1999).

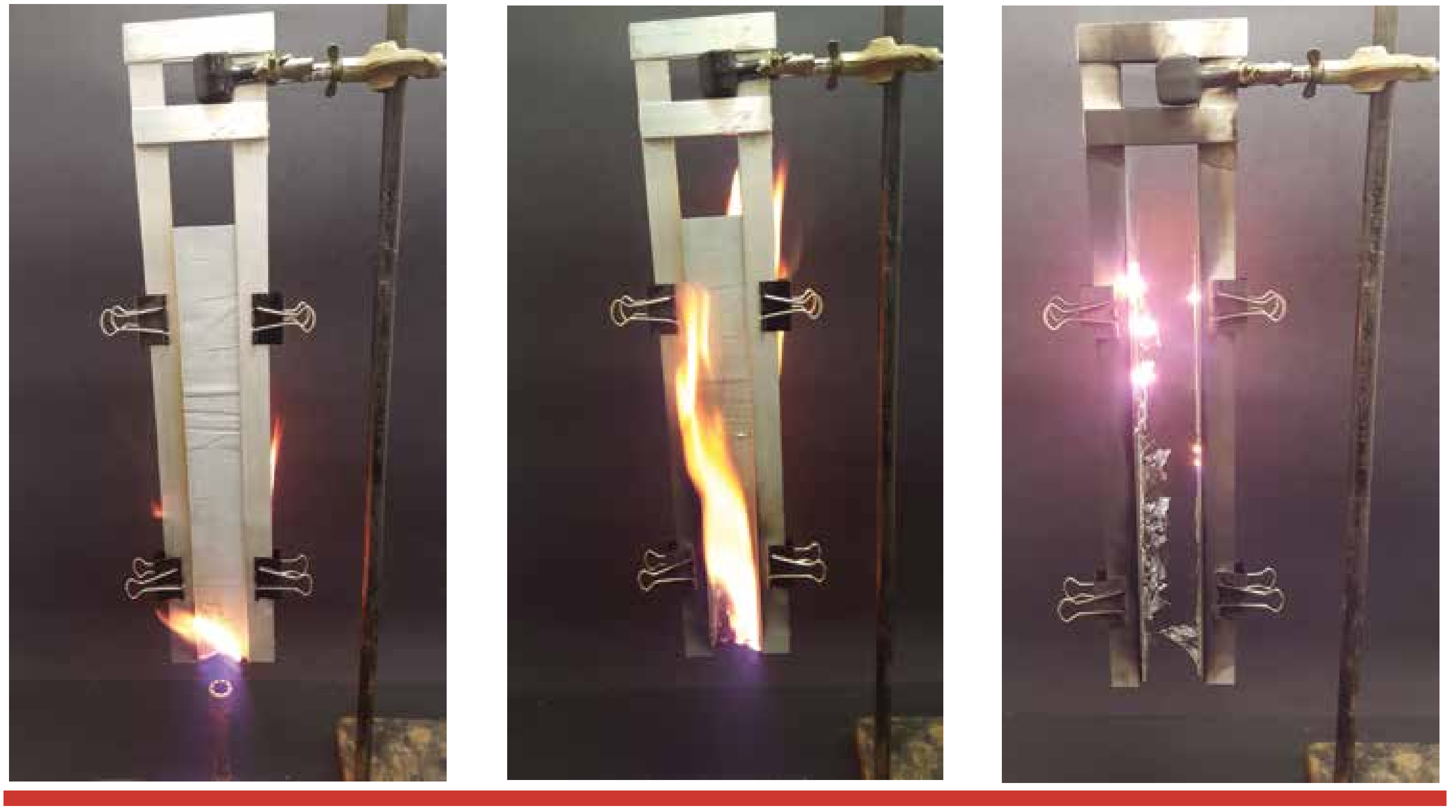


Figure 1. Our apparatus for vertical flame testing. (a) Start of flame test. (b) Afterflame. (c) Afterglow.

outer skin taut for aerodynamic purposes as well as to protect it from wind, water, and small objects. This "Incendiary Paint Theory" (IPT) has merit for two reasons: (i) Hydrogen burns with an invisible flame, yet the *Hindenburg* was consumed in an enormous yellow and red fireball. One might conclude that something other than hydrogen was burning. (ii) The ship held its position for a few seconds before the stern crashed to the ground. One might conclude that the gas cells were intact when the fire started.

COMBINING PHYSICS AND HISTORY IN THE LABORATORY

We used the IPT as the basis of a new, inexpensive lab activity focusing on the flammability of fabrics. Our activity is modeled after the vertical flame test, ASTM D 6413–99, which has been adopted as an accepted federal test standard.[4]

We started by presenting students with the historical background information described in the previous sections. Next, we emphasized two concepts: (i) The goal of our activity is not to prove or disprove the IPT, but to showcase how physics can be used in the real world, and (ii) even though our activity focuses only on a vertical flame test, it gives us a quantitative understanding of how flammability is tested and how results can be used to unravel the *Hindenburg* disaster.

Sample preparation: We chose to test fabrics that were easy to make and inexpensive to buy, yet nicely approximate the outer coverings of the airship. To create the fabric that approximates the covering on the upper portion of the ship, we rolled cotton swatches with a layer of clear lacquer, then a layer of black primer with iron oxide as its tinting agent, then three layers of aluminum resin paste (Genesis LV 1060, purchased at Sherwin-Williams). To create the fabric that approximates the covering on the lower portion of the ship, we rolled cotton swatches with a layer of clear lacquer, then three layers of aluminum paste. We used uncoated cotton swatches as a control. Students trimmed each of these three samples into five strips (12 in × 3 in). Each strip was placed into a frame of sheet metal that secured the strip on two sides, leaving the bottom edge exposed. The frame was clamped together at four locations and suspended in a laboratory hood.

Testing: Each strip was tested and the average of five strips was reported per fabric. A Bunsen burner, with 10-mm inside diameter barrel, was used to create a 1.5-in-high 99%-pure methane flame. The flame was applied for 12 ± 0.25 s (flame-to-strip), as measured by a stopwatch. Students filmed each trial using cell phone cameras in "slow motion" mode [Fig. 1(a)]. Once the flame was removed, students continued to film the strip until any visual flame or glow self-extinguished [Fig. 1(b) and 1(c)].

Analysis: Using their video clips and a ruler, students determined the "afterflame," the time a visible flame remained on the strip; the "afterglow," the time a visible glow remained on the strip; and the "char length," the distance from the edge of the strip to the furthest point of damage. They then calculated the burn rate (char length divided by afterflame) and extrapolated the time needed to burn a 106.1-foot-long swatch of the strip (1/4 of the *Hindenburg*'s maximum circumference) and the total burn time by adding the vertical burn times for the fabrics covering the lower and upper halves of the ship.

Results: Results support the notion that leaking hydrogen, and not incendiary paint, is the most plausible source of fuel for the fire that consumed the *Hindenburg*. The outer fabrics just do not burn at a fast enough rate to consume a ship the size of the *Hindenburg* in a minute. Our dataset shows that a fire would need ~112 minutes to burn a distance roughly equal to the height of the ship, that is to say, from the underside to the topside of the ship.

As a side note, a 2007 episode of the popular show *MythBusters* (Episode 70 —"The *Hindenburg* Mystery") found similar results.[5] Although the episode is not peer reviewed and should be viewed with some skepticism, it is a phenomenal visual resource that can be shown to students to emphasize or solidify certain concepts. The episode serves as a good closure activity and can be downloaded from iTunes for $1.99.

CONCLUSION

The 80th anniversary of the *Hindenburg* disaster presents a compelling case study that brings powerful teaching opportunities to a variety of disciplines. First, the anniversary raises historical awareness in our students while bringing real world applications of physics to them.

Next, the physics of flammability can be treated appropriately at the introductory level since only careful measurements of time, distance, and weight are needed. Our case study can serve as a start-of-the-semester laboratory exercise where safety, measurement, and error analysis are emphasized. Conversely, our case study can also serve as a capstone project in a senior-level engineering course.

> "[J]ust as scientific theories are open to reexamination in the light of new or confounding observations, so too are historical events open to revisitation and scrutiny."

Third, the resulting analysis shows students that just as scientific theories are open to reexamination in the light of new or confounding observations, so too are historical events open to revisitation and scrutiny.

ACKNOWLEDGMENTS

The author acknowledges James DeLuca, chemist extraordinaire, for his insights into sample preparations. The author also acknowledges the reviewers of this manuscript, who significantly strengthened the presentation of this work. ●

This paper, edited and condensed for space reasons, originally appeared in The Physics Teacher *55, 293 (2017). Copyright 2017, the American Association of Physics Teachers. http://dx.doi.org/10.1119/1.4981031*

4. American Society for Testing and Materials, ASTM D 6413-99, Standard Test Method for Flame Resistance of Textiles (Vertical Test), *Annual Book of ASTM Standards* (ASTM, West Conshohocken, PA, 2016).

5. "MythBusters: Hindenburg MiniMyth." Retrieved from http://www.discovery.com/tv-shows/mythbusters/videos/Hindenburg-minimyth/ on Jan. 3, 2017.

Sigma Pi Sigma Member Updates

We all have stories to tell of accomplishments, civic activities, academic activities, honors won, promotions, publications, and career changes. Below are just a few of the impacts Sigma Pi Sigma alumni have had on their communities.

University of Illinois at Chicago
Mustafa Khan, 1989

Khan recently published his second book, *Musings of a Neurologist*. It is a collection of papers on theoretical physics and mathematic neurology.

Georgian Court University
Amy Applegate, 2013

Applegate recently finished her first year of teaching Physics First at Mt. Olive High School in Flanders, New Jersey.


Photo by Julie Powell.

Stephen F. Austin State University
William Lee Powell, Jr., 1997

Powell began a new career a year ago, in July 2016, leaving a faculty/planetarium position at the University of Nebraska Kearney to become an associate dean of academic affairs at Collin College in McKinney, Texas. He misses research and being in the classroom but enjoys the challenge of administration, particularly at this rapidly growing (and already quite large), well-respected two-year college.


Photo courtesy of Kentucky Academy of Sciences, University of Louisville.

Murray State University
Dylan R. Stewart, 2017

Stewart graduated summa cum laude with a BS in Engineering Physics in May 2017 and started his PhD research at the University of Florida in the Department of Electrical and Computer Engineering. He is working on image segmentation algorithms for better understanding the seafloor.

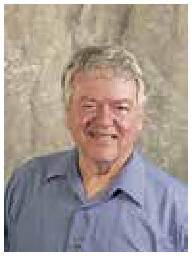


Photo by Randy Barth.

Drexel University
John Degnan, 1967

Degnan was elected a 2017 Fellow of the Optical Society of America (OSA) and also joined the OSA Traveling Lecturers program. In April he gave an invited lecture on satellite laser ranging and its applications for the OSA affiliate in Rochester, New York, and a lecture on single photon lidars (SPLs) used to rapidly generate wide-area, high-resolution, 3D topographic and bathymetric maps from an aircraft at rates up to 6 million pixels per second.

Utah State University
James Sainz, 2013

Sainz received his MS in Physics from the University of Massachusetts Amherst and is now teaching physics and calculus at The Loomis Chaffee School.

Manhattan College
Joe Bassi, 1974

Bassi recently published his book, *A Scientific Peak: How Boulder Became a World Center for Space and Atmospheric Science*, through the American Meteorological Society Press (2015). The work explains the process from the 1930s to 1950s by which Boulder went from a small college town in the foothills of the Rockies to an international center for science.


Photo courtesy of Kathryn Hollowood.

Roberts Wesleyan College
Kathryn Hollowood, 2015

Hollowood started last fall as a graduate student working towards a PhD in Biomedical Engineering at Rensselaer Polytechnic Institute in Troy, New York. She is a research assistant in Dr. Juergen Hahn's Systems Biology group. Her research involves applying statistical methods to data involving patients on the autism spectrum versus their neurotypical peers in an effort to better understand the disorder.

Share your updates!

Visit http://www.sigmapisigma.org/sigmapisigma/radiations/member-news to submit your information.

Bringing Astronomy Research into the Classroom with Astrobites

by Susanna Kohler, Astrobites Administrator

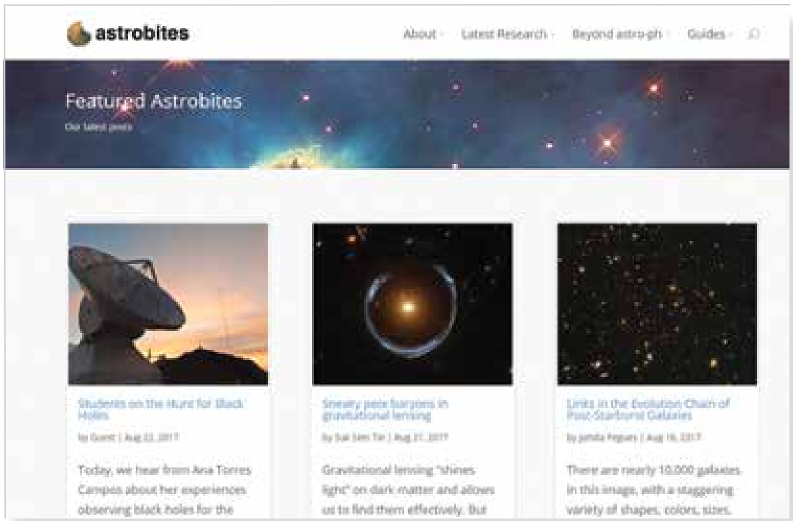
Newton's laws, Keplerian orbits, geometrical optics—the science discovered hundreds of years ago is crucial for building a foundation in physics and astronomy. But shouldn't we also be sharing the field's latest breakthroughs with early-career scientists? Experiencing the excitement of the Kepler mission's latest exoplanet discoveries is arguably just as important in astronomy education as learning about Kepler's laws.

Unfortunately, accessing recent research developments is often easier said than done. Scientific literature tends to be dense and difficult to parse for anyone not in the immediate field. Seven years ago, a team of graduate students tackled this problem and brought a new resource to life: Astrobites.

> "Experiencing the excitement of the Kepler Mission's latest exoplanet discoveries is arguably just as important in astronomy education as learning about Kepler's laws."

Meet Astrobites

Astrobites is a daily blog that acts as a reader's digest of astrophysical literature, making current astronomy results accessible to more than just the researchers in that field. Every day a graduate student from the Astrobites collaboration selects one article from the arXiv, a public preprint server where scientists publish their work, and summarizes it in a brief post intended to be understandable by undergraduate physics and astronomy majors.



For an example of an Astrobites article, see "TRAPPIST-1: Just Right?" on pp. 18–19. For more visit https://astrobites.org/. Image courtesy of Astrobites.

Astrobites posts typically run around 500–1500 words, and they strive to be jargon-free. Each Astrobites summary first provides the background that readers might need, explaining the historical context for the research and why the study presented in this paper is important. The summaries then present the main results from the paper and a few plots or figures from the study, with careful explanation of what's being represented in each. All Astrobites posts include a link back to the original article—which is freely available on the arXiv—so that readers can easily access the full study for more information after they read the Astrobites summary.

Growth and Expansion

Astrobites has grown rapidly since its inception in 2010. The blog is now powered by a rotating team of graduate-student volunteers from around the country and the world, with a roster of about 30 authors active each year. Over the past seven years, Astrobites' 100+ current and alumni authors have collectively built an archive on the site of more than 1,500 summaries of astrophysical research papers. During this time, Astrobites' readership has grown to more than 17,000 unique visitors per month, encompassing undergraduates, graduates, educators, researchers, and astronomy enthusiasts.

In addition to paper summaries, Astrobites also strives to offer other information useful for undergraduate physics and astronomy majors. The site features posts on career navigation (with subjects like how to study for the physics GRE, or how to apply to graduate school), personal experiences (with subjects like what it's like to travel to Antarctica to use the South Pole Telescope, or interviews with notable scientists in the field), and current events (with summaries from recent astronomical meetings, or discussions of hot topics like NASA press conferences). Astrobites even has a section devoted to publishing brief posts submitted by undergraduate readers summarizing their own research projects.

Formalizing Support for Educators

Astrobites is also expanding directly into the classroom. Educators began independently using Astrobites in their classes within the first year of the site's formation. The Astrobites organization interviewed these educators early on and compiled a summary of their strategies for incorporating Astrobites into undergraduate classes. This summary appeared as a published article in the *Astronomy Education Review* (Sanders et al. 2012).

This year, the organization has moved to formalize its support for educators seeking to adopt Astrobites as an instructional tool. The 229th meeting of the American Astronomical Society in January 2017 marked the initiation of an Astrobites educator support workshop titled, "Introducing Current Research into Your Classroom." The workshop brought together 25 instructors from higher-education institutes with a team of Astrobites graduate-student authors to discuss effective ways to use Astrobites in science classes and to brainstorm how the Astrobites collaboration can better support such use.

Classroom Strategies Summarized

The workshop covered three specific examples for how Astrobites could be incorporated into classes: providing Astrobites posts for reading assignments, having students conduct a research project based on Astrobites articles, and having students write their own Astrobites-style posts.

1. Astrobites posts as reading assignments

In this activity, students are asked to read an assigned Astrobites article and respond to guided questions that test reading comprehension and conceptual understanding. This approach can be used as a way of supporting the fundamental topics covered in class with recent research results in the field. It also helps to expose students to the process of how science is done. One way these readings could be used is as pre-lab assignments, to connect lab activities to current research.

Attendees discuss using Astrobites in the classroom during a workshop at the 229th meeting of the American Astronomical Society. Image courtesy of Astrobites.

2. Astrobites research projects

In this activity, students are asked to select a research topic and then identify and read several Astrobites articles related to that topic. Students then prepare a written paper or class presentation based on this independent research. In advanced courses, students can be asked to read the original paper as well, so that the Astrobites article serves as scaffolding to introduce them to that material. This activity allows students to explore a topic in more depth, providing them with access both to the context and the current research results related to that topic.

3. Write your own Astrobite

In this project, designed with upper-level undergraduate or graduate classes in mind, students write their own Astrobites-like article to summarize the content of one or more research papers. This activity helps students build research, literature-understanding, and communication skills.

Materials Available

The educators at the workshop left with a full set of lesson-plan materials produced by Astrobites—including step-by-step instructions, suggestions for adapting the lessons to different class levels across the undergraduate and graduate spectrum, sample student handouts, and grading rubrics—as well as personalized discussions of how they could adapt these materials to their classes.

Meanwhile, the Astrobites collaboration gained direct feedback from educators on how to improve the above materials and their support for more effective use in undergraduate and graduate classrooms. The collaboration updated the lesson-plan materials based on the educator feedback, and they have now been published in the *American Journal of Physics* (Sanders et al. 2017). They are also publicly available on the arXiv (https://arxiv.org/abs/1706.01165). Naturally, this new paper has already been covered on Astrobites (https://astrobites.org/2017/06/11/astrobites-lesson-plans/).

Connecting with You

Since Astrobites' launch, dozens of educators have sent in reports of how they have used the site with their students. Some have incorporated the site into undergraduate and graduate classes, some use the site to introduce new astronomy researchers to the literature, and several have even organized Astrobites-based journal clubs at their home institutions.

The Astrobites collaboration is delighted with the education community's adoption of the site and is eager to continue to build this joint effort to augment astronomy and physics education with current research results. If you, too, are interested in using Astrobites in your classroom or at your institute, the Astrobites collaboration is here to help! And whether or not you'd like assistance, the team would love to hear about your experience. You can contact the collaboration at astrobites@gmail.com. ●

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Site: http://astrobites.org

Lesson-plan materials: https://arxiv.org/abs/1706.01165

N. E. Sanders et al., "Preparing undergraduates for research careers: Using Astrobites in the classroom," Astron. Educ. Rev. 11, 010201 (2012).

N. E. Sanders et al., "Incorporating current research into formal higher education settings using Astrobites," *Am. J. Phys,* 85, 10 (2017).

TRAPPIST-1: Just right?

by Elisabeth Matthews, Phd Candidate, University of Exeter, Astrobites Contributor

Back on May 12th, 2016, the discovery of three planets around the star TRAPPIST-1 was announced—in classic imaginative astronomer fashion, the planets were named *b, c* and *d*. It was a big deal, leading to a *Nature* paper, a NASA press release, and some speedy follow-up work taking a look at the atmospheres of *b* and *c*. The atmospheric studies confirmed that these two planets don't host puffy and hydrogen/helium dominated atmospheres. This is notable, as a puffy hydrogen or helium atmosphere would make the planet uninhabitable. Incidentally, these were the first ever Earth-sized planets to have their atmospheres studied.

TRAPPIST-1 is an exciting system as it's basically right in our astrophysical backyard: extremely close to us, at just 12 parsecs. For reference, even Alpha Centauri, the nearest star system to us, is 1.34 parsecs away. Not only does this make the system feel tangible, it also makes follow-up and characterization work much easier to carry out.

New planets!

As you may have read already, the new *Nature* paper that we're discussing in this bite confirms the presence of several more planets in the TRAPPIST-1 system. The system now boasts seven planets, with orbital periods between 1.5 and 12 days. These planets are all confirmed directly by observing their transits—the dips of light as the planets pass directly in front of the star and block a small amount of the star's light. These can be seen in Figure 1. The first two planets, *b* and *c,* are the same as in the previous paper. The authors do find, however, that the two transits previously ascribed to the *d* planet are actually two different planets! An extended period of observations from various ground- and space-based observatories confirms the presence of four different planets: *d, e, f* and *g*. Finally, a potential seventh planet, *h*, is also observed—but only one transit of this planet is seen, so it is a more tentative detection. Bored of the alphabet yet? Figure 2 shows the planets graphically instead—or try this interactive tool: https://exoplanets.nasa.gov/newworldsatlas/1969/.

Planet tug-of-war

Dynamically, it's very interesting to observe such a tightly packed system. For context, if the system was superimposed on our own system, all seven planets would all be closer than Mercury. The planets orbit in a so-called mean motion resonance, where the orbits of neighboring planets are all small-integer ratios (*b* to *c* is 8/5, *c* to *d* is 5/3, etc.) and their closely matched orbits likely stabilize each other. These dynamic interactions mean that strong Transit Timing Variations (TTVs) are observed. In other words, the transits happen up to half an hour 'early' or 'late' on each individual orbit, as they are pulled and pushed by their neighboring planets. This is useful to us, since it allows the masses to be measured. Without the TTV data, only the radii of each

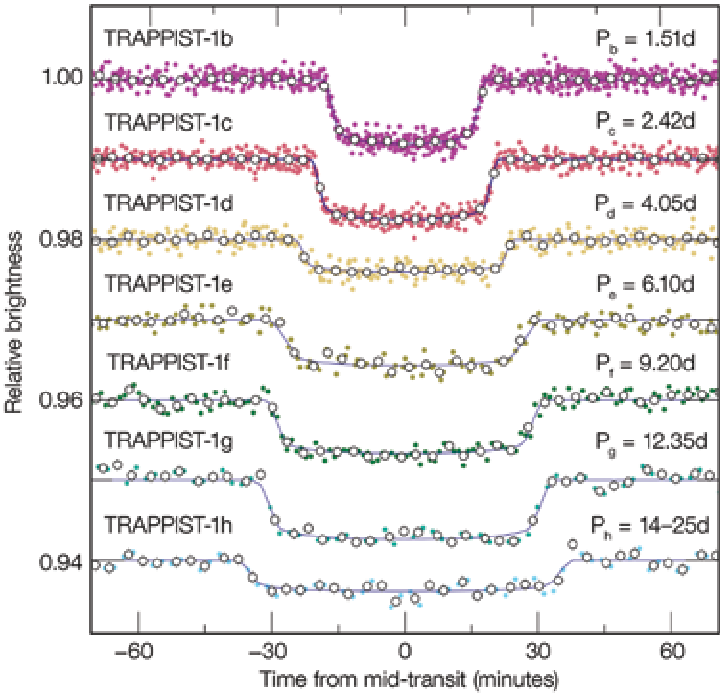


Figure 1. The transits for each of the seven planets. The colored spots show individual flux measurements, stacked over several transit observations, while the large circles show the binned data. Credit: ESO/M Gillon et al.

planet could be inferred from the transit data. The first six planets are confirmed to be rocky planets based on their masses and radii, although the composition of *h* is yet to be determined since only one transit has been observed and this makes the TTV analysis impossible for now!

Water, water everywhere?

This system is particularly exciting as all seven planets are predicted to have equilibrium temperatures in the range where water is liquid. In other words, they're considered to be in the habitable zone. Exoplanet climatology isn't quite as simple as all that, though! TRAPPIST-1 is a tiny M-dwarf star, just 8 percent the mass of the Sun. As previously stated, the planets are all in very small orbits, with a full orbit taking 1.5 days for the closest planet and just 12 days for the furthest out planet. Interestingly, the smaller, fainter star coupled with these short orbits means that these planets receive pretty similar levels of radiation from their star as the solar system planets do from the Sun (Figure 3). As the authors point out, planets *c, d* and *e* are exposed to very similar levels of radiation as Venus, Earth and Mars, respectively.

Since the planets are all so close to their star and are in such close proximity, they are likely tidally locked, as is the case for hot Jupiter type systems. In addition, the authors of the paper simulate the climates of each planet. They find that the *b, c* and *d* planets are

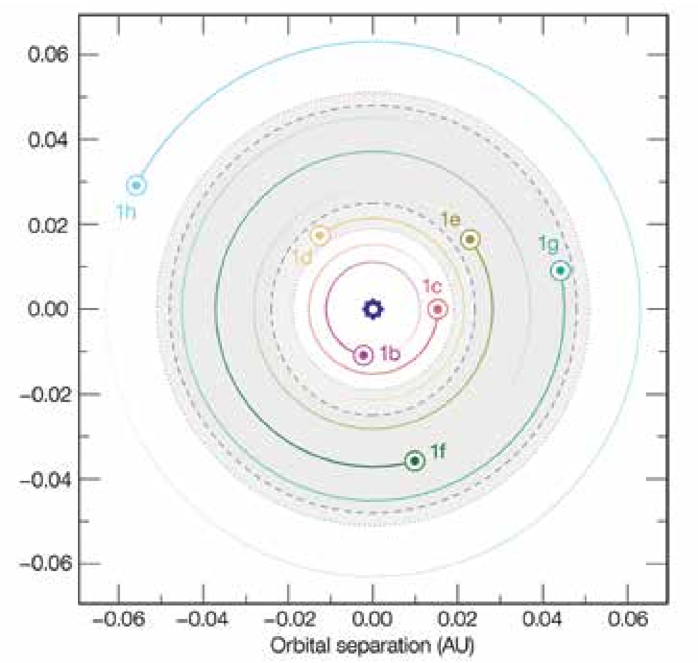


Figure 2. A graphic representation of the seven orbiting planets. The gray zone indicates the region where the authors hypothesize oceans would be able to form. Credit: ESO/M Gillon et al.

all likely to undergo a runaway greenhouse scenario. The further out planets *e*, *f* and *g*, however, appear able to harbor water oceans. Even on the inner planets—*b, c* and *d*—it is possible that there is some liquid water on limited regions of the surface.

Before you get too excited, it's worth noting that Venus, Mars and Earth are all in the 'habitable zone' of the Sun—just like these TRAPPIST-1 planets. As you've probably noticed, Earth is habitable but Venus and Mars are both pretty unpleasant, with Venus hosting sulfuric acid clouds and Mars plummeting to -73 Celsius at night. Check out the astrobites article at https://astrobites.org/2011/12/07/venus-as-a-non-habitable-exoplanet/ for more analysis of 'Venus as an exoplanet'.

So, what next?

As it happens, the Kepler Observatory is actually staring at this system right now: it has a 70-day campaign on this patch of sky, from December 15th 2016 through to March 4th 2017. The Kepler data will be made publicly available immediately after the campaign. Not only does this mean you can get your hands dirty playing with the data if you like, but you can also bet that several exoplanet teams around the world will be itching to do some of their own analysis. We're certainly likely to be hearing more science from the system soon! [Editor's Note: This data is now available at http://archive.stsci.edu/k2/trappist1/.]

The James Webb Space Telescope will almost certainly have a go at characterizing these atmospheres after it launches in 2018. However, this is going to be hard work. David Wilson wrote an Astrobite (https://astrobites.org/2016/05/26/searching-for-signs-of-life-with-the-james-webb-space-telescope/) about the difficulties observing the atmospheres of TRAPPIST-1 *b* and *c*, and the situation for the new planets is likely to be similar.

SETI, the Search for Extra-Terrestrial Intelligence, has already pointed its antennae towards TRAPPIST-1, just in case there are aliens trying to talk to us. Of course, the success of this mission would rely on (a) the planets being habitable, (b) the planets being inhabited, (c) the alien life having evolved to intelligence and (d) that intelligence emitting the sort of signals SETI look for. Well, it's worth a shot, anyway!

Looking further ahead, next-generation ground-based telescopes like the European Extremely Large Telescope, set to be completed in 2025, will be able to detect water on these planets and carry out further atmospheric characterization.

It's certainly clear that TRAPPIST-1 will be under a lot more scrutiny in the near future! ●

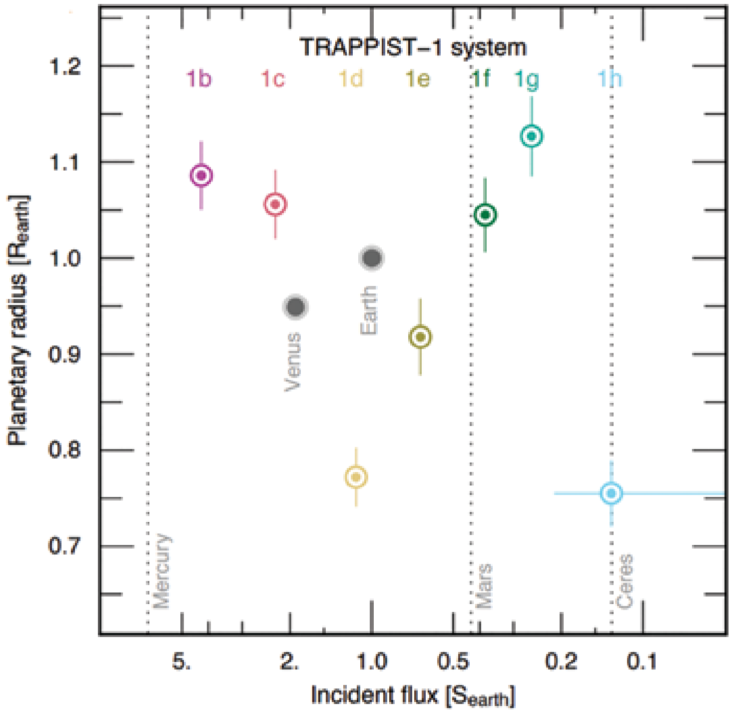


Figure 3. A comparison of the TRAPPIST-1 system and our own solar system. Planets are shown by radius and incident solar flux, with the Earth and Venus also indicated. The flux of Mercury, Mars and Ceres is also shown, with their radii being too small for the y-axis of this plot. Reprinted by permission from Macmillan Publishers Ltd: Nature. Gillon, M. et al. Seven temperate terrestrial planets around the nearby ultracool dwarf star TRAPPIST-1, Nature, 542, 456–460 (23 February 2017), copyright 2017.

This summary originally appeared in Astrobites on Feb 22, 2017, https://astrobites.org/2017/02/22/trappist-1-just-right/.

Paper Title: "Seven temperate terrestrial planets around the nearby ultracool dwarf star TRAPPIST-1"

Authors: Michaël Gillon, Amaury H. M. J. Triaud, Brice-Olivier Demory et al.

First Author's Institution: Space Sciences, Technologies and Astrophysics Research (STAR) Institute, Université de Liège, Belgium

Status: Published in *Nature*, doi:10.1038/nature21360

Updating the Careers Toolbox

by Brad R. Conrad, Kerry Kidwell-Slak, Toni Sauncy, and Katherine Zaunbrecher
Career Pathways Project Team

In 2014, the American Institute of Physics published the first edition of the Career Pathways Project. This National Science Foundation–funded project developed and assembled a comprehensive set of tools to help physics and astronomy majors identify and secure careers after finishing their bachelor's degrees. This work was profiled in the Spring 2014 issue of Radiations as "Taking the 'Hidden' out of 'Hidden Physicists.'" Since this first edition, countless students have participated in Career Pathways workshops led by faculty and staff and gone on to successful careers in a wide range of fields. Many departments have taken the additional step of embedding the material into their curriculum to ensure their students have this critical information prior to graduation. However, as we all know, good things can always be made better, so the Career Pathways team has reassembled to develop the Careers Toolbox for Undergraduate Physics Students & Their Mentors—Version 2.0.

In addition to a new visual identity, the updated guide will encourage more independent use by students and feature the following enhancements:

- Updated statistics from AIP's Statistical Research Center on where physics bachelor degree holders go after graduation, typical starting salaries, and an overview of knowledge and skills regularly used by physics bachelor degree holders employed in the private sector.
- Improved guidance for students from their first year of college through (and beyond!) graduation.
- Sample resumes and tips on how to stand out in an interview.
- Updated tools to help students articulate their achievements and skills.
- Increased emphasis on seeking out and engaging in experiences including student organizations, internships, research, service-learning, and projects.
- Detailed discussions on the appropriate use of a CV versus a resume.
- Redesigned worksheets and exercises to support independent student work.

Whether you are on the job market yourself or have an aspiring physics major in your life, we encourage you to check out Careers Toolbox 2.0 and make use of its resources!

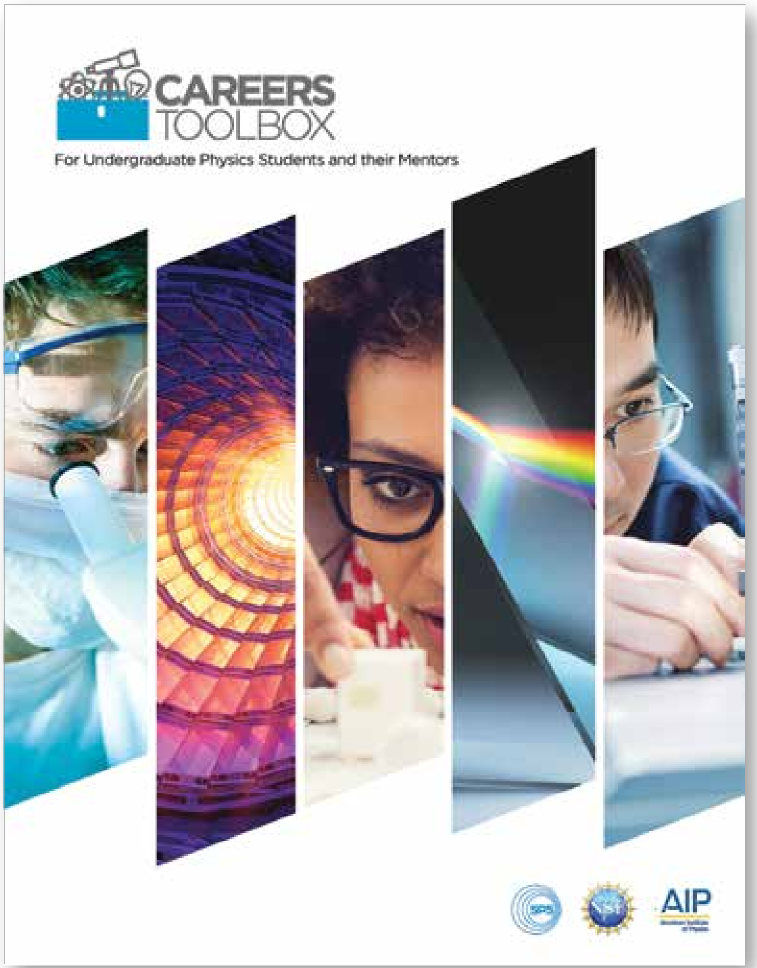


Image courtesy of AIP.
http://www.spsnational.org/career-resources/career-pathways.

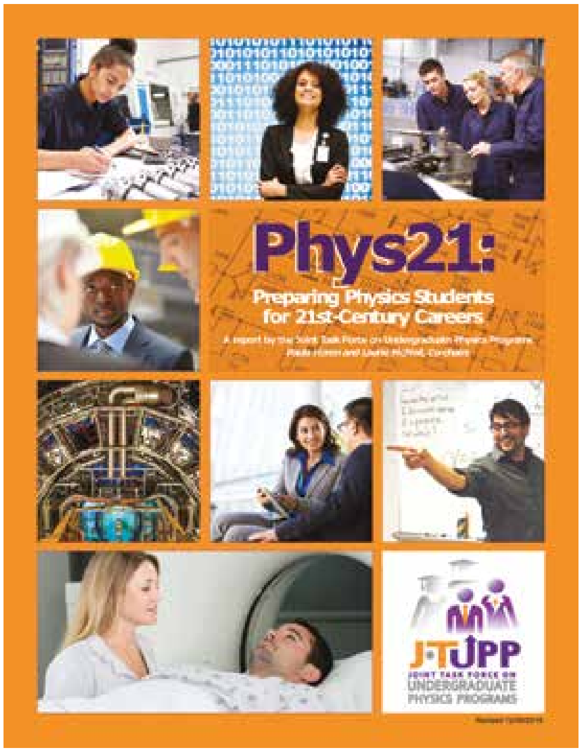
Preparing Students for 21st Century Careers

by Kendra Redmond, Contributing Writer

Physics students heading down the path to becoming professors, researchers, engineers, teachers, programmers, and other professionals in the modern age are entering a diverse and exciting employment landscape—a landscape that many feel unprepared to navigate.

What skills and knowledge should the next generation of undergraduate physics degree holders possess to be well prepared for a diverse set of careers?

This is the question posed to the Joint Task Force on Undergraduate Physics Programs (J-TUPP), a group of leaders in physics academia, industry, and education that was convened in 2014 by the American Association of Physics Teachers and the American Physical Society and supported by the National Science Foundation.



The *Phys21* report is available at http://www.compadre.org/JTUPP/report.cfm. Design by the American Physical Society (CC BY 4.0).

> "What skills and knowledge should the next generation of undergraduate physics degree holders possess to be well prepared for a diverse set of careers?"

J-TUPP tackled this question by synthesizing information from an array of reports and studies that address the career paths taken by physics bachelor's degree recipients and the skills and knowledge valued by today's employers. Their findings are detailed in a new report, *Phys21: Preparing Physics Students for 21st Century Careers.*

Aimed primarily at physics department leaders, the report compiles the knowledge, skills, and attitudes that graduates need for successful careers; learning goals that physics departments can adopt to promote their graduates' success; and descriptions of ways that physics departments, professional societies, and funding agencies can ensure that those learning goals are being met. It also highlights why paying attention to career preparation is important in the first place—the ways in which doing so can enrich and diversify departments, empower students, and support local communities.

Phys21 doesn't promote overhauling core physics content, rather, it suggests a variety of ways in which departments can intentionally incorporate skills like technical writing, project management, teamwork, and computer programming into existing courses while using industry-standard software. To this end, the report includes case studies of physics departments of different sizes and scopes already incorporating these skills into the major in various ways.

"To better prepare students in this way does not require that a department abandon the rigorous technical education that physicists take pride in," write cochairs Paula Heron (University of Washington) and Laurie McNeil (University of North Carolina at Chapel Hill) in the report. "It does, however, require that physics faculty members become informed about the skills and knowledge valued by potential employers of their graduates, and that departments make appropriate modifications to curricular and cocurricular aspects of their programs."

Phys21 and its case studies highlight several ways in which departments can work with alumni and local physicists to better prepare students for 21st century careers. If you are a Sigma Pi Sigma member interested in giving back to the physics community, perhaps one of these ideas will resonate with you:

- Volunteer to give a colloquium or informal talk to your local physics department or SPS chapter.
- Invite local departments to tour your place of work or attend relevant events on your campus.
- Recruit interns and recent graduates from among local physics departments.
- Check in with physics faculty members at your alma mater and let them know where your career has taken you, the skills your industry looks for in new hires, and how you'd like to support current students.

To learn more and download *Phys21*, visit http://www.compadre.org/jtupp/.

The Inventor and Entrepreneur

Michael Brewer
CEO, Allurdata Inc. and Gravaton Energy Resources Ltd., LLC
Sigma Pi Sigma Colorado Mesa University Chapter '90

Photo courtesy of Michael Brewer.

"I look at every problem as a potential solution waiting to be found."

I'm a physicist who invents practical applications and then builds businesses around those applications. Because of my physics background, I look at every problem as a potential solution waiting to be found.

I started and run a software company, Allurdata Inc., that provides software solutions to the healthcare industry. Lowering the total cost of care with better outcomes has been and continues to be our mission. In order to do this, I invented a software framework that can be applied to just about any disparate data system and bring data normalization and analytics to the forefront.

Currently, we are working on goggles that can reveal signs of human diseases when the wearer's eyes are examined. This project is the result of an offer to tutor an optometry student from my alma mater in physics. The student had written a paper on wavefront technology and optometry applications. After reading this paper, I immediately started thinking about what problems this technology could solve.

I also started and run an energy company, Gravaton Energy Resources, that aims to bring low-cost, sustainable energy to market. I invented a system that takes daily air temperature changes and converts those changes into mechanically stored energy that can be released later to power devices such as generators or pumps. As temperatures change every day, everywhere, this is 100% sustainable. I was inspired to create this system after observing how my hot lunch reacted to the Tupperware it was in. One of the first things I learned in the physics lab was to observe what is happening around me.

Running multiple companies is a challenge, especially when they are so different, but I hire really good people and provide them with the tools they need. I'm available to be in the trenches, but my primary focus is company visionary and inventor. I provide the overall strategy and we all make it happen!

I've always had an entrepreneurial attitude. At a young age, I would follow my grandmother on her egg route and sell homemade cookies to her clients. (I was 5 at the time, and the cookies were made of mud.) I've also been lucky in that I've had some great business and personal mentors along the way. One of the main reasons I mentor and provide scholarships today—to honor those who gave to me.

Solving business problems is a lot like solving physics problems: you have parameters that need to come together to formulate an answer and you go through a logical progression to do so. The world has pretty much an unlimited supply of problems, and physicists at all levels are educated and trained to solve problems. It seems obvious that we need more people studying physics. There is no better foundation for life than a degree in physics. You can be and do just about anything.

"There is no better foundation for life than a degree in physics."

I believe in giving back to the communities in which I live, and therefore feel it is my duty to help support physics students in whatever manner I can. I have done this by tutoring physics and calculus, sponsoring student travel to PhysCon, and setting up scholarship opportunities.

One of my proudest accomplishments in academia was helping to get Sigma Pi Sigma and the Society of Physics Students to Mesa State University (now Colorado Mesa University) while I was a student there. I still wear my gold pin with pride. ●

The Medical Physicist

Melissa Lamberto
Medical Physicist at the Department of Radiation Oncology at PinnacleHealth's Cancer Center
Sigma Pi Sigma University of the Sciences Chapter '17

Photo courtesy of Melissa Lamberto.

"It is okay to not always know what to do right away! Sometimes I have to do my research and find alternative solutions with the resources I have available."

Do you want a great conversation starter? Become a medical physicist! Most people I meet ask me the same follow-up question, "You're a what?!" I think it's one of the perks of my title because I get to be the first person to teach them what a medical physicist does! As a medical physicist, I solve new and interesting problems every day. My role in the department is to monitor the safety and efficiency of radiation treatments for our cancer patients. I use my physics background to monitor and calibrate our radiation equipment, implement new technology, and find solutions to technical issues with our systems.

Every patient is unique, so our goal is to come up with the best individualized plan to shrink the tumor, prevent future disease spread, and/or relieve the patient's pain. To get the job done, we work as a cancer care team—the radiation oncologist who prescribes the treatment, the radiation oncology nurse who manages the patient's day-to-day care, the dosimetrist who creates the treatment plan, the radiation therapist who positions the patient for their daily radiotherapy treatment, and, of course, the medical physicist. My role in the group is to provide quality assurance throughout the process. On top of that I work with equipment vendors, engineers, IT specialists, state regulators, and even housekeeping! Coordinating with all of these people is often challenging, but my role as a physicist is to ensure the patient's safety is preserved. I need to make sure that all of the important information is relayed to everyone involved in our patients' care.

On top of working with a variety of people, I get to work with a wide range of equipment. We use cutting-edge technology to deliver treatment in different ways. For example, we can treat the patient with radiation externally from a linear accelerator, or internally with brachytherapy. I need to be an expert in each of these special techniques so I can detect anything from a minor malfunction to a major error. This can be a challenge, especially when multiple problems come up at once. One thing I've learned through my work experience is that it is okay to not always know what to do right away! Sometimes I have to do my research and find alternative solutions with the resources I have available.

Ultimately, though, I get to use physics fundamentals to directly help people stand up to cancer. This is the most rewarding feeling, because I know I am doing something that makes a difference during the most difficult time of a person's life. ●

Share Your Hidden Physicist Story

One of Sigma Pi Sigma's greatest assets is its diversity. Stemming from a common interest in and aptitude for physics, our members have gone on to pursue a multitude of interesting and unusual career paths. Now, more than ever, we seek to draw on the wisdom and experience of our alumni.

If you work outside the traditional physics community, please share your story at www.sigmapisigma.org/hidden.

Responses will be selected for publication in each issue of *Radiations* magazine.

Congratulations
to the newest members of Sigma Pi Sigma

Abilene Christian University
Kaylin Baker
Reuben Byrd
Jacob Caughfield
Eric Hamilton
Caleb Hicks
Brett Hunt
James Johnstone

Adelphi University
Allan Delarosa
Natasha Mohan
Kristen Oldja
Tracy Paltoo
James St. John

Angelo State University
Michael Burt
Alyssa Davenport-Herbst
Jose Duran
Axel Jacquesson
Deyton Riddle
Ashley Wellman

Appalachian State University
Erika Brescia
Jennifer Burris
Andrew Eagle
Ethan Finlay
Scott Hancock
Daniel Hatcher
Julia Hinds
Robert Hughes

Auburn University
Ryan Barker
Joshua Gardner
Cary Laird
James Malloy
Martin Wang

Augustana College
Zayne Blumberg
Daniel Janus
Samuel Totten
Matthew Tuttle-Timm

Austin College
Sophie Anderson

Austin Peay State University
Megan McCracken
Jo Lynn Tyner
Jamin E. Welch
Konstantin Y. Yakshin

Ball State University
Manar Alenezi
Maha Alossiami
Tuffaha Alshammari
Dustin Carter
Brendan Ferris
Dylan Griffith
Kyle Jones
Robin Klause
Alexander Neal
Lillie Robinson
Nathaniel Sparrow
Samuel Teye

Baylor University
Andrew Baas
Christopher Chamness
Carson Heschle
Raquel Katch
Nick Larson
John Lawrence
Taylor Robinett
Adryanna Smith

Benedictine College
John Beckman
Benjamin Bogner
Aidan Gara
Marie Rioux
Nathaniel Strandquist

Berea College
Kyaw Hpone Myint

Berry College
Alex Crouchman
Alexandria Skinner
Chris Whitmire

Bethel University
Nathaniel Anderson
Reese Ferrin
Isaac Goetzman
Tanner Hermanson
David Huffman
Greta Knefelkamp
Joshua Kolbow
Aaron Ludvigsen
Joseph Nelson
Benjamin Schindler
Andrew Schwarz
Stephen Self
Nicholas Stone
Sarah Thorud
Aidan Tollefson
Daniel Upcraft
Erik Vaage
Nathan Wahlberg

SPS Historian Earl Blodgett (far left) with the new initiates of Sigma Pi Sigma at California Lutheran University. Photo courtesy of Earl Blodgett.

Binghamton University, State University of NY
Jaymes Flournoy
Noam Hiltzik
Bradley Phelps
Vincent Plisson
Mathew Reed
Peter Tomlinson

Bloomsburg University of PA
Michael Algeo
Adam Beck
Richard Gusick
Ian Lamey
Harrison Ludewig
Timothy Mackiw
Robert Sherman
Hannah Shriver
Anastasia Timofeeva

Boston College
Noah Barnett
Natasha Bednarz
Matthew Bonidie
Erik Liu
Hanyi Lu
Paul Menker
Ryan O'Connor

Bradley University
Jeffrey Bannister
Michael Wiedl

Bridgewater College
Sean Alberts
Ocean Armstrong
Alexis Czarnatowicz
Allen Ervin
Jeremy Gingrich
Jeremy Pannebaker

Bucknell University
Matthew De Santis
Caroline Edelman
Nathan Wagner

Buffalo State University
Caitlin Horvatits

Butler University
Jason Bradley
Ben Lange
Sedrick Weinschenk

California Lutheran University
Jennifer Anderson
Fransheska Berrios
Mickey Da Silva
Dominic Lunde
Christina Muren
William Parquette
Savannah Sipes

California Polytechnic State Univ., San Luis Obispo
Kevin Armenta
Brandon Fields
Frank Gonzalez
Jacob Hass
Philip Hatcher
Matthew Kehrli
Ryan Lau
Donald Loveland
Joshua Mann
Aidan McGuckin
Caroline Paciaroni
Jessica Pilgram
Hannah Simons
Tomas Snyder

California State University, Chico
Christopher Ard
Eric Ayars
Charris Gabaldon
Tori Goff
Robert Keen
Nicholas Nelson
Elizabeth Pham

California State University, Northridge
Behnam Amlashi
Paul Talledo
Blake Tinoco

California State University, Sacramento
Mark Samuel Abbott
Moses Avetisyan
Caleb Mosakowski
Carlos Pereyra
Cordell Sagan-Lawson
Juan Solorio
Aleksandar Tadic

California State University, San Marcos
Farrah Beattie
Andrea Bruno
Carina Maciel
Uriel Rodea
Bibiana Urquiza Resendiz

Carthage College
Stephen Janke
Ashley Marquette
Michael Merritt
Jordan Rice

Central Michigan University
Jacob Davison
Jacob Elliott
Santosh Gaire
Mahmudul Hasan
Changfeng Jiao
Sharad Mahatara
David McClain
Shree Neupane
Stylianos Nikas
Rajendra Paudel
Mir Hadi Razeghi Kondelaji
Suresh Thapa
Jared Williams
Trivanni Yadav

Central Washington University
Jessica Carder
Jacob Rothschild

Centre College
William Hellman
Anh Nguyen
Reuben Russak-Pribble
Isaac Vock
Tyree Wilmoth

Chicago State University
Felicia Davenport
Keenan Lambert
Calvin Powell
Denzel Tucker

Christopher Newport University
Daniel Carpenter
Matthew Lomicka
Lydia Lorenti
Ralph Marinaro
Katie Whitcomb

Coe College
Ugur Akgun
Dahlia Baker
Garrett Bohach
Chevelle Boomershine
Anthony DeCeanne
Firdevs Duru
Victoria Eng
Gregory Goukas
Hanna Koster
Scott Michalek
Dalton Shadle
Ian Tillman
Collin Wilkinson

Colby College
Sam Arthur
Yohannes Asega
Kathryn Butler
Thomas Cleary
Tarini Hardikar
John Leahy
Yuxuan Li
Alan Ottenstein
Calvin Robbins
Kenny Robbins

Colgate University
Zachary Cleary
Ishir Dutta
Katherine Karnes
Jonah Kudler-Flam
Eric Palmerduca
Zachary Weaver

College of Charleston
Tristan Aft
Sam Bleser
Manuel Canas
Elyana Crowder

Julia Imperatore
Stanley McAfee
Linsey Passarella
Ashley Rice
Collin Weiwadel
Lukas Zalesky

College of the Holy Cross
Kevin Curtin
Seth Kraft
Daniel O'Brien
Zachery St. Pierre

Colorado Mesa University
Jeremiah Moskal

Colorado School of Mines
Jeremiah Moskal
Emily Atkinson
Michael Bainbridge
Jonathan Barolak
Steven Clark
Alexandra Culler
Mark Dudley
Spencer Fretwell
Daniel Gaydos
Joseph Gibson
Anastasia Gladkina
Madeleine Hanley
Paige Husa
Matthew Kowalsky
Randy Lemons
Matthew Martin
Claudia Schrama
Timothy Reeder
Colin Roberts

Concordia College
Thelma Berquo
Austin Heins
Luiz Manzoni

Connecticut College
Nikolas Burks
Lucas Guliano
George Sarkar
Daniel Shinnick
Andrew Stutzman

Creighton University
Olayinka Akinyemi
Sean Lindgren
Mehdi Maleki Sanukesh
Benjamin Marcussen
Michael Mimlitz
Gunnar Nelson
Wayne Peterson
Dan Pham
Sruti Prathivadhi-Bhayankaram
Joseph Preimesberger
Gregory Tschann
Anh Vo
Dat Vu

Davidson College
Cortland Coxhead
Alex Demopoulos
Collin Epstein
John Herron
Alex Karbo
Tan Phan
Ryan Stempert
Xan Stoddard
Jack Taylor
Tina Yuan

Denison University
Jiatao Cui
Adrian Miller
Nicholas Pellar
Julia Proctor
Nicholas Staniszewski
Gan Xu
Shuheng Zhao

DePauw University
Melinda Franke
John Sampson

Dickinson College
Christopher Fritz
Jiahao Han
Sean Jones
Tyler Richey-Yowell
Kevin Skowronski

Dillard University
Pierre Desil
Wydglif Dorlus
Dr. John Eslick
Daniel Jagessar
Shaniah Johnson
Shaelynn Moore
Jovan Roaches-Lambey
James Watson
Jamaya Wilson

Doane University
Eric Bird
Haoxuan (Martin) Huang
Braden Knuth
Sarah Vaughn
Taylor Wehrs

Drew University
Ashley Bloodgood
Michael Clancy
Jenny Soter

Duke University
Jordan Fleming
Craig Madrak
Kaitlin McCreery
Jeong Min Park
Wei Tang
Yuqi Yun
Tianqing Zhang

Duquesne University
Victoria Leonard
Adam Sneath
Jonathan Stapchuck
Jason Weideman

East Central University
Ryan Cloud
Taylor Coss
Mitchel Moore
Kylee O'Dell

Eastern Kentucky University
Ralph Eastham
Aldo Garcia-Guinto
Justin Groves
Mason Reeves
Love Richburg

Eastern Michigan University
Paul Amell
Donald Anderson
John Davis
Blake Hendrix
Dominic Lesniak
Jared
Powell
Jonathan Skuza
Cory Townes

Elizabethtown College
Abby Beyer
Aleeyah Colbert
Liam Coverdale
Dillon Dotson
Dominic Giancarlo
Samuel Hirshberg
Matthew Koerber
Hui Liu
Nolan Ovelman
Evan Pallante
Alec Proffitt

Elon University
Julia Filloon
Brian Matejevich
Erin Murnane
Sydney Schilling

Embry-Riddle Aeronautical University
Mark Beach
Miles Bengtson
Sergei Bilardi
Edmund Cintron
Eliza Gazda
William Griffin
Liam Gunter
Stanimir Letchev
Adam Moss
Sarena Robertson
Shane Stebler
Logan Turco
Anissa Zacharias

Embry-Riddle Aeronautical University, Prescott
Zoe Crain
Leah De Laurell
Ryan MacLeod
Stephen McMillan
Calley Tinsman

Emory University
Zhou Fang
Junghyun Kim

Fairfield University
Robert Cordery
Andrew Danick
Robert Davis
Connor Gleason
Thomas Greenwood
Robert Hansen
Joshua Heilweil
Ravina Hingorani
Karim Kharbouch
Christina Ochoa
Brandon Thomas
Dennis Turano

Florida International University
Gabriel Casabona
Justin Cata
Luis Fernandez
Cynthia Nunez
Mario Olivares
Francesco Sessa

Florida State University
Griffin Bradford
Eric Britt
Leon Hostetler
Alejandro Sanchez

Sigma Pi Sigma members at Florida International University providing tutoring for students in introductory courses. Photo courtesy of Florida International University SPS chapter.

Fort Hays State University
Rodrigo Bauza
Brendan Burgee

Fort Lewis College
Dylan Bunn
Lane Schultz

Frostburg State University
Allen Benton
Caleb Godwin
Nicholas Huff
Brian Leech

Furman University
Charles Garner
Cameron Grondines
Zachary Miller
Mark Perry
Amber Vargas

Georgia College and State University
Allison Jacques
Nicolas Merino
Matthew Pearson
Allison Wilkinson

Georgia Institute of Technology
Rachel Barker
Kevin Choi
Nathaniel W. Moore
Evan Seitz

Georgia Southern University
Elizabeth Ashwood
Anne Delua
Benjamin Eller
William LePain
Xiaomeng Wang

Georgia State University
Colten Cross
Christopher Thurman

Gettysburg College
Sarah Hansen
Amanda Krehbiel
Gordon McCann
Paul McDonnell
Savannah Miller
Dylan Mosquera

Gordon College
Kelly Herrick
Alexander King
Sumin Kyoung
Qiang Jacob Yang

Grand Valley State University
Brandon Aho
DaiLynn Dietz
Bailey Groendyke
Thomas Killeen

Grove City College
Samuel Beiler
Seth Byard
Isaac Hendrickson
Connor Murphy
Caleb Nasman
Hannah Tack
Emily Tharnish

Gustavus Adolphus College
Mikaela Algren
James Bork
Nathan Huber
Nicholas Hulstrand
Derek Huntley
Grace Kerber
Ian McKeag
William Riihiluoma
Rochelle Widmer

Henderson State University
Luke Geoffrion
Arden Hall
Trevor Hicks

Hillsdale College
Christos Giannakopoulos
Laura Salo

Hofstra University
Laura Bennett
Zuzana Calbo
Michael Nino

Hope College
Von Bunnell
Daniel Clark
Jason Gombas
Emily Joosse
Caleb Sword

Houston Baptist University
Maaz Ahmed
Hamza Bhalli
Quynh Do
Otto Gadea
Francisco Herrera
Henry Ho
Audrey Le
Colton Roath

Initiates List 2016–17

Levin Soh
Amanda Tran
Michelle Yates

Howard University
Ameer Blake
Ryan Hubbard
Keenan Hunt-Stone
Sergio Smith
Brianna Thomas

Illinois Institute of Technology
Rui An
Yonas Gebre
Diego Gutierrez Coronel
Keith Hermanek
William Limestall
Beverly Lowell
David Mahler
Wangping Ren
Hilal Saglam
Rachel Seibert
Chang Xu

Illinois State University
Andrew Eggers
Noah Osman
Zachary Romersberger
Cory Russ
Prestin Van Mieghem

Indiana State University
Mitsuko Korobkin
Daniel Merrill

Indiana University Purdue University - Fort Wayne
Cy Bentley
Benjamin Hunley
Michael O'Connor
Alyssa Robison

Indiana University South Bend
Haley Borsodi
Anthony Hanner
Brian Huge
Levi Klopfenstein
Phillip Marmorino
Paige Oedekerk
Michael Rauschenbach
Jared Ryman
Sandeep Sengupta
Christopher Warkentin

Ithaca College
Salvatore Ferrone
Alexander Gable
Amy Parker
Kevin Pomer

Jacksonville University
Misha Chalkley
Peter Hidley
Jeremy McDermet
Travis Pulliam

James Madison University
Max Cannon
Ian Davenport
Nicholas Duncan
Justin Leas
Joseph LoPreto
Zach Marinelli
Aaron Midkiff

John Carroll University
Aydan Hanlon
Matthew McGreal
Alexandra Montesano

Juniata College
Fadzai Fungura
Yu Gu
Kate Jamison
Joshua Katz
Mark Pearson
Janet Peifer
Kang Yang

Kansas State University
Benjamin Archibeque
Jeremiah Clark
Kaleb Cox
Pauline Dredger
Natasha Graham
Brett Kippley
Margaret Lang
James Minton
Jacob Peyton
Amber Thompson
Cheyne Weis
Tristan Wells Filbert

Kent State University
Jonathan Boyd
Benjamin Hivick
Michael Skowrons
Jacob Taylor
Corey Zickel

Kenyon College
Ellen Holmgren
John Lyons
Graham Reid
Christian Solorio
Timothy Sullivan
Avery Tishue

Kettering University
Sally Dagher
Eric Golab
Devin Richardson
Megan Warteman

Lafayette College
Ian Miller
Brandon Pugnet

Lawrence University
Rylo Ashmore
Kirstin Edwards
Aedan Gardill
Anh Hoang
John Hosmer-Quint
Christopher Kiehl
Theodore Kortenhof
Joseph Liberko
Rachel Lindley
Cody Poole
Clayton Ristow
Alexander Shahbazi
Peiying Yu

Lebanon Valley College
Justin Cammarota
Jeffrey Dundore
Nicholas Pollak

Lewis University
Samuel Baker
William Kostecka
David Santefort
Ryan Smith
Sean Smyth

Longwood University
Nicole Marzolf
Esteban Sosa Garduno

Louisiana State University Baton Rouge
Rory Bentley
Benjamin Box
Zachary Bradshaw
Margarite LaBorde
Patrick Quebedeux
Brian Razin
Derek Walker

Loyola University Maryland
Adrian Halarewicz
Dalton Spatz

Loyola University - New Orleans
Tirthabir Biswas
Chasen Himeda
Christopher Lorenzo
David Olivier
Randy Qafaiti
Spencer Rosenbohm
Cody Smith

Luther College
Zachariah Martin
Megan Petzold

Lycoming College
Brendan Drachler
Ian LaBar

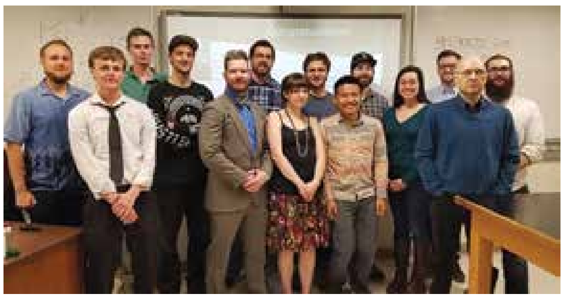
Lynchburg College
Alex Vaughan

Manchester University
Thomas Dean
Benjamin Niederhelman
Kidist Tessema

Manhattan College
Christina Hibner

Marietta College
Thomas Korda
JiangHong Wan

Marquette University
Bradley Cole
Thomas Dietz
Anthony Francisco
Noah Greenberg
Margaret Johnston
Elise Rimsa



Metropolitan State University and University of Colorado – Denver each chartered new chapters and welcomed their first classes of initiates in 2017. Photo courtesy of Metropolitan State University.

Ryan Schumm
Brian Touhy

Massachusetts Institute of Technology
Abdullah Alsalloum
Brandon Benson
Uttara Chakraborty
Shi-Fan Chen
Alexander Dalzell
Boryana Doyle
Matthew Hodel
Robert Jones
Saarik Kalia
Yu-Ting Liu
William Moses
Alana Papula
Connor Popik
Andres Rios Tascon
Tomohiro Soejima
Nagisa Tadjfar
Michael Traub
Vickie Ye
Chengkai Zhang
Grace Zhang
Kevin Zhou

McDaniel College
Gracie Chaney

Mercyhurst University
Marina Frato
Christian Gamboa
Mary Jaskowak
Jenna Uhlig

Messiah College
Lindsey Barner
Andrew Grove
Hallie Miller

Metropolitan State University of Denver
Kempton Albee
Pathik Evan Bollaidlaw
Michael Chambliss
Keegan Karbach
Jessica Nelson
Michael Painter
Brendan Richards
Michael Roos
Heather Whittier

Miami University
Hong Cai
Lindsay Darkins
Mitch Mazzei
Robert McCutcheon
Dylan Palo
Tej Poudel Chhetri
Alexander Staron
Anthony Young

Wei Zhou

Middle Tennessee State University
Bassam Aboona
Jackson Cole
Emma Gist
Hannah Graham
Benjamin Kulas
Stephanie Lough
Aric Moilanen
Jeffery Summers
Beverly Warner
Nicholas Whitt

Midwestern State University
Tonderai Madamba
Roderic Savage
Nicholas Utley

Millersville University
Keith Coasey
David Doerr
Elizabeth Dulac
Kevin Goring
Dylan Huska
Isaac Whitcraft

Minnesota State University Moorhead
Erin Aadland
Andrew Block
Elias Holte
Laura Maixner
Paige Meyer
Stefan Nelson
Jared Saunders

Moravian College
Brittani Costa
Nicholas Mazzella
Dylan McDonald
Shayna O'Boyle

Morehouse College
Ibrahim Apata
Xavier Bonner
Samad Emory
James Stukes

Mount Holyoke College
Xiaoxue Gao
Laura Hunter
Amy Longstreth
Puyang Ma
Kathleen Smith

Muhlenberg College
Carlos Herrera Acevedo
Alan Mendez
Richard Morash
Carly Press
Kristina Qualben
Kelly Tornetta

Murray State University
Patrick Haney
Dylan Stewart

National University of Singapore
Pulkit Agarwal
Swaminathan
Ananthanarayanan
Meer Ashwinkumar
Philemon Chan
Philip Chan

Poon Jun Xian
Tan Jyh Harng
Rachel Seah
Zi Heng Wong
Wee Siang Edmund Yuen

Nebraska Wesleyan University
Matheus Bustamante
Carter Lyons
Trevor McKeown
Trey Seibel

New Mexico Institute of Mining and Technology
Matthias Banet

New Mexico State University
Zachary Chiodini
Michael Kaemingk
Elijah Schold
Taylor Uselman
Rico Vallejo

New York University
Joseph Corrado
Akshunna Dogra
Sophie Dvali
Adolfo Holguin
Kaitlyn Morrell
Ahmed Sherif
Mats Thijssen
Niclas Wahlstrom
Jiayang Wang
Jeffrey Wang
Yusheng Zhao

North Carolina State University
Thomas Bailey
Ryan Brandt
Emily Brown
David Calvert
Bryan Chu
Keilah Davis
David Sedano
Jessica Sullivan
Bjorn Sumner
Jared Michael Taylor
Johnathan Turner

Northern Arizona University
Tyler Dawson
Winston Fredrickson
Sean Graham
Corrie Vanlaanen
Robert Voinescu

Northwest Nazarene University
Kelsey Martin
Ian Neil
Andong Yue

Northwestern University
Lauren Barmore
Rebecca Diesing

Occidental College
Emily Duong
Leah Feuerman
Adam Florsheim
Michael Harriss
Brian Okimoto

Ohio Northern University
Eric Collins

Shota Hodono
Austin Howell
Carly Mathewson

Ohio University
Zachary Bernens
Zak Blumer
Ari Blumer
Brandon Coleman
Taylor Gardner
Esther Grossman
Joseph Pincura
Sara Sand
Justin Warren

Ohio Wesleyan University
Joseph Emerson
Shouta Fukamachi

Old Dominion University
Daniel Ens
Alexander Maddock
Amethyst Maps
Juan Rodriguez

Oregon State University
Yousif Almulla
Bethany Bachmeier
Ryan Bailey-Crandell
Matthew Ball
Benjamin Bauml
Hazel Betz
Gregory Brandt
Elliot Capek
Nicholas Cassar
Katelyn Chase
Karandeep Cheema
Rafid Chowdhury
Kelda Diffendaffer
Patrick Flynn
Darlene Focht
Michael Forkner
Jesse Hanson
Cassandra Hatcher
Isaac Hodges
Ryan Lance
Tymothy Mangan
Ikaika McKeague-McFadden
Jeremy Meinke
McKenzie Meyer
Chris Miraflor
Austin Mullins
Micah Nash
Gabriel Nowak
Evan Peters
Jesse Rodriguez
Heidi Schellman
Tanner Simpson
Abraham Teklu
Megan Tucker
John Waczak

Penn State Erie, The Behrend College
Chrystopher Goodteacher

Pittsburg State University
Georgette Searan

Presbyterian College
Musashi Briem
Ellen D'Amico
Jonathan Turnley
Salem Wright

Providence College
Claire Kleinschmidt

Radford University
Jacquelyn Burns
Joshua Carroll
Liuni Chen
Morgyn Church
Teagan Eaker
Logan Fisher
Ryan Fry
Timothy Milloff
Nicholas Schrecongost
Matt Van Shufflin
Nick Whisler

Randolph College
Yuriy Snyder

Randolph-Macon College
Todd Baber
Shawn Barry
Gregory Beale
Ashley Easterling
Jacob Hickman
Alex Keller
Rebecca McGilvery
Susan Snee

Rensselaer Polytechnic Institute
Hunter Belanger
Ethan Brown
Peter Craig
Edwin Cruz Aguirre
Andrew Cupo
Andrew DiBiasio
George Dowhan
James Flamino
Jennifer Freedberg
Zachary Harris
Ravi Panse
Alan Pearl
Natalya Sheremetyeva
Leaf Swordy
Humberto Terrones
Esther Wertz
Madison Wyatt
Anthony Yoshimura

Rhodes College
Jordan Ankersen
McKenna Davis
Madisen Duke-Bruechert
Luke Fairbanks
Eleanor Hook
Matthew Huber
Saad Khalid
Mary Kate Meacham
Joel Michelson
James Stuckey
Taichen (Leo) Zhou

Ripon College
Robert Appleton
Robert Enright
Nay Htet
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