Radiations

SPRING
2018

The official publication of Sigma Pi Sigma

SCIENCE TOURISM

Travels Through the **Atomic Age**

Walking in **Benjamin Franklin's Footsteps**

Cleveland State **Reactivates** Its Chapter

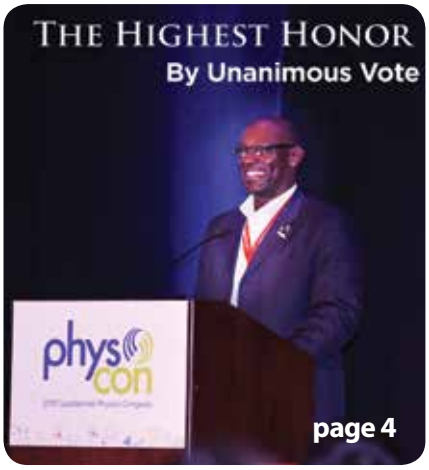
GradSchoolShopper.com

GradSchoolShopper.com
is a FREE service for undergrads!
Sign-up for a FREE account on
our site OR get the book for FREE!

Interested in listing your department?
Contact: info@gradschoolshopper.com
(301) 209-3026

AIP
American Institute of Physics

Contents



ON THE COVER

Star trails swirl around Polaris, the North Star, above the Hobby-Eberly Telescope at the McDonald Observatory at the University of Texas, Austin.

Credit: Ethan Tweedie Photography.

Departments

Radiations

Spring 2018
Volume 24, Issue 1

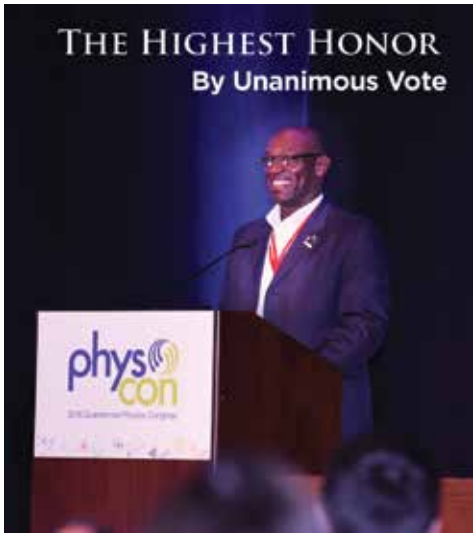
Radiations (ISSN 2160-1119) is the official publication of Sigma Pi Sigma, the physics honor society, published twice per year by the American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3841. Printed in the USA. Standard postage paid at Columbus, OH. POSTMASTER: Send address changes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

President's Corner

Looking *Forward:* Solve the Unsolved

by Willie S. Rockward, Sigma Pi Sigma President, and Brad R. Conrad, Director, SPS and Sigma Pi Sigma



As elections for Sigma Pi Sigma president wrap up this spring, Brad Conrad and I would like to leave everyone with a few guiding thoughts that I hope you are able to keep with you well into the future. First, I'd like to thank you for your support and confidence in allowing me to serve as your Sigma Pi Sigma president since 2014. I look forward to my continued involvement in Sigma Pi Sigma and SPS because "the highest honor" is to honor scholarship, encourage interest in physics, share fellowship among those who excel in physics, and promote an attitude of service.

Through our involvement in Sigma Pi Sigma and SPS, we have learned to embrace the following:

Physics is for everyone! Or, more accurately, physics has been and always will be for everyone, because it takes everyone to make it all happen. This concept sometimes gets lost in the frenzy of life, careers, and classes, but it's a beautiful realization about the pursuit of truth. The deepest scientific truths of the universe are never found by one person, in one moment. As physicists, we don't seek to *solve the solved*; rather we seek to *solve the unsolved*, and that will take all of us. So to explore the unknown and investigate the strangeness that is the observable universe, we share what we learn, think, and hypothesize as a community.

We each have something to contribute, especially in-reach and outreach. The problems we investigate vary far and wide, as physics—and the fundamental relationships we study—touch so many professions and disciplines. We have been successful because we have approached these diverse problems with a diverse group of people. It's this variance in approach that will help us solve the problems of the 21st century and beyond. Yet, to fully realize our potential, we must make sure we reach out not just to friends or classmates, but to everyone, from all experiences and disciplines. Searching for the unknown shouldn't be limited to a select group of people or generation.

We must provide opportunities for the future of physics, unborn. While Sigma Pi Sigma membership honors excellence within the field, members are also called to encourage interest in physics at all levels. One of the main ways we support our newest members and the next generation of physicists and astronomers is through our Physics Congress, or PhysCon. Sigma Pi Sigma and the Society of Physics Students will host PhysCon 2019 in Providence, Rhode Island, from November 14–16, 2019. Our theme nicely summarizes our intent: We'll be **Making Waves & Breaking Boundaries.** One of PhysCon's co-chairs, Steve Feller, shares more about this volunteer-led conference on page 9.

While this congress is vital for the future of physics, we're only able to fund and organize it because of the financial support of many Sigma Pi Sigma members. By supporting an endowment for this conference, we can ensure that PhysCon exists in perpetuity and that future generations of students are able to become the problem solvers of the next generation. As we are a grassroots organization, every little bit makes a big difference to the students. All donated funds will go directly to supporting inclusive undergraduate conferences. Become a sustaining member and please help us make PhysCon 2019 a reality by visiting **donate.aip.org/centennial-campaign.**

Physics is for everyone. When everyone contributes, we, collectively, provide opportunities that further our goal of solving the unsolved. We must strive to make our community as open, wide, and vibrant as the science that we study.

When we reach in through outreach, we generate fellowship, encouragement, scholarship, and service—all together, it is the pursuit of excellence that defines us. We become the problem solvers of the next generation. **We are because physics is!**

Sigma Pi Sigma Is Building Bridges at Cleveland State University

by Samantha Tietjen, SPS Member, and Kiril Streletzky, Chapter Advisor & Zone 7 ZC, Cleveland State University

The physics department at Cleveland State University (CSU) has boasted impressive growth over the past 12 years, and with it have come successes in both employment and graduate program acceptance. Recent graduates have gone on to NASA, NREL, CERN, Cleveland Clinic, Caltech, Johns Hopkins, and Carnegie Mellon, among others.

The growth has been attributed to the program's academic quality, as well as research and teaching opportunities available to undergraduates within the department. "It is very rare to have a department that is both small enough to really care for each student and also academically rigorous and rich with research and teaching opportunities," says 2011 graduate Krista Freeman (PhD, Carnegie Mellon, postdoc at University of Pittsburgh). "So I always think to myself how lucky I was to get the best of both worlds."

Meanwhile, student engagement has also flourished through CSU's award-winning Society of Physics Students (SPS) chapter. But while growth in these areas has helped to foster connections with recent graduates, there's been little interaction with alumni who are well established in their fields. CSU's SPS hopes to bridge this gap by reviving the university's Sigma Pi Sigma chapter, which started in 1969 but has been dormant since 1972.

The link the chapter will create between students and alumni who are active in industry and academia is essential for physics majors nearing graduation and for students seeking research or employment experience. A planned 2018 induction ceremony and formal networking dinner will begin opening up these invaluable pathways.

Says 2009 graduate Vincenzo LaSalvia, now a process engineer at NREL, "The plentiful opportunities and experiences that I was fortunate to accumulate throughout my years [at CSU] are what definitively shaped my calling as an engineer and innovator." The goal for CSU's reestablished Sigma Pi Sigma chapter is to connect current students with alumni like Vincent who have excelled in physics.

The CSU Outreach Team after hosting a NASA astronaut at Campus International K-8 Cleveland public school. From left to right: Jim Pitchford (CSU alumnus), Tony Dobrila, John H. Oldham (Logistical Innovations, Inc., exhibits specialist and lunar sample coordinator), Dr. Kiril Streletzky (CSU SPS advisor), Samantha Tietjen, Dr. Krista Freeman (CSU alumni/Carnegie Mellon alumnus), Aubrey Lokey. Photo courtesy of Kiril Streletzky.

Information on the successes of CSU physics alumni is being carefully and disseminated. Photo courtesy of Samantha Tietjen.

RIGHT: Drace Adams and Samantha Tietjen with CSU alumnus Dr. David C. Spelic during his visit to CSU's SPS chapter. Photo courtesy of Kiril Streletzky.

Your *Favorite* Science Spots

1. Giza Plateau, Cairo, Egypt

According to famed Egyptologist W. M. Flinders Petrie, the perimeter of the Great Pyramid is 3023.22 feet and the height is 480.69 feet. This gives a perimeter-to-height ratio of 6.28 or 2 Pi, making this pyramid a representation of a hemisphere on the ground. This is a fantastic construction and mathematics feat, especially when you consider the date of construction.

– Steven Frasher, 1969, US Naval Academy

2. European Space Agency

My first time visiting the European Space Operations Centre (ESOC) was in October 2017, during the launch of the latest Copernicus satellite, Sentinel-5p. ESOC coordinates satellite control, monitoring, and data retrieval for the European Space Agency. I helped cover the launch on the official ESOC social media channels, and met several members of the Mission Control team!

– Lisa McDonald, 2016, Coe College

3. Lick Observatory, Mt. Hamilton, California

Lick Observatory was the first permanently occupied mountain–top observatory. In those days [the scientists] lived on the mountain; we lived and breathed astronomy. I not only learned about the science, I also learned about the integrity and collegiality of the field.

– Sethanne Howard, 1986, Georgia State Univerity

We asked Sigma Pi Sigma members to tell us about the places that have been especially memorable to them through their scientific careers. Below is a small sample of the exciting places our members have visited in the name of science.

4. Yellowstone National Park, Wyoming

This place has the highest concentration of geysers in the entire world and shifted my research interests from astrophysics to geophysics.

– Mara Reed, 2017, University of Wisconsin-Eau Claire

5. My kids' eyes, Arizona

My favorite science spot is my kids' eyes! The magic and awe they behold in the world is a constant reminder for me to pause and think, to enjoy and relish the beauty in the micro level – that which they don't see – yet!

– Benita Riesgraf, 2001, Lewis and Clark College

6. Green Bank Observatory, West Virginia

Visiting the tranquil observatory immediately summons up romantic visions of what once was: a mecca where young and old radio astronomers could gather and shed the distractions of daily life to study, learn, and live together.

– David Buch, 2017, West Virginia University

7. Virginia State College, Virginia

While studying physics at Virginia State College, Dr. John M. Hunter built cubicles in the basement of Colson Hall. Each physics major was assigned one of these cubicles; this was our own personal space to perform the experiments that were assigned as independent research.

– James H. Stith, 1971, Virginia State University

8. The Braun-Ruddick Seismograph Station, New York

What look like simple tabletop devices are a series of seismometers that can detect vibrations from an earthquake halfway around the world. Since the station is automated, measurements are taken continuously, always ready for the next big earthquake.

– Michael Wood, 1994, The Catholic University of America

PHYSICS TODAY | JOBS

is your resource for targeted STEM jobs.

Find your future at physicstoday.org/jobs

Get Ready: **PhysCon '19** is Making *Waves* in Providence

by Steve Feller, Coe College Physics Department, Co-Chair PhysCon 2016 and 2019, and Chair PhysCon 2008 and 2012

The three pictures in this announcement are wonderful reminders about PhysCon 2016, held in Silicon Valley. In the first picture below, Jocelyn Bell Burnell, discoverer of pulsars and honorary chair of both the 2016 and 2019 congresses, visits with students and me. What a thrill for these participants! How exciting it was to be able to chat informally with a true heroine of science.

Below that is a picture of the Coe College contingent, 39 strong. What an experience we all had—what memories and camaraderie resulted. Over a year later, we are still buzzing over the wonderful speakers, workshops, tours, and friends we made. We are ready to come, in force, to Providence, Rhode Island, for PhysCon 2019, November 14–16, 2019. Almost 1,200 people, mostly students, attended in 2016 and we expect 1,500 total attendees in 2019. Our theme? **Making Waves & Breaking Boundaries.**

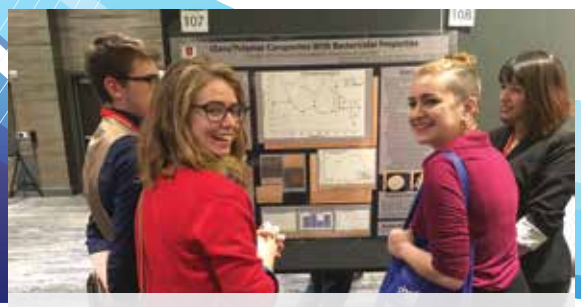
First row (left to right): Dhalia Baker, Jocelyn Bell Burnell, Brittney Hauke, and Isabell Diggens; second row (left to right): Steve Feller, Collin Flynn, and Patrick Kralik. Photo courtesy of Steve Feller.

PhysCon is a very special chance to network, give a poster, hear a plenary talk from one of the best in physics, gain self-confidence, make lifelong friends among colleagues from around the nation and abroad, and, frankly, to become excited by and engrossed in state-of-the-art physics.

For example, imagine the excitement of learning about supersymmetry from Dr. Jim Gates during a plenary talk and then having an intimate conversation with him after about his incredible ideas. That happened at PhysCon 2016.

What makes this event particularly special for undergraduates is that it is specifically designed for them. There is no other meeting like it in physics. Undergraduates will be front and center on the national stage.

As Sigma Pi Sigma members, you have a unique opportunity to support this event and current physics and astronomy students. We encourage you to reach back to your chapters to encourage their attendance, give to support the Congress Student Travel Fund at donate.aip.org, or even plan to attend yourself to serve as a mentor to today's students. Check *Radiations, The SPS Observer, Physics Today,* and the congress website (www.sigmapisigma.org/congress/2019) for updated details as we add speakers, tour sites, and the like. PhysCon 2019 will surely be the largest gathering of undergraduate physics majors in history. Don't miss your opportunity to take part!



(Left to right) Patrick Kralik, Chevelle Boomershine, Isabella Sorenson, and Victoria Eng at PhysCon 2016. Photo courtesy of Steve Feller.

LEFT: The Coe College 39 at PhysCon 2016. Photo courtesy of Steve Feller.

Fall 2017 Chapter Awards

Congratulations to the following winners of the Fall 2017 Chapter Awards. These awards are made possible in part by generous contributions from Sigma Pi Sigma alumni. For examples of past award-winning projects, visit www.spsnational.org/awards/chapter-awards.

Future Faces of Physics

Future Faces of Physics Awards are made to SPS chapters to support projects designed to promote physics across cultures. The goal of the Future Faces of Physics Award is to promote the recruitment and retention of people from groups historically underrepresented in physics.

Adelphi University
Labs for Kids
James St. John (Leader)
Matthew Wright (Advisor)

California State University – San Marcos
CSUSM's Aim for Diversity in Physics
Jesus Perez (Leader)
Justin Perron (Advisor)

Coe College
G5: Girls are the 5th FUNdamental Force
Annie Ruckman (Leader)
Firdevs Duru (Advisor)

University at Buffalo
Women in Physics
Samuel Powers (Leader)
Salvatore Rappoccio (Advisor)

University of Southern Mississippi
Promoting Physics in Mississippi
Megan Payne (Leader)
Michael Vera (Advisor)

University of the Sciences
Strange Science: Unmasking the Weirdness of the Quantum Realm
Brett Conti (Leader)
Roberto Ramos (Advisor)

Utah State University
PhysX: High School Girls Exploring Opportunities in Physics
Vanessa Chambers (Leader)
David Peak (Advisor)

SPS Chapter Research

The SPS Chapter Research Award program provides calendar-year grants to support local chapter activities that are deemed imaginative and likely to contribute to the strengthening of the SPS program.

Florida Polytechnic University
Feasibility Studies of Dolomites from Phosphatic Pebble for Thermochemical Energy Storage and CO_2 Sequestration
Wyatt Liptak (Leader)
Sesha Srinivasan (Advisor)

Ithaca College
The Naked Eye Observatory
Adam Rabayda (Leader)
Michael Rogers (Advisor)

Purdue University – West Lafayette
Quantitative Evaluation of Pedestrian Movement Models: A Real Many-Body Problem
Adam Kline (Leader)
Rafael Lang (Advisor)

Suffolk University
Neutron Production and Detection Techniques Around A 15 MeV Medical LINAC
John Thomas (Leader)
Prashant Sharma (Advisor)

University of Central Florida
Cavendish Experiment
Brian Ferrari (Leader)
Costas Efthimiou (Advisor)

University of Maryland
Constructing a Watt Balance to Redefine the Kilogram
Siddhartha Harmalkar (Leader)
Donna Hammer (Advisor)

Marsh W. White

Marsh W. White Awards are made to SPS chapters to support projects designed to promote interest in physics among students and the general public. The award dates back to 1975 and is named in his honor for his long years of service to ΣΠΣ, and the community.

Cleveland State University
Lunchtime Physics Club for True Inquirers
Samantha Tietjen (Leader)
Kiril Streletzky (Advisor)

Florida Polytechnic University
STEM Day Outreach at Florida Polytech
Wyatt Liptak (Leader)
Sesha Srinivasan (Advisor)

Hamline University
Renewable Energy in Units Anyone Can Understand
Zachary Pearson (Leader)
Lifeng Dong (Advisor)

Henderson State University
Science Olympics
Jackson Baber (Leader)
Shannon Clardy (Advisor)

Ithaca College
Phun with Physics
Adam Rabayda (Leader)
Michael Rogers (Advisor)

University of Alaska Fairbanks
Solarpalooza: A Solar Viewing Experience
Riley Troyer (Leader)
David Newman (Advisor)

University of Maine
Renewing Physics Demos for Community Outreach
Graham Van Goffrier (Leader)
Charles Hess (Advisor)

University of Rochester
Physics Pentathlon
Adina Ripin (Leader)
Frank Wolfs (Advisor)

University of Southern Mississippi
Promotion of Physics in the Hattiesburg Community
Megan Payne (Leader)
Michael Vera (Advisor)

University of the Sciences
Renewable Energy: Sustainable and Attainable
Austin Vantrease (Leader)
Roberto Ramos (Advisor)

Utah State University
Sucking Life Back into Physics Demos
Benjamin Lovelady (Leader)
David Peak (Advisor)

Sigma Pi Sigma Chapter Project

The Sigma Pi Sigma Chapter Project Award provides funding of up to $500 for chapter inductions and events.

Adelphi University
Alumni Dinner
James St. John (Leader)
Matthew Wright (Advisor)

Cleveland State University
Reviving the Sigma Pi Sigma Chapter at Cleveland State
Samantha Tietjen (Leader)
Kiril Streletzky (Advisor)

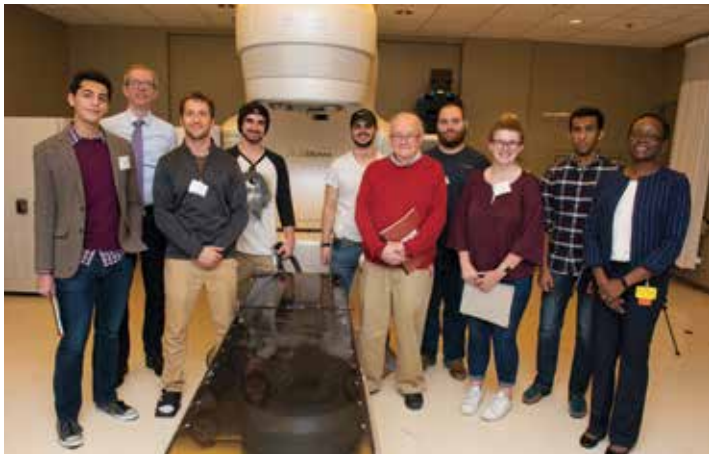
Colorado School of Mines
Physics for the People: Community Lecture Series
Emily Atkinson (Leader)
Timothy Ohno (Advisor)

St. John's University
Science for Humanity
Rachel Tyo (Leader)
Charles Fortmann (Advisor)

University of Maine
The Sigma Pi Sigma Induction & Awards Banquet
Samuel Borer (Leader)
Patricia Byard (Advisor)

University of Maryland
Sigma Pi Sigma Induction Ceremony & Banquet Dinner with Physics Alumni
Siddhartha Harmalkar (Leader)
Donna Hammer (Advisor)

University of the Sciences
Sigma Pi Sigma: Celebrating Diversity in Physics
Alyssa Petroski (Leader)
Roberto Ramos (Advisor)



Suffolk University SPS Chapter members at Massachusetts General Hospital where they collect data for their SPS Chapter Research project.

Exploring the Scientific Centers in Europe

by Ugur Akgun, Associate Professor of Physics, Coe College, and Firdevs Duru, Assistant Professor of Physics, Coe College

In May 2017, 16 Coe College physics students had the opportunity to visit many of Europe's current and historical scientific centers and to learn about the culture of physics in Europe. We designed this three-week-long course, titled Scientific Development in Europe, based on our extensive research collaborations, and personal connections, in various European countries.

Our first stop was Amsterdam. The first day we visited the European Space Agency's (ESA) ESTEC campus, located about an hour away in Noordwijk. ESA is an international space research center with 22 member states. ESTEC is the center for science missions—such as to the International Space Station—and spacecraft missions. Among the ESA's many missions, Coe College students are most familiar with the Mars Express, which has been orbiting Mars for over a decade. Duru and her students use its data to understand the ionosphere of the red planet. The students had the opportunity to go on a very engaging tour that summarized all of the past, current, and near future ESA projects.

The next day we visited the Leiden University physics department. The university was established in 1575 and was home to historical figures such as Hendrik Lorentz, Heike Kamerlingh Onnes, and Paul Ehrenfest. The physics department showed us great hospitality. We visited the Onnes Laboratory, where liquid helium was first made, and toured four different modern laboratories where cutting-edge imaging research is being conducted.

As part of the class, students were required to complete cultural tours in each country. In the Netherlands, our cultural stops were the Van Gogh Museum, the Rijksmuseum, the Keukenhof tulip gardens, and the historic city of Leiden.

After four busy days in Amsterdam, our coach bus took us to Geneva, Switzerland. Our top destination in the city was CERN, the largest particle physics laboratory in the world, with over 30 member nations. Akgun and Duru had both worked on the Compact Muon Solenoid (CMS) experiment of the Large Hadron Collider (LHC), where the Higgs boson was discovered in 2012. Coe students have been actively working on upgrade studies of the CMS detector since 2011.

Our collaborators took us 100 meters underground into the LHC tunnel, which was a thrilling experience for everyone. We also visited the Payload Operations Control Centre (POCC) of the Alpha Magnetic Spectrometer (AMS) experiment, a collective effort by NASA and CERN. The AMS experiment is looking for dark matter, antimatter, and missing matter from a module on the International Space Station.

Also in Geneva, we visited the United Nations to appreciate the largest international collaboration outside of the sciences.

Our last activity in Switzerland was a day trip to Bern, where we visited the house Einstein lived in when he was a patent clerk. While there, he wrote the revolutionary 1905 papers that introduced special relativity, linked mass and energy, and changed physics forever.

Our trip continued to Italy. We made a cultural stop in the historic city of Milan, where we visited the magnificent Duomo, the Sforza Castle, and many small, old churches with glorious frescoes. In Trieste, we visited the Abdus Salam International Center for Theoretical Physics (ICTP), where theorists from all over the world collaborate to discover new frontiers in physics. During the ICTP tour, students learned about Abdus Salam, the Pakistani Nobel laureate who established the center in 1964.

We then visited Italy's Elettra Synchrotron Light Source facility, also in Trieste. Unlike the other facilities, Elettra is controlled by a single country, yet it still hosts scientists from around Europe.

We spent our final day in Italy on a trip to the magnificent city of Venice, then continued on to Prague, which served as the capital of the Holy Roman Empire and was home to Tycho Brahe, Johannes Kepler, Christian Doppler, Ernst Mach, and even Albert Einstein.

Charles University, established by the Emperor Charles IV in 1348, is the best place to learn about the history of science in Prague. Our collaborator,

physics professor Frantisek Nemec, gave us a special tour of the Charles University Museum. The museum is located in the underground vaults of the ancient university building and showcases the almost 600-year-long history of the university, including the Chemistry Nobel awarded to Jaroslav Heyrovsky.

In Prague we also got a very detailed tour of the COMPASS Tokamak, housed at the Institute of Plasma Physics of the Czech Academy of Sciences. The COMPASS Tokamak is a functional device that allows scientists to study the fundamentals of energy production via fusion. This knowledge will be used in the much larger fusion reactor ITER (International Thermonuclear Experimental Reactor), currently being built in France.

Our last stop on this long expedition was Copenhagen, where we visited the Niels Bohr Institute of Theoretical Physics. Here, the Copenhagen Interpretation was developed by Bohr and his disciples Werner Heisenberg, Wolfgang Pauli, and Paul Dirac. The institute's historian gave us a tour that brought this very important era of quantum physics to life for our students. We also learned some interesting facts—for example, the first location of CERN's theory division was the building adjacent to the Bohr Institute. We wrapped up our trip with a visit to Rosenborg Castle and enjoyed the eclectic city of Copenhagen.

Our motivation for the trip was mainly to show our students that the diversity and high level of international collaboration found at European scientific institutions is the key to success in modern science. Our students reflected this in their final reports, pointing out that every European they met could easily speak multiple languages and had traveled much more than typical Americans. The diversity within the scientific institutes was notable as well. For example, at Leiden University, the research scientist giving us a tour was Italian. At CERN, our guides were British and Georgian, and at Elettra the tours were led by a Turkish scientist. The Bohr Institute historian was British, and a Russian led our tour of the UN in Geneva.

The three-week trip covering ten European countries was a once-in-a-lifetime experience for all of us. Although the logistics and planning were time consuming, the end product was worth the effort. Our students learned a lot, not only from visiting scientific centers and museums, but also from simply walking the streets of foreign cities. ●

LEFT: Attending the introductory seminar at the European Space Agency.

TOP: Leiden University Department of Physics, historic Onnes Laboratory where the first liquid helium was obtained.

BELOW: At the entrance of CERN, Meyrin campus outside of Geneva.

All photos by Ugur Akgun.

At Charles University of Prague.

In Niels Bohr's office listening to the historian of the institute.

Take a Tour Through the Atomic Age

by Rachel Kaufman, Editor

On January 27, 1951, the U.S. Department of Energy conducted the first above-ground test of an atomic device at the Nevada Test Site, 65 miles northwest of Las Vegas. The explosion could be seen as far away as San Francisco.

So naturally, as the Cold War—and atomic research—continued, the good people of Las Vegas did what made sense for Sin City: They turned the detonations into tourist attractions.

History books record that casinos offered "atomic cocktails" and "bomb parties" and that tourists flocked to watch detonations.

Nearly 70 years later, the thrills and horrors of the atomic age still attract tourists.

"If you're interested in history, looking at the history of nuclear weaponry is a great way to [organize a vacation]," says Nathan Hodge, a national security reporter and the coauthor of *Nuclear Family Vacation*, "because it was something that shaped the entire Cold War, and the era that we live in today as well." The book, despite the humorous title, isn't really about a "vacation," but does explore some of the more famous nuclear-related sites around the world.

Today, the lessons of the atomic age seem more relevant than ever. There are far fewer nuclear weapons in the world today than during the peak of the Cold War, but many more countries now possess them, according to the *Bulletin of the Atomic Scientists*. Just this year, the group announced that its "Doomsday Clock" had been moved 30 seconds closer — the "time" is now two minutes to midnight.

Timothy Karpin and Jim Maroncelli combed the United States for traces of the Cold War nuclear complex. They wrote about what they discovered in *The Traveler's Guide to Nuclear Weapons.* And what they found is that—almost no matter where you live—you are not far from a place that was important to the history of nuclear weapons. "Most citizens probably think that nuclear weapons were created in a very small number of hidden facilities, buried in a cave inside a mountain," says Karpin, whose background is in geophysics. "Few understand that they're literally down the street—or at least used to be."

The guidebook describes test sites and national labs, but also, for example, the Harshaw Chemical Company in downtown Cleveland, which produced uranium compounds and is still under remediation. The list of sites runs the gamut "from residential to the industrial to natural," says Karpin.

Should you be interested in exploring the history of the atomic age, take heart: Many facilities *want* you to visit. "People want to tell the story," says Maroncelli, who has a biology background but has consulted at Oak Ridge National Laboratory. "I've gone on several tours where I was the entire audience." You don't need a top-secret connection to visit most national labs. Lawrence Berkeley National Lab offers tours monthly. The Nevada Test Site (now known as the Nevada National Security Site),

A sign encouraging secrecy among workers at Oak Ridge National Laboratory. Today, Oak Ridge hosts thousands of visitors a year. Photo by James E. Westcott, official U.S. Army photographer for the Manhattan Project.

where the US conducted nearly a thousand nuclear tests (and to this day conducts "subcritical" tests of parts of nuclear weapons), holds twice-monthly tours. It's even possible to tour the Hanford Site, where plutonium was made for use in the first nuclear bomb, even though it is the most contaminated nuclear site in the United States.

Given the time and, frankly, trouble—many of these tours require serious advance planning—of visiting nuclear sites, why would a tourist bother?

"The topic is an extreme edge of the human experience," says Maroncelli. "Now we have, for the first time, the ability to commit suicide as a species. We'd never had that before."

Maroncelli adds that in the course of researching *The Traveler's Guide,* he and Karpin met people who had worked in a number of the facilities that built the weapons. "It was interesting to encounter people who were proud of their work. You can't criticize that... They had various opinions... about how they were saving the world by making these things."

"It almost made me wish we had the opportunity to work in a situation like that," he says.

Project Faultless: At the Nevada Test Site, this pipe is all that remains of a test that was part of Operation Crosstie. The pipe was originally level with the ground. Photo by Michael D. Herren/CC-BY-SA.

If you go:

Nevada National Security Site
Free tours approximately twice-monthly. Check website for details and registration:
http://nnss.gov/pages/PublicAffairsOutreach/NNSStours.html

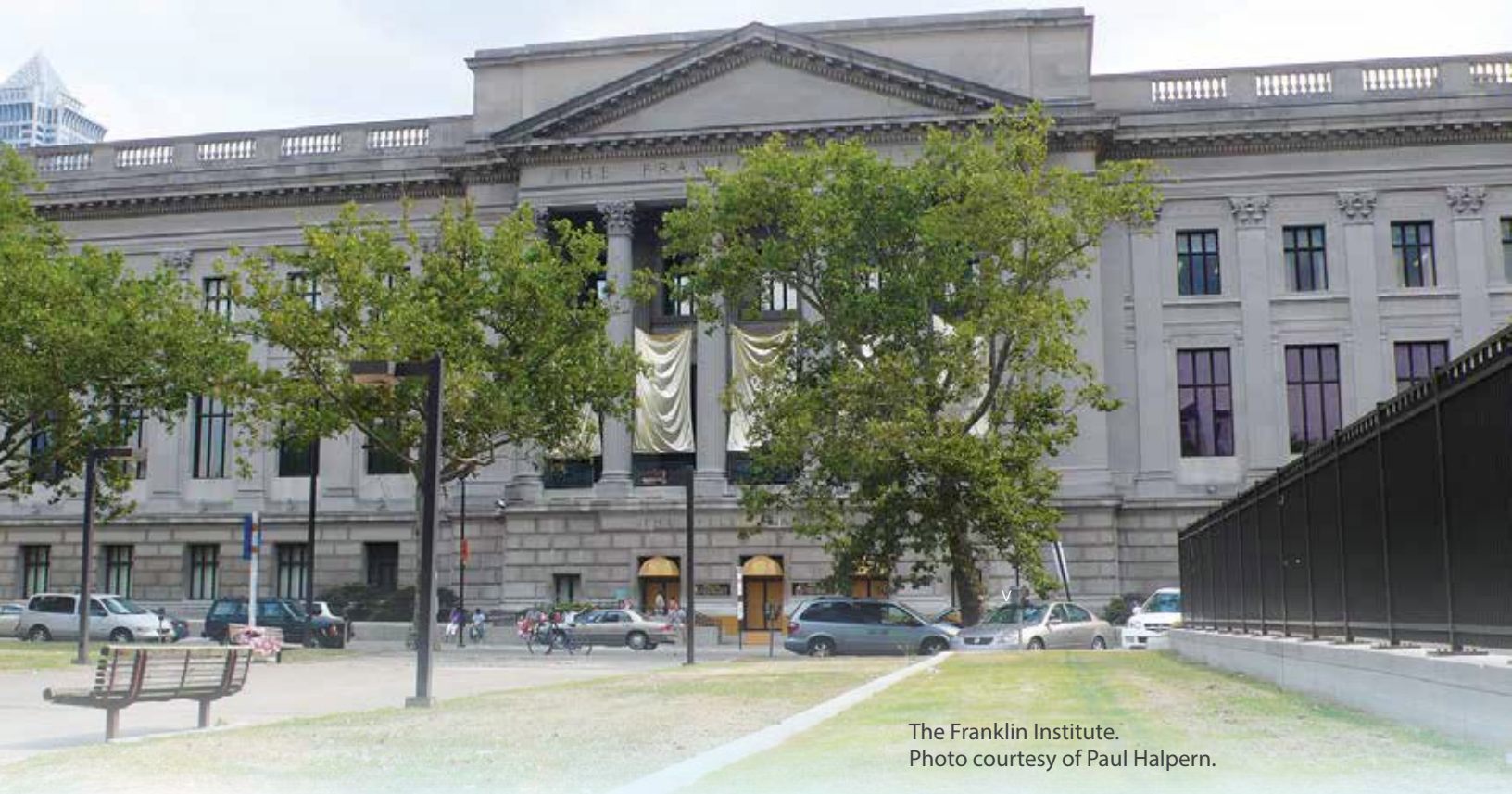
Lawrence Berkeley National Lab
Free tours the third Friday of every month, except for December. Check website for details and registration:
http://www.lbl.gov/community/tours-faq/berkeley-lab-tour-information/

Hanford Site
Tours offered regularly, but 2018 schedule not yet posted. Check website for details:
http://www.hanford.gov/c.cfm/publicTours

100+ more sites in ***The Traveler's Guide*** **to Nuclear Weapons, available from www.atomictraveler.com**

In Franklin's Footsteps:
Exploring the History of Physics in Philadelphia

by Paul Halpern, Professor of Physics, University of the Sciences



The Franklin Institute.
Photo courtesy of Paul Halpern.

Everyone knows about Philadelphia's political history, particularly during the American Revolutionary War. Yet it is also rich with the history of physics, dating back to the colonial era. Let's take an excursion to the "City of Brotherly Love and Sisterly Affection" and soak in some science vibes from the past.

History of physics permeates Philadelphia's downtown street grid. Its four major city squares are named after personages with at least some connection to physics: Washington Square, named after George Washington (who was originally a surveyor); Logan Square, named after James Logan, who played a pivotal role in introducing Newton's work to the colonies (including early editions of the *Principia*); Franklin Square, named after Benjamin Franklin, well known for his groundbreaking explorations of the physics of electricity; and Rittenhouse Square, named after David Rittenhouse, who made pivotal contributions to optics and astronomy.

It is on Logan Square, linked to the Benjamin Franklin Parkway, that we find The Franklin Institute, one of the many sites in Philadelphia that bears Franklin's appellation. Franklin lived in Philadelphia from 1723 until his death in 1790 (aside from multiyear stays in London and Paris), and is therefore appropriately well honored. A large, classically styled building with a columned façade, The Franklin Institute houses one of the leading hands-on science museums in the United States, a collection of Franklin artifacts, and the Benjamin Franklin National Memorial.

In the center of the memorial is a six-meter-high statue of Franklin, sculpted by James Earle Fraser. Beyond the memorial is the science museum, which features numerous exhibits, including a 26-meter Foucault pendulum and a large steam train built in 1926. Outside the museum building is a Grumman Lunar Module, built for the Apollo program. Not associated with the institute, but still of interest, a monument to Polish astronomer Nicolaus Copernicus lies across Logan Square. In 2005, the Franklin Institute was presented with the first American Physical Society (APS) historic physics site plaque in recognition of Benjamin Franklin's achievements.

Franklin's connection with physics went at least as far back as 1746, when Peter Collinson, a prominent London merchant and member of the Royal Society, sent him a package that included a glass tube used

for electrostatic experiments and an article by Swiss professor Albrecht von Haller that described what was then known about the field. Making great use of the tube and the article, Franklin embarked on an intensive exploration of the nature of electrical properties. During the late 1740s, Franklin reported to Collinson a number of spectacular insights about electricity, including a definition of the concept of positive and negative charge, and establishing that electrical attraction and repulsion can act over a distance rather than just through contact.

Another Philadelphia museum dedicated to Franklin is Franklin Court, the site of his former home and print shop, located near the corner of Market Street and Third Street. Although the original building was demolished in 1976, during the bicentennial of American independence, the ruins of the house's cellar and foundations were excavated, and new structures were built to offer a sense of how it looked. An underground museum, free to the public, showcases Franklin's achievements.

Several streets away from Franklin Court are other notable sites related to Franklin. Franklin's grave is located in Christ Church cemetery near the corner of Fifth Street and Arch Street. It is a tradition to toss pennies on his grave marker for good luck. At Fifth and Vine Street is the entrance to the Benjamin Franklin Bridge. Within its entrance plaza stands a metal sculpture commemorating Franklin's purported "kite and key" electrical experiment. Designed by Japanese-American artist Isamu Noguchi, *Bolt of Lightning* was erected in 1984.

David Rittenhouse, while certainly not as well known as Franklin, was another Philadelphia-based physics luminary. Adept at building mechanical devices, Rittenhouse set out in 1767 to build an orrery: a machine replicating the motions of the planets and moons in the solar system using Kepler's laws as a guide. In 1769 he investigated the transit of Venus by constructing a modified refracting telescope to measure the exact time of the transit. The goal was to use observations of the transit around the world to obtain the distance from the Earth to the sun through the method of parallax.

In the 1780s, Rittenhouse constructed the first diffraction grating. By placing fine hairs parallel to each other, he produced a grating with about 250 lines per inch and created a distinct interference pattern with six bright spectral lines on either side. Borrowing optical instruments from Franklin, including a prismatic telescope and micrometer, he measured the angle to each spectral line and discovered integer ratios between the higher order and first order lines. In the 1790s, he investigated the effects of air density on pendulum irregularity and designed a suspended pendulum that was balanced such that the buoyant forces on either side cancelled out.

Rittenhouse was born in 1732 in an early industrial community, set on a stream, that was then outside the boundaries of Philadelphia. Later incorporated into the city, the restored enclave is now called Historic RittenhouseTown and is open for tours. In 1825, Philadelphia renamed what was previously called Southwest Square after him, and Rittenhouse Square soon became known as one of the fanciest locations in the city.

Both Franklin and Rittenhouse are honored at the University of Pennsylvania, where each played a role in its early history—the former with a statue and an athletic field, and the latter with the David Rittenhouse Physics Laboratory. Penn has played an important role in the history of physics, including the Nobel-Prize-winning work of physicists Robert Hofstadter (electron scattering in nuclei), J. Robert Schrieffer (superconductivity), and Raymond Davis Jr. (solar neutrinos).

Penn's very first professor of physics, George Frederick Barker, was close friends with Thomas Edison and played a role in the commercial use of electricity. His donated collection of early Edison light bulbs is on display in the lobby of Rittenhouse Lab. Another early Penn physicist, Arthur Goodspeed, claimed to have been the first physicist to expose a photographic plate to x-rays (unknowingly, at first, before Röntgen's discovery) and was a pioneer in their medical use.

So we see that there is far more to Philadelphia than just the Liberty Bell, Independence Hall, and the steps made famous by Rocky. No matter where you look, there are monuments to a grand history of physics discovery. ●

TOP LEFT: Benjamin Franklin statue.

TOP RIGHT: Copernicus monument.

BOTTOM LEFT: Franklin Court.

BOTTOM RIGHT: Edison light bulbs at the David Rittenhouse Laboratory, University of Pennsylvania.

All photos by Paul Halpern.

9‘ Scopes to Scope Around the Country

by Korena Di Roma Howley, Contributing Editor

Griffith Observatory
Flickr/CC-BY: demxx

In an age of increasing urbanization, reaching for the stars can seem even more challenging for a generation of people who’ve never really seen them. According to the UN, city dwellers now make up the majority of the world’s population, and for them a permanent curtain of artificial light has fallen over the cosmos. Enter astro-tourism, where the stars are the destination—at least from the comfort of well-appointed observatories. In the US, places that were largely known only to astronomers are welcoming more and more visitors—some curious, some longing to get their first proper glimpse of the Milky Way. Here are our recommendations for a stellar experience.

Yerkes Observatory (Wisconsin)

Located just 80 miles outside Chicago, the circa 1897 Yerkes Observatory evokes a time when fictional Victorian tinkerers assembled time machines and moon-bound projectiles. Built just four years after the Chicago World’s Fair, which introduced humanity to a spate of enduring novelties, Yerkes was no exception in an era of superlative scientific achievement. The so-called “birthplace of modern physics”—and former hive of the University of Chicago’s Department of Astronomy and Astrophysics—still claims the world’s largest refracting telescope.

Daily guided tours are available, and spots can be reserved for nightly programs that allow you to look through the telescopes. Visit the website (http://astro.uchicago.edu/yerkes/) for tour times and program schedules. Be sure to take in the whimsical architectural details and expansive grounds, which occupy 77 acres on Wisconsin’s Geneva Lake. If you plan to stay in nearby Williams Bay to soak up the all-American scenery, bring along a copy of Jules Verne’s *From the Earth to the Moon* for chilly nights.

Griffith Observatory (California)

One of the world’s most famous—and visited—observatories, Griffith has transcended its public astronomy roots to become a staple of Hollywood tourism. Opened to eager crowds in 1935, today it sits astride a network of family-friendly trails that afford photo-worthy city and ocean views.

In addition to outdoor telescopes, visitors have access to the Zeiss refracting telescope, which, according to the observatory’s website, more people have looked through than any other telescope.

Admission to the observatory and its grounds is free. Open Tuesday to Friday, 12 p.m. to 10 p.m., and weekends, 10 a.m. to 10 p.m. Closed Mondays. Visit the website (http://www.griffithobservatory.org/) for parking and other transportation options.

Mount Graham (Arizona)

Three impressive telescopes sit atop a peak in southern Arizona’s Pinaleño Mountains, about two hours from Tucson. Operated by a research arm of the University of Arizona’s Department of Astronomy, Mount Graham has had its share of controversy, including concerns for Native American sacred land and a local squirrel species. The costly Large Binocular Telescope (LBT), in operation after decades of delays, is one of the highest resolution optical telescopes in the world.

Guides at Mount Graham take a holistic approach to informing the public. Tours—offered mid-May through October—include information on the mountain’s history, wildlife, and geology. Following lunch on the summit, visitors see the LBT, the Submillimeter Telescope, and the Vatican Advanced Technology Telescope. Advance reservations are required and can be obtained by contacting Eastern Arizona College’s Discovery Park Campus at (928) 428-6260 and via email at discoverypark@eac.edu.

Cherry Springs (Pennsylvania)

Tucked in a rural corner of northern Pennsylvania, Cherry Springs State Park attracts visitors from around the country—and the world. Within a day's drive from most of the metropolitan areas on the eastern seaboard, it sits like a secret portal to the night sky, both extraordinarily dark and uniquely positioned for viewing a central area of the Milky Way during summer months.

The secret is getting out, with visitors coming "just for one night under the stars," according to education specialist Tim Morey. "It's something that's really struck a chord in people." In 2017, astronomy programs saw nearly 16,000 attendees, up from around 2,500 in 2009, a year after Cherry Springs was designated a Dark Sky Park by the International Dark-Sky Association.

Though nothing's guaranteed, be sure to time your visit with the new moon and clear skies for optimal viewing. The park is open year-round. Check the website (http://www.dcnr.pa.gov/StateParks/FindAPark/CherrySpringsStatePark/Pages/default.aspx) for information on upcoming events and current conditions.

Green Bank Radio Observatory (West Virginia)

If you've ever wanted to escape the noise of modern life and contemplate the universe, head for the National Radio Quiet Zone, which offers 13,000 square miles of radio silence in eastern West Virginia. Here, the Green Bank Telescope (GBT)—the largest fully steerable instrument of its kind—listens for energy waves from space without the interference of Wi-Fi, radio, or other signals.

Taller than the Statue of Liberty, the GBT itself is an impressive sight. Guided tours of the observatory begin with demonstrations and a short film before a bus takes visitors to view the GBT and other telescopes up close. The site also hosts monthly star parties (weather permitting) and Science Center exhibits. The website (http://greenbankobservatory.org/) has a calendar of upcoming events.

Pine Mountain Observatory (Oregon)

Located about an hour's drive from Bend, Oregon, Pine Mountain sits at an elevation of 6,300 feet and serves as a research observatory for the University of Oregon's physics department. The primary viewing instruments are 24- and 15-inch telescopes inside the observatory, plus portable telescopes and binoculars.

Public tours on Friday and Saturday evenings from Memorial Day to late September are followed by guided views of the night sky. If the weather is favorable, viewings can go late into the night. Visitors can bring their own telescopes to use on observatory grounds or at the nearby Forest Service campsite (http://pmo-sun.uoregon.edu).

BOTTOM : The Green Bank radio telescope in West Virginia. Photo courtesy of Jiuguang Wang.

Mauna Kea (Hawaii)

Rising nearly 14,000 feet, the island of Hawaii's lofty, sometimes snow-covered peak is a sacred place for native Hawaiians, one that connects them deeply to their roots. For astronomers, the mountain—the world's highest when measured from the seafloor—is an ideal base for powerful telescopes aimed at the souls of distant galaxies. More than a dozen world-class telescopes now march along the summit, and the overlap of scientific endeavor and spiritual significance hasn't been without controversy. Always be respectful while on the mountain and observe the visitor rules(http://www.ifa.hawaii.edu/info/vis).

While the telescopes themselves aren't open to the public, the sunset that silhouettes their domes is unparalleled, even for Hawaii. Afterward, join the free stargazing sessions at the Maunakea Visitor Information Station on Tuesdays, Wednesdays, Fridays, and Saturdays, when guides will help direct your gaze through public telescopes.

McDonald Observatory (Texas)

The University of Texas at Austin's McDonald Observatory sits beneath a swath of some of the country's darkest skies. In addition to having half a dozen sophisticated telescopes, the observatory boasts what its website calls "one of the first and most productive lunar ranging stations."

Daytime tours are available daily from 10 a.m. to 5:30 p.m. (closed some holidays). Popular, family-friendly star parties and twilight programs—which include constellation tours and telescope viewings—are sellout affairs, so advance reservations are highly recommended. Visit the website (https://mcdonaldobservatory.org/visitors) for prices and schedule.

Kitt Peak (Arizona)

High above Arizona's sunbaked Sonoran Desert, Kitt Peak National Observatory offers stunning views both skyward and across the surrounding valley. Established in 1958, it represents the world's largest array of optical and radio telescopes, and astronomers there have made important discoveries, including high-redshift galaxies and evidence of dark matter.

Guided tours of the observatory are available daily from 9 a.m. to 3:45 p.m. The visitors center closes on some major holidays and under unforeseen circumstances. Call to confirm they're open before setting out. Nighttime programs include stargazing and a dark-sky discovery program. Check the website (https://www.noao.edu/kpvc/) for prices and schedules.

Note that although weather doesn't always cooperate, attempt to time any stargazing visits to clear nights under a new moon. And no matter what the season or location, always dress in warm layers and close-toed shoes. Check websites carefully for up-to-date hours, prices, and handicap accessibility.

LEFT : Kitt Peak Aerial. Photo Credit: P. Marenfeld/NOAO/AURA/NSF and E. Acosta/ LSST/AURA/NSF

RIGHT: Mauna Kea Observatory. Photo Credit: Flickr/CC-BY: E Palen

FYI
SCIENCE POLICY NEWS FROM AIP

News You Can Use:
FYI Tracks Science Policy and Funding

by Rachel Kaufman, Editor

No matter whether you're working in physics, astronomy, or a different field, if you're interested in science policy, FYI should be at the top of your reading list.

A service of the American Institute of Physics, FYI publishes news and information on the federal government's physical science policymaking process. Are you interested in learning about the government's funding priorities? FYI has a whole series on federal science budgets. The EPA's stance on climate change? FYI published a piece in December detailing EPA head Scott Pruitt's questioning of the science behind greenhouse gas regulations. FYI also covers issues that don't initially seem to be scientific in nature, such as proposed changes to the United States' visa program. Such changes could affect foreign-born scientists' ability to work or study in the country.

What you won't find at FYI are any "alerts" or calls to action. "We take a lot of pride in being a nonpartisan voice in the community," says Alexis Wolfe, a science policy analyst and writer for FYI. "Regardless of where you stand on the political spectrum, we want people to be informed."

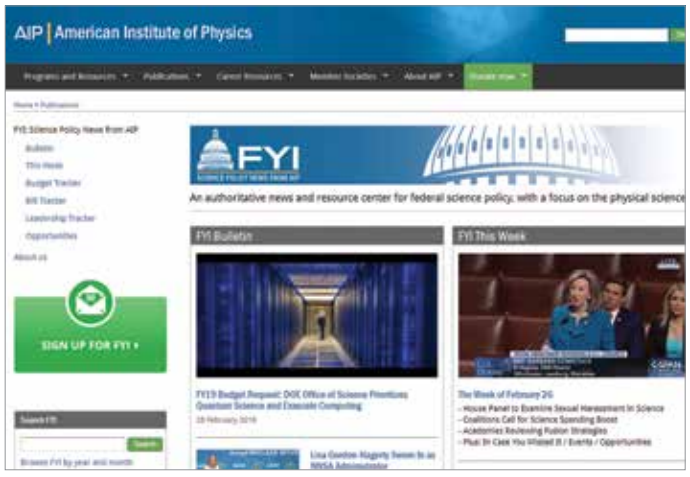
The publication is nearing its 30th birthday, having started in 1989 as a mailed newsletter. Now it's entirely online, as a weekly newsletter, a monthly digest, and 3–4 weekly deep dives, looking at specific and timely topics. A recent deep dive covered the rise of China's STEM workforce and National Science Board findings showing how the US is at risk of losing its global R&D leadership.

These pieces are, as advertised, deep. "We do our homework and our legwork when we do these analyses," Wolfe says. Last year, FYI analyst Will Thomas published a story looking into the legislative record of NASA administrator nominee Jim Bridenstine, a sitting congressman in Oklahoma. Thomas found that Bridenstine had introduced a bill that would have rewritten NASA's main objectives to prioritize space exploration and exploitation while putting scientific research in the background. That report, Wolfe says, was picked up by mainstream publications and this specific bill came up at Bridenstine's confirmation hearing. (Bridenstine has yet to be confirmed by the full Senate.)

In addition to its news reports, the site also tracks the federal science budget, pertinent legislation going through Congress, and leadership appointments at federal science agencies.

FYI's readers include scientists within and outside of government, policymakers, and graduate students, though anyone who considers themselves a "science advocate" could be an FYI reader. "It's so critical for tenured professors to understand the political situation," Wolfe says. But, "Anything that happens in DC ultimately affects the rest of the country. We do the analysis and legwork for people to understand what's happening and how it will affect their everyday lives." ●

To subscribe to FYI's news and information, visit https://www.aip.org/fyi/fyi_subscribe.



Applied Physics, Grand Boulevards, and the "Social Dimension"

by Dwight E. Neuenschwander, Southern Nazarene University

"Science and technology, like all original creations of the human spirit, are unpredictable… We can rarely see far enough ahead to know which road leads to damnation. Whoever concerns himself with big technology, either to push it forward or to stop it, is gambling in human lives."[1]

In early 1934, 29-year-old German architect Albert Speer received his first major commission. Not only was this commission an irresistible opportunity for a young professional seeking a big break, but it also changed Speer's destiny—and eventually the lives of millions of people. The commission came from the new chancellor of Germany, Adolf Hitler. For the next eight years in his role of chief architect, Speer was drawn into Hitler's inner circle, working closely with his famous client, who had seemingly unlimited resources. Speer was to design the "architectural megalomania" of grandiose palaces, monuments, and oversize public buildings that Hitler envisioned for Berlin as the centerpiece of the Third Reich's empire.

In February 1942 Hitler changed Speer's portfolio, appointing him minister of armaments and war production. As the war turned against Germany, to maintain factory production schedules Speer became complicit in using slave labor from occupied countries. At the Nuremberg trials following the war, Speer was sentenced to 20 years in Spandau prison. "I waived the right to an appeal," he recalled. "Any penalty weighed little compared to the misery we had brought upon the world."[2]

In prison he reflected over his decisions and actions, what he saw and what he had chosen not to see. The memoir of this technically savvy Third Reich chief architect and minister of armaments and war production closes by recalling excerpts of the speech he was allowed to make at Nuremberg. There he had offered a dismal assessment of technology's leverage in human affairs. While advances in technology bring so many obvious advantages to civilization, they do not necessarily measure advancement towards a civil society, as Speer observed:

The criminal events of those years were not only an outgrowth of Hitler's personality. The extent of the crimes was also due to the fact that Hitler was the first to be able to employ the implements of technology to multiply crime.

I thought of the consequences that unrestricted rule together with the power of technology—making use of it but also driven by it—might have in the future. This war… had ended with remote-controlled rockets, aircraft flying at the speed of sound, atom bombs… In five to ten years it would be possible for an atomic rocket, perhaps serviced by ten men, to annihilate a million human beings in the center of New York within seconds.… The more technological the world becomes, the greater the danger.

…As the former minister in charge of a highly developed armaments economy it is my last duty to state: A new great war will end with the destruction of human culture and civilization. There is nothing to stop unleashed technology and science from completing its work of destroying man which it has so terribly begun in this war.… [3]

Model of Albert Speer's plan of the grand boulevard that Hitler dreamed about for Berlin. At the far end sits the Great Dome; in the foreground sits the triumphal Arch. Photo credit: Bundesarchiv, Bild 146III-373 / CC-BY-SA 3.0, CC BY-SA 3.0 de.

Concerning unleashed technology's ability to destroy mankind, common ground could be found between the Nazi's minister of armaments and a refugee who left Germany to escape Nazi brutality. In a 1950 open letter published in *Science* which was addressed to the newly formed Society for Social Responsibility in Science, Albert Einstein wrote, "In our times scientists and engineers carry a particular moral responsibility, because the developments of military means of mass destruction is within

1. Freeman Dyson, *Disturbing the Universe* (Basic Books, New York, 1979), 7.
2. Albert Speer, *Inside the Third Reich* (Macmillan, New York, 1970), 618.
3. *Ibid.*, 615.

their sphere of activity."[4] Two years later Melba Phillips, alarmed that research agendas were being driven by military applications, described a sad irony in the same journal. "The greatest humanitarian opportunity ever offered to science," Phillips wrote, "namely, the technological development of vast backward areas of the earth—has become manifest and realizable in our epoch.…[But this] has received only the most paltry governmental support and is largely ignored. What has replaced it? A vast program of military research, which transforms the humanitarian aim of science into its opposite…"[5]

The weaponization of physics did not begin with DARPA, the Manhattan Project, or the Peenemünde V-2 factory. In a 1991 speech to a conference of physics teachers, Freeman Dyson described the "six faces of science": three ugly faces and three beautiful faces. Two of the ugly faces of science are its being "tied to mercenary and utilitarian ends, and tainted by its association with weapons of mass murder."[6] If physicists had their way, weapons of mass murder would never be the *goals* of physics research any more than the domestication of animals was *intended* to produce the horseback-mounted marauding Scythians who plundered the agricultural surpluses of settled peoples.[7]

The weaponization of physics says more about human nature than it does about physics and technology. We must live with the bitter but unavoidable reality that from the beginning of mankind's adventures with technology, weapons have always been a priority of applied physics. According to spurious legend, in 212 BCE, Archimedes supposedly set enemy ships afire through the applied geometrical optics of "burning glass" mirrors. Even though that event probably never happened,[8] that so early a tale of applied physics emphasizes destruction illustrates the point. Even our revered Galileo found it necessary to shrewdly market his slide-rule-like calculator as a "military compass."[9] Some things never change.

Such realities illustrate the "law of unintended consequences," which "twists the simple chronology of history into drama."[10] The atomic bombings of Hiroshima and Nagasaki were unintended consequences of the innocent desire to understand how nature works within the nucleus. As intellectual companions of those who stumbled across nuclear fission when following that desire and as intellectual companions of those who, under duress but with great cleverness, quickly turned that discovery into effective weapons, we can empathize with Ted Taylor's feelings on the dilemma presented by these weapons' seductive glitter and dark consequences:

The trait I noticed immediately was inventiveness… "If something is possible, let's do it," was Ted's attitude. He did things without seeing the consequences. So much of science is like that.

Driving away from the lights of Santa Fe and up into the mountains towards Los Alamos, Taylor fell into a ruminative mood… "I thought I was doing my part for my country.… I no longer feel that way… The whole thing was wrong. Rationalize it how you will, the bombs were designed to kill many, many people. I sometimes can't blame people if they wish all scientists were lined up and shot." –Stanislaw Ulam, recalling Ted Taylor [11]

Speer's point about the downsides of technology also apply beyond the existential threat of nuclear weapons, extending to technologies in everyday life. He gloomily observed,

The nightmare shared by many people [is] that someday the nations of the world may be dominated by technology—that nightmare was very nearly made a reality under Hitler's authoritarian system…[12]

Hitler's dictatorship was the first dictatorship of an industrial state in this age of modern technology... By means of such instruments of technology as the radio and public-address systems, eighty million persons could be made subject to the will of one individual.… The instruments of technology made it possible to maintain a close watch over all citizens… [13]

He concluded, with some pessimism, that technology can, itself, become a kind of dictatorship. But he also saw the remedy, here as against all dictatorships, in people demanding their autonomy:

Every country in the world today faces the danger of being terrorized by technology…Therefore, the more technological the world becomes, the more essential will be the demand for individual freedom and the self-awareness of the individual human being as a counterpoise to technology…[14] *Dazzled by the possibilities of technology, I devoted crucial years of my life to serving it. But in the end my feelings about it are highly skeptical.* [15]

One wonders what Speer would say about technology's rule over us today, such as automation that deskills people[16-18] and makes workers unemployable;[19-20] social media that promises connections but delivers isolation;[21] half a dozen all-powerful corporate overlords reaching into

4. Albert Einstein, *Ideas and Opinions* (Three Rivers Press, New York, 1954, 1982), 26.
5. Melba Phillips, "Dangers confronting American science," *Science* **116** (Oct. 24, 1952), 439–443.
6. Freeman Dyson, "To teach or not to teach," *Am. J. Phys.* **59** (June 6, 1991) 490–495.
7. Jacob Bronowski, *The Ascent of Man* (Little, Brown, & Co., Boston, 1973), 79–80.
8. See *MythBusters* Episode 46, "Archimedes' Death Ray," https://mythresults.com/episode46.
9. Jacob Bronowski, ref. 7, 200.
10. Theodore White, *In Search of History: A Personal Adventure* (Harper & Row, New York, 1978), 304–306.
11. John McPhee, *The Curve of Binding Energy: A Journey Into the Awesome and Alarming World of Theodore B. Taylor* (Farrar, Straus, and Giroux, New York, 1974), 120.
12. Albert Speer, ref. 2, 615–616.
13. *Ibid.,* 614–615.
14. *Ibid.,* 616
15. *Ibid.,* 619.
16. Nicholas Carr, *The Glass Cage*: *Automation and Us* (Norton, New York, 2014).
17. Matthew Crawford, *Shop Class as Soulcraft: An Inquiry into the Value of Work* (Penguin Books, New York, 2009).
18. Mark Bauerlein, *The Dumbest Generation: How the Digital Age Stupefies Young Americans and Jeopardizes Our Future* (Penguin Books, New York, 2009).
19. Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (Houghton Mifflin Co., Boston, 1954).
20. "Humans Need Not Apply," YouTube video, https://www.youtube.com/watch?v=7Pq-S557XQU.
21. Sherry Turkle, *Alone Together: Why We Expect More from Technology and Less from Each Other* (Basic Books, New York, 2011).

Linus Pauling picketing the White House as part of a mass demonstration protesting the resumption of US atmospheric nuclear tests. Photo courtesy of National Archives.

every corner of our lives[22]; technology creep, perpetual noise, and endless distractions that leave little space for thoughtful reflection; [18, 23 – 26] or the "close watch" of ubiquitous surveillance and Big Data.[25-26]

In 1936 Hitler enlarged Speer's architectural commission into the task of redesigning Berlin. Hitler envisioned spectacular monuments that would remind future generations of the Reich's greatness, as surviving architecture bears witness to ancient Rome's achievements. He insisted on a wide, three-mile-long central boulevard in Berlin, featuring at one end a colossal arch three times the height of the Arc de Triomphe in Paris, and at the opposite end a great dome reaching seven hundred feet to the globe-topped summit, enclosing 16 times the volume of St. Peter's Basilica in Rome. Hitler was so focused on his monuments that he overlooked the everyday needs of the city's inhabitants. As Speer tried to work into the magnificent triumphal boulevard mundane but essential concerns such as traffic flow patterns,

[Hitler] would look at the plans, but really only glance at them, and after a few minutes would ask with palpable boredom: "Where do you have the plans for the grand avenue?" Then he would revel in visions of ministries, office buildings and showrooms for major German corporations, a new opera house, luxury hotels, and amusement palaces… His passion for building for eternity left him without a spark of interest in traffic arrangements, residential areas, or parks. He was indifferent to the social dimension. [27]

We physicists and astronomers are passionate about learning the deep secrets of nature and using them to fuel innovation. Do we have grand "boulevards" of our own? Do we assume that because we revel in the marvelous technical applications made possible by physics that everyone else will love them too? To take an example, people have been concerned about automation and robots making human beings unemployable since the dawn of robotics.[16,19-20,28] Yet automation and robotic development continue with unleashed acceleration, suggesting that its most enthusiastic advocates may have chosen not to see its human costs in the social dimension.

We might take a lesson from events in the history of physics that were contemporary with Speer's architectural drawings of the Berlin that never was. A few years ago some students in my Science, Technology, and Society (STS) class wrote to Professor Dyson and asked him, "What do you consider to be science's biggest mistake?" His reply, which emphasized the social consequences of a physics discovery, was immediate:

Science's biggest mistake happened in 1939 after nuclear fission was discovered, before the beginning of World War Two. The physicists could have organized an international meeting of experts to discuss the problem of nuclear weapons, as the biologists did in 1975 when the sudden discovery of recombinant DNA made genetic engineering possible. The biologists agreed on a set of rules to ban dangerous experiments, and the rules have been effective ever since. The physicists could have done something similar in 1939, and there was a good chance that nuclear weapons would never have been built. But the chance was missed. Once World War Two had begun in September 1939, it was too late, because the scientists in different countries could no longer communicate. [29]

In a recent meeting of the American Association for the Advancement of Science, Mark Frankel, director of the AAAS Scientific Responsibility, Human Rights and Law Program, urged all scientists to think more deeply about their social responsibilities. He reminded his colleagues, "The communities in which you live and the communities much farther out…are ultimately affected by the work that you do."[30]

Because of the law of unintended consequences, we cannot foresee all the effects of our work, even in the communities where we live. Even so, what responsibility do we bear for influencing research applications towards humanity-affirming rather than humanity-diminishing ends? Like addicts, do we feel compelled to do something just because we can, without seeing the consequences? I do not know the answers to these questions. Perhaps appreciating the questions is more important than answering them. Perhaps living within the questions could point to useful guiding principles. Scientists are supposed to look at new ideas with a critical, peer-review eye. That means we have to *care*. A student in a recent

22. See Farhad Manjoo, "Tech's Frightful Five: They've Got Us," *NY Times,* May 10, 2017, https://www.nytimes.com/2017/05/10/technology/techs-frightful-five-theyve-got-us.html; "How Five Tech Giants Have Become More Like Governments Than Companies," National Public Radio interview on the program *Fresh Air,* October 26, 2017; transcript at https://www.npr.org/2017/10/26/560136311/how-5-tech-giants-have-become-more-like-governments-than-companies.
23. Nicholas Carr, *The Shallows: What the Internet is Doing to Our Brains* (Norton, New York, 2011).
24. Matthew Crawford, *The World Beyond Your Head: On Becoming an Individual in an Age of Distraction* (Farrar, Straus, and Giroux, New York, 2015).
25. Cathy O'Neil, *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy* (Crown, New York, 2016).
26. "Every step you take: As cameras become ubiquitous and able to identify people, more safeguards on privacy will be needed," *The Economist* (Nov. 16, 2013), 13.
27. Albert Speer, ref. 2, 93.

28. The Robot series of Isaac Asimov [including *I, Robot* (1950), *The Caves of Steel* (1953), *The Naked Sun* (1957), *The Robots of Dawn* (1983), *Robots and Empire* (1985)] explores the relationships between humans and robots and morality when robots do all of the work and much of the thinking. If robot labor was an option in Speer's armaments factories, one wonders what would have happened to the people who were forcibly taken as slave laborers from occupied countries.
29. *Dear Professor Dyson: Twenty Years of Correspondence Between Freeman Dyson and Undergraduate Students on Science, Technology, Society and Life,* D. E. Neuenschwander, ed. (World Scientific, Singapore, 2016), 141.
30. Elisabeth Pain, "The social responsibilities of scientists," *Science* (Feb. 16, 2013), http://www.sciencemag.org/careers/2013/02/social-responsibilities-scientists.

section of the STS class articulated this important insight:

Some preliminary discussion [in class] has caused me to think about who we are as human beings…Humans are increasingly being replaced by machines in the workforce, much like how horses were replaced with the advent of the automobile and tractor…

So, I have wondered, does anything make humans special? While wrestling with this, I have considered one thing that sets humans apart from machines: We have the ability to care… Autonomous boats could theoretically have searched for survivors of the flooding in Houston [from Hurricane Harvey], but they could not have cared about those they saved like the human rescuers certainly did. Machines would be motivated by code, not a sense of morality…[31]

Evoking Robert Pirsig, the real business of applied physics is caring.[32] Our ethical responsibilities as physicists go beyond the obligation to maintain the truthful practices whereby professional trust is earned.[33]

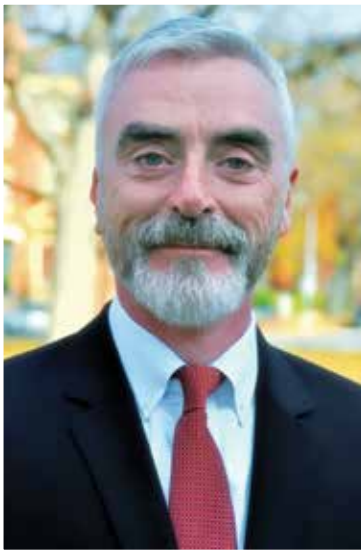
Our work inevitably touches the lives of everyone outside our profession, too. Physics can tell us what *is*, but physics cannot tell us what we *ought* to do. In a 1939 speech Albert Einstein made this point clear: "Objective knowledge provides us with powerful instruments for the achievements of certain ends, but the ultimate goal itself and the longing to reach it must come from another source. And it is hardly necessary to argue for the view that our existence and our activity acquire meaning only by the setting up of such a goal and of corresponding values."[34]

May we not get so focused on our grand boulevards that we forget the citizens who have to live with them, for better and for worse. When implementing the values of human creativity and initiative that drive innovation, let it not be at the cost of other human values such as self-reliance, individual freedom, self-awareness, personal adventure, identity, empathy, and caring. *All* these values, working coherently together, are necessary for the human experience to be a journey of fulfillment. Our responsibility as scientists and engineers goes beyond being clever and doing accurate technical work. The skepticism we routinely practice over claims in a physics paper should also be applied to the glowing promises of promoters of the widget du jour who have their own agendas. Our responsibilities include, in an essential way, slowing down to thoughtfully reflect over potential consequences and caring enough to make sure we are never "indifferent to the social dimension." ●

Deep appreciation is extended to STS students across 30 years for their questions and insights on these topics, and to Professor Freeman Dyson for his wise, gracious correspondence. Thanks to Brad Conrad whose insightful and helpful suggestions improved this article.

31. Travis Vernier, essay for Science, Technology, and Society course, September 5, 2017, Southern Nazarene University. Used with permission.
32. Robert Pirsig, *Zen and the Art of Motorcycle Maintenance: An Inquiry Into Values* (Morrow, New York, 1974, 1999), 35.
33. Jacob Bronowski, *Science and Human Values* (Harper and Row, New York, 1956, 1965).
34. Albert Einstein, ref. 4, 42.

AIP Welcomes New CEO **Michael H. Moloney**



Experimental physicist Michael H. Moloney assumed the role of CEO on March 5, following unanimous approval by AIP's Board of Directors. Moloney becomes the ninth executive to lead AIP and will sit on the Executive Committee of the SPS and Sigma Pi Sigma National Council. He previously held the position of director for space and aeronautics at the Space Studies Board and the Aeronautics and Space Engineering Board of the US National Academies of Sciences, Engineering, and Medicine. He's a senior member of the American Institute of Aeronautics and Astronautics, an AIP-affiliated society, and was inducted into the International Academy of Astronautics in 2016 for his leadership in space policy.

Moloney says he's looking forward to embracing the great opportunities that AIP, its societies, the community in general, and humanity at large will face in the 21st century. "Science is rapidly changing and becoming more interdisciplinary," he says, "and the fields of physical science connect like never before."

The Teacher

Mary E. Williams-Norton, Professor Emerita at Ripon College

"Every child should be able to have fun with physics."

This was my mission for 37 years. I am now retired, but during my career as a professor at Ripon College, I taught physics and astronomy to undergraduate students. I also taught them how to teach.

My elementary and secondary science teaching courses for undergraduates turned future teachers into advocates for physics. I hope I showed them—so that they could show their future students—that men AND women, boys AND girls can both enjoy and succeed in science, especially physics.

This wasn't always easy, of course. I often had students who said that they weren't any good at math or science, or that they didn't like the subjects. How do you expect to teach children math or science if you don't have a good attitude toward the material, or believe in your own abilities?

I also encountered men who believed that women and girls couldn't do science. Of course, this attitude was deeply frustrating. I am just one of thousands of counterexamples to that argument.

In addition to teaching, I have spent my career directing grant-supported projects to improve elementary-school science education, which is such a critical time for sparking a child's interest in physics. I also advised the Physics Fun Force, the outreach arm of Ripon's SPS chapter. The Fun Force taught hundreds of elementary-school students about forces, energy, sound, light, buoyancy, and other basic physics concepts, as well as about astronomy and the wonders of our solar system. Children were able to learn about these concepts through hands-on investigation.

Because of my Welsh heritage, I also started projects connecting Wisconsin elementary schools to schools in Wales. The American students learn a bit of Welsh, and the Welsh students learn about American culture (as well as learning how to find Wisconsin on a map!).

It was so rewarding to share the fun of physics with people of all ages, especially young children and their teachers. If you think this is your calling, too, I encourage you to become active in outreach. Take every opportunity you can to share your excitement about physics with others. Share with them how much fun it is to do physics experiments and observe the night sky. Good luck, or as we say in Welsh, *pob lwc*!

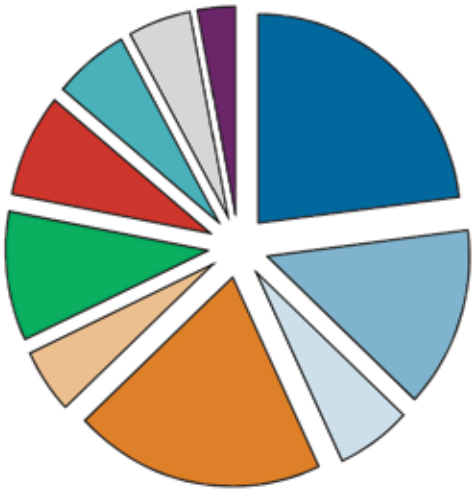
All photos courtesy of Mary E. Williams-Norton

PHYSICS TRENDS Spring 2018

Who's Hiring Physics PhDs?

For a listing of many of the employers who hired new physics PhDs by field, visit:

www.aip.org/statistics/whohiresphds



Thank you for your generous donations

Your gifts make possible an enriched program and additional resources for America's next generation of physicists, scientists, researchers, and professionals in the physical sciences. By supporting our programs, you show your investment in the future. Sigma Pi Sigma and the Society of Physics Students broaden the professional and educational opportunities for students outside the classroom by providing lifelong learning initiatives, professional development, and leadership training. Thank you for your generosity in 2017. Donate today at **http://donate.aip.org**.

Support Level Key

Donor names appearing beside the following symbols have given $100 or more to Sigma Pi Sigma. The four highest levels of giving are:

- ✶ Leader
- ⌘ Patron
- ♦ Mentor
- ○ Sponsor

Abilene Christian University
Hannah F. Hamilton
✶ Joshua L. Willis

Adelphi University
○ Peter Esser
○ Susan Yvonne Roldan

Akron, University of
Ronald Alva Meyer
John Stearns Redfield

Alabama, University of
Samuel Denham
James Roger Huckle
Robert A. Moore
Bobby E. Pyle

Alma College
○ Paul Splitstone

Angelo State University
○ Toni D. Sauncy

Appalachian State University
John R. Archer
Thomas Leo Rokoske

Arizona State University
○ Brittney Morgan Hauke
Robert Marzke

Arizona, University of
Benjamin M. Herman
Martin Hochdorf
♦ Edwin Rutledge Jones
Sanford Lipsky
○ Peter B. Lyons

Arkansas-Fayetteville, U of
Gary Culp
Larry D. Merkle
○ Karen A. Williams

Auburn University
○ Michael David Haworth
Lawrence George Karch

Augsburg College
○ Brian Jay Anderson
○ Donald C. Williams

Augustana College
Brian Jay Anderson
Scott A. Slaith
Mark Steven Taylor

Austin College
Terrance Dale Lingren
Sherry Jo Logusch

Austin Peay State University
○ Carson Ronald Slosberg

Ball State University
Ronald M. Taylor

Baylor University
Bertram B. Geeslin
○ John Randy Hall

Benedict College
Jimi Tayo Yerokun

Benedictine College
Joseph Benedict Anthony
Joseph S. Hickert

Birmingham-Southern College
John Littrell Darby
William Shores Stalcup

Boston College
William M. Plansky
Philip Henry Sheridan

Bowling Green State University
Pamela J. Darwin
Joseph William Synk

Bradley University
Conley I. Stutz

Bridgeport, University of
Douglas John Basarab
Marc Edward Read

Brigham Young University
Larc Edward Read
Layne K. Jensen
Randy Dick Olsen
○ Peter Polgar
Lew Wood

Bucknell University
Matthew J. Fawcett
Donald K. Miller
Eugene P. Miller

Cal Poly-San Luis Obispo
○ William C. DeGraffenreid

California State University-LA
Costas Lymberis
♦ Gilbert A. Miranda

California State University-Long Bch
○ Albert J. Franco
Chi Yu Hu
Neil K. Perl

California State University-Northridge
Arthur Altshiller

California State University-Sacramento
✶ Gwendolyn M. Buchholz
✶ Charles Harriso Hunt

California-Berkeley, U of
Laurence Britt Schweitzer

California-Irvine, U of
○ William & Janice Parker
✶ Keith Runge
Brigitte J. Vaccarella
Richard and Nancy Vodhanel

California-Los Angeles, U of
○ Sonia C. Balcer
○ Robert L. Cady
○ David Ming-Ge Chen
Christopher M. Crane
♦ David Garfinkle
Stuart Goldenberg
Joel S. Kvitky
Erno H. Ross
Larry L. Simmons
○ Richard H. Stanton
Ronald C. Stearns
John J. Wood

Cameron University
David Richard Little

Carson-Newman College
Douglas S. Shafer

Carthage College
○ Kendra Redmond

Central Arkansas, U of
William Slaton

Central Missouri State Univ
⌘ Frederick H. K. Rambow
Allen Roy Landin
Merlin Dale Ring
♦ James H. Taylor

Central Oklahoma, U of
Buster Owens Alexander

Citadel, The
○ William M. Calvert

Clark University
○ Webster F. Smith

Clarkson University
○ Kendra A. Eagan
♦ Steven Allen Feller
○ Eileen Michelle Romano
○ Richard Clark Summermatter

Clemson University
Laurence B. Rice

Cleveland State University
Joseph Anthony Horvath
○ Noel Boyd Sargent
Kiril Streletzky

Coe College
○ Ugur Akgun
Dahlia Baker
Victoria Eng
Dalton Shadle

Colby College
Catherine A. Garland

Colorado Mesa University
Nickalaus Clemmer
○ Michael Eric Peterson

Colorado School of Mines
Frank A. DeLuca

Colorado-Boulder, U of
Dennis A. Becker
John Edward Bellotti
○ Dewitt Edward Harrison
L T. Ostwald
Willard L. Talbert
Helen Marie Worden

Connecticut, University of
Harvey A. Alperin
○ Gary Raymond Austin
Richard L. Barrett
Robert B. Bossoli
○ Richard E. Davis
✶ Robert Lawrence Del Boca
Robert V. Erickson
Herb F. Helbig
○ Gerald C. Holst
John R. Owens
Donald E. Powers
Richard C. Szymanski
○ Thomas Joseph Welsh

Cooper Union
Armand Michael De Palo
Marilyn Kraus
James Michael McMahon

Creighton University
Thomas H. Zepf

Dallas-Irving, University of
○ Jeffrey Laba

Davidson College
Henry Claude Griffin

Dayton, University of
✶ Philip John Anthony
Richard A. Hieber
♦ Thomas O. Tiernan

DePaul University
○ Mark C. Burlingame

Delaware, University of
David Joseph Barsky
○ Thomas F. Lovorn

Denison University
Lee Hayford Coen

Denver, University of
♦ Stephen W. Behnen
✶ William R. Rolingson

DePauw University
♦ Chris Gottbrath
○ Keith Kenter

Detroit, University of
Thomas G. White

Dickinson College
Greg Mark Ajamian
Todd L. Baker

Drew University
Leonard C. Feldman

Drexel University
○ William R. Barchet
○ Roberto C. Ramos
Ferdinand Reetz III
♦ Franklin L. Robinson

Duquesne University
James R. Messmer

East Central University
○ Carl T. Rutledge

East Stroudsburg University
○ James B. Nesbitt

Eastern Illinois University
○ Merri Lynn Horn

Eastern Michigan University
✶ Diane A. Hanawalt-Jacobs
Timothy H. Marvin

Eastern Oregon State College
Kevin L. Bier

Elmhurst College
Roy J. O'Kelly
Alice J Ramsay

Embry-Riddle Aeronautical Univ
○ Charles C. Vuille

Emory University
Matthew S. Abrams
⌘ George Richard Dyer
John Funke
○ Jack E. Rowe
Burnette T. Sheffield

Evansville, University of
Byron B. Batteiger
Darrell Megli
○ Lester Wayne Morgan
Frederick W. Van Haaften

Florida Inst of Technology
○ Susan Ann Chambers
Rudy A. Frahm

Florida State University
♦ Sharon Eileen Kromhout-Schiro
Jean Willits Lane
⌘ Philip J. Wyatt

Florida, University of
♦ Evelyn Joan Boettcher
John B. Danese
Robert Deming Dwyer
Ronald M. Keyser
♦ David M. Richardson

Franklin & Marshall College
○ James Stephen Balent
John Gerald Dommel
○ Yancy Donald Edwards
○ Mark Kozak

Frostburg State University
○ Gary Lee Hendrickson

George Washington University
✶ Mark V. Hughes
Thomas Kelsall

Georgia Inst of Technology
○ Daniel L. Albritton
○ Robert Scott Fortenberry
○ Edwin Greco
○ Werner Adam Metz
○ Eugene T. Patronis
Michael G. Thackston

Georgia State University
Thomas Eugene Blackburn
Alan Hull
○ Eongwei Lai

Georgia, University of
Marvin Robert Maddox

Gettysburg College
Bruce K. Horne
Richard Leon Keiser
Ruth E. Kumler

Grove City College
⭘ DJ Wagner

Guilford College
Nicholas Brendan Remmes

Hanover College
Joseph S. Wakefield

Heidelberg College
Suzzanne Eleanore Falvey

Hofstra University
Ted Andresen
Mary J. Hickey
Erin Reagan
Paul Edward Seidel
♦ William M. Terrone

Holy Cross, College of the
Salvatore Francis LaMesa
Frank Robert Tangherlini

Houston, University of
Charles S. DeJohn

Hunter College of the CUNY
Padmanabhan Santhanam

Idaho State University
Larry J. Morford
Linda Marie Morford

Idaho, University of
Gary L. Bennett

Illinois Benedictine College
⭘ Thomas J. Kotek
⭘ Fred John Schlick
⭘ Dominick John Stella

Illinois Inst of Technology
Alan G. Kepka
James R. Voss
Earl Zwicker

Illinois-Chicago, U of
Julian Y. Ares

Indiana U of Pennsylvania
Russell Harriso Couch

Indiana University-Bloomington
Timothy M. Small

Iowa State University
Mark Robert Keever
⌘ James and Hildegard Vary

James Madison University
Eric Hoppmann
⭘ Raymond A. Serway

John Carroll University
Joseph John Szente

Juniata College
⭘ Justin T. Schultz

Kansas, University of
David K. Brice
⭘ Larry L. Dike
Charles Lee Francis
⭘ Dean & Cynthia W. Halderson
⭘ Richard G. Leamon
⭘ Norris Stanley Nahman
✶ Luther W. Smith
⭘ Robert G. Spahn

Kentucky, University of
♦ Alan Dale Arvin

Kettering University
Sally Dagher

Lake Forest College
MaryAnn Hayes

Lamar University
George Ervin Durling
Darla Jean Smith

Lee College
Thomas O'Kuma

Louisiana St Univ-Baton Rouge
Jack Giammerse, Jr.
Richard T. Rauch
Alfred L. Stoessell

Louisiana Tech University
Jonathan David Gaston

Louisiana Univ at Lafayette
John R. Meriwether
⭘ Danelle M. Tanner
⭘ Katherine N. Zaunbrecher

Louisiana University at Monroe
Jack Brien Dunn
♦ Sharon Lynn Fleming

Louisville, University of
David Norvil Brown
Ramon B. Krebs
Nareshchandra P. Shah

Loyola University, New Orleans
⭘ James M. Gross

Maine, University of
⭘ Samuel Borer
⌘ Ernest B. Brigham
Edward John Connor
Richard A. Knight
Paul F. McGuire
⭘ Victor A. Mortenson

Manchester College
Wilfred G. Brill
Gary Lee Heisler

Marquette University
⭘ Clifford Kelley
Edward J. Mattson
Paul George Miller

Maryland-College Park, U of
⭘ Joseph M. Dasbach
John Wendell Fowler
⭘ Richard S. Graham
✶ Donna Hammer
⭘ William H. Lupton
⭘ Carla Gretchen Messina
Sarah Ashley Monk

Massachusetts Inst of Tech
John Christophe Driscoll
David M. Kushner

Massachusetts-Dartmouth, Univ
Joseph David Rando

Massachusetts-Lowell, U of
Edward Benjamin Hanfling
Timothy Paul Largy
Ralph Francis Simmons

Miami University
Ramsey and Bonnie D. Johnson
Scott Randall Leonard
✶ James Kevin McCord

Michigan State University
Ross D. Brazee
Walter Bruce Zimmerman

Michigan-Ann Arbor, U of
♦ John A. Dodds
Thomas Gerald Heller

Minnesota, University of
⭘ Thomas M. Christensen
Jeanne Hladky
⭘ Robert O. Pepin
⭘ Greg Roelofs

Missouri-Kansas City, U of
♦ Teresa M. Froncek

Missouri-Rolla, University of
John L. McDaniels

Monmouth College
Joseph H. Othmer

Monmouth University
Peter Feldmann

Montana State University
⭘ Larry D. Kirkpatrick

Morehouse College
Orhan Kemal Oz
⭘ Willie S. Rockward

Mount Holyoke College
⭘ Elinor Louise Gates

Muhlenberg College
David Alan Detwiler

Muskingum University
Paul Leroy Morris
✶ David Paul Maruszewski

Nebraska Wesleyan University
⭘ Charles H. Jackman

Nebraska-Lincoln, U of
David J. Sellmyer

Nevada-Reno, University of
Robert Gehrke
Robert Phillip Rosenbaum

New Mexico State University
♦ Paul H. Daggett
⭘ Patti & James Gillespie

New Mexico, University of
⭘ David H. Dunlap

New Orleans, University of
Dane Joseph Morris
Barry Bernard Muhoberac
⭘ Louis Albert Vedros

New York University
Louis G. Markatos
Monroe Franklin Richman

North Carolina State Univ
Jack M. Penny
Alfred J. Stamm

North Carolina-Asheville, Univ
Aisling Power
⭘ Randy Booker

North Carolina-Chapel Hill, Univ
William Peter Fitzgerald

North Dakota State University
⌘ Jeffrey Allan Schmidt
⭘ Kevin Jack Haugrud

North Texas, University of
Roger D. Campbell
Robert Arthur Gardner

Northern Illinois University
Robert M. Nishimoto

Northeastern University
Nicholas DePorzio

Northern Arizona University
Constance E. Cripps
Jeremy E. Smith

Northern Illinois University
⭘ Steven A. Overmyer
Larry R. Sill

Northern Iowa, U of
Paul Richard Heller
Ducta Vo

Northwestern State Univ LA
✶ Gary D. White

Occidental College
✶ Nariman M. Dastur
⭘ George L. Johnson
⭘ Brian Emerson Newnam
John L. Worcester

Oglethorpe University
⭘ Eleanor J. Fulton

Ohio Northern University
⭘ Michael J. Garee

Ohio State University
⭘ Vincent L. Donlan
Ints Kaleps
♦ Ray E. Kidder
Evelyn S. Kinzel
⌘ Frank Judson Leech
Edward R. Niple
William H. Robinette
Sylvia J. Whitt

Ohio State University - Research Foundation
⭘ James P. Brack

Oklahoma City University
David Davison
James D. Merrick

Oklahoma State University
♦ John A. Freeman
⭘ James E. Hurt

Oklahoma, University of
⭘ Bruce Lee Evatt

Old Dominion University
⭘ Ronald Charles Glaser
John Lescher
⭘ Russell T. Lutton
Charles R. Welch

Oregon State University
Kirstie Lee Finster
Bruce Gibbs
Dennis C. Henry
⭘ William Henry McLain
Robert M. O'Brien
⭘ Shirley Stekel

Oregon, University of
Elijah Meyerc

Pennsylvania State University
James S. Brunner
Sandor Caplan
Elizabeth Ellen Cox
⭘ Barbara C. Faust
✶ John A. Herritt
Julian Reinheimer
Robert Wade Stanley

Pittsburg State University
Jamal Johnson

Pittsburgh, University of
Robert Philip Devaty
Dave Wasil

Polytechnic University
⭘ Raffael J. Guidone
Edward G. Yarr

Providence College
⭘ Michael R. Coussa

Purdue University
Marvin Kemple

Purdue Univ-West Lafayette
Edmund Kenneth Banghart
Harold E. Boesch
⭘ William W. Bower
Teresa L. Cole
✶ Gary Randall Cunningham
⭘ Robert Edward Daniell
⭘ Robert M. Goodwin
⭘ John K. Gotwals
⭘ Robert J. Miller
♦ Melvin Moriwaki
✶ Donald L. Nelson
⭘ Clarence E. Oyer
Richard Robert Soendlin
Steven J. Stendahl
William F. Tozer
⭘ Mark Montgomery Weber

Randolph College
Peter Sheldon

Rensselaer Polytechnic Inst
Bradley Arnold Flanders
Andrew Kalnin
Richard F. Rapids
⭘ John Reynders V
Julian M. Tishkoff
⭘ Mark Joseph Tollin
John & Katherine Vitko
Bruce Matthew Wexler

Rhodes College
John Timothy Atkinson
⌘ Jenna K. Smith
⭘ Montgomery L Smith

Rice University
⭘ Jonathan Hwa Chung Luke
Suliana Manley

Richmond, University of
Michael C. Kusheba
♦ William S. Ryan

Ripon College
Xavier Michael Polanski
Michelle M. Witt

Roanoke College
Robert Stephen Johnson

Rochester Inst of Technology
✶ John D. Andersen
♦ Brad Conrad
Dolores A. Federation
Ronald Paul Manginell
Franklyn K. Schwaneflugel

Rochester, University of
Michael John Heinecke
Steven Torrisi

Saint Joseph's University
James A. Dibiase
Robert A. Morris
Kenneth D. Steckler
⭘ Kenneth C. Young

San Diego State University
♦ Gerald D. Cahill
Robert Earl Naegeli
Richard M. Zarnowitz

Santa Clara University
⭘ David Shaw Brown
Ken M. Claiborne

Scranton, University of
Thomas F. Strelchun

Seton Hall University
Hannah Buckner
⭘ Peter E. Stamer

Sewanee: The Univ of the South
⭘ Corinne Konoza

Siena College
⌘ Charles T. Knight

South Carolina, University of
⭘ Carl Rosenfeld

South Dakota Sch Mines & Tech
⭘ Fred Joe Kopp

South Dakota State University
Steven D. Ness

South Dakota, U of
Martin Carl Predoehl

South Florida, U of
Laurence William Twigg

South, University of the
♦ Edward Brent Perkins

South Carolina, U of
⭘ Thomas Charles Sayetta

Southern Colorado, U of
Richard L. Dickson
⭘ Dwight E. Neuenschwander
✶ Timothy Grant Van Loon

Southern Mississippi, U of
Grayson H. Rayborn
Harold Wallace Stevens

Southwest Missouri State University
Luis Manuel Rivera

St. Lawrence University
Sylvia A. Watkins
Ann Marie Yates

St. Mary's College of Minnesota
Richard J. Smith

St. Olaf College
⭘ Gary Gene Gimmestad
Paul D. Larson
Douglas N. Paulson
⭘ Howard K. Rockstad
William H. Schlichting

St. Peter's College
Frances Dapas
David Z. Jacome
Allen Traficante

Stetson University
⭘ David Charles Williams

SUNY at Albany
Paul Charles Bono
Richard A. Coppola
⭘ Peter C. Landi
Bruce Marsh
♦ Stephen Sanders
⭘ Joseph M. Sullivan

SUNY at Binghamton
Millie Calistri-Yeh
John Joseph Veselka
Howard Mark Zendle

SUNY at Plattsburgh
Lonny R. Kauder

SUNY at Stony Brook
Naomi Mizuno
Christopher E. Naylor
Michael F. Shlesinger

Temple University
Martin M. Roffman
Bernard Rudin

Tennessee-Chattanooga, U of
Sandra McConne Burnett
⭘ Arvel L. Fincher
Mary Jeanne French
✶ Jon Raymond Visser
⭘ Kenneth W. Wingo

Tennessee-Knoxville, U of
J. Ernest Breeding, Jr.
♦ Edward R. Fleming
Sandra Jo Hinsdale
♦ John L. Hubisz
⭘ James Stroud Jarratt
⭘ Philip Woodson King
Joshua Shai Shimony

Texas A&M Univ-College Station
⭘ Douglas Scott Abraham
Lloyd Joseph Probst
⭘ Arthur William Woltman

Texas Christian University
Graham G. Kent

Texas Tech University
Lynn A. Boatner
⭘ Dwain Kent Butler
⭘ Stephen & Mariglyn W. Glenn
⭘ George H Thacker
⭘ Kevin Carl Walter

Texas-Austin, U of
⭘ Steven Wendell Evans
⭘ Jeff Leo Kodosky
Dennis Cates Wylie

Texas-El Paso, University of
Aurora V. Bustos
Randal Eric Gibson

The College of New Jersey
Warren James Jochem

Thomas More College
Michael Theodore Eismann
Michael Joseph Schmidt

Toledo, University of
Steven Robert Federman
Henry J. Simon

Trinity College
Hugh W. Ewart
♦ Robert D. Price
♦ Allyn J. Washington

Trinity University
Gustav N. Van Steenberg

Tufts University
Charles Alan Bruns
⭘ Maurice E. Halladay

Tulane University
Norvell O. Scott
William M. Yeager

Tulsa, University of
⌘ Michael G. Wetzel

Union College
⭘ John Patrick Berreen

United States Air Force Academy
♦ Alina Gearba-Sell

United States Naval Academy
♦ Jack Bernard Giessner
William Walter Matzelevich
Leonard D. McCumber
James Edward Schreiber
Kurt Friedrich Studt
James Bryant Waddell

Upsala College
⌘ Albert D. Helfrick

Utah State University
⭘ Vanessa Chambers

Utah, University of
⭘ Carlos M. Bowman
⭘ Jessica T. Gledhill
Richard G. Hills
Allen S. Jones
Paul I. Kingsbury
Dick L Tatro

Valencia College
Irina Struganova

Vanderbilt University
Edward R. Seufert
♦ Donald Rex Wright

Villanova University
♦ James Charles Lochner
⌘ Anthony Joseph Martino

Virginia Commonwealth University
⭘ Mahela & Jonathan Morrow-Jones

Virginia Military Institute
⭘ Stuart Weygand Serenbetz
⭘ John Hackworth Tucker

Virginia State University
⭘ James H. Stith

Virginia Tech
James Lewyn Mc Donald

Virginia, University of
Gregory A. Ashe
Steven L. Carter
Brianna Hogan
Steven Louis Kipp
Edward H. Lynch
Raymond E. Modlin

Washington, University of
Jared Canright

Wayne State University
Harry L. Gubbins
⌘ Fern Sally Katz

West Florida, U of
Paul Michael Barlow

West Virginia University
Anna M. Allen
Frank E. Hoge
Wesley Shanholtzer
Fred R. Smith

Western Illinois University
Alexander K. Dickison
Jerry W. Forbes
Ronald F. Legner
Richard H. Meservey

Western Kentucky University
Glenn P. Glasgow
Donald T. Harris

Western Washington University
John Robert Cline

Westminster College
John Fontanella
Edward R. Mansell
Roger & Helen Allen Metzler

Wheaton College - IL
H. Clay McDowell
Norman John Richert
Charles Paul Riedesel

Wichita State University
⭘ Frank S. Pistotnik
♦ Timothy and Jeanne T. Scrivner
Gordon L. Wood
Janice Elaine Woods

Widener University
Charles J. Garneski

Wilkes University
Gary L. Katulka

William & Mary, College of
⭘ Richard & Judy R. Babcock
⭘ Lee E. Harrell
Jean A. Muench
William E. Slauson
♦ Robert Bruce Stevens
William Jacob Tropf

William Jewell College
⭘ Blane Baker
Dean L. Berry
⭘ Sheldon L. Levy
⭘ Carl D. McElwee

Wisconsin-Eau Claire, U of
Keith Daniels
Douglas Harvey Pearson
⭘ Robert Steven Schneider

Wisconsin-River Falls, U of
♦ Earl Blodgett
♦ Ann M. Deml
Gary T. Holm
⭘ Lowell I. McCann

Wisconsin-Superior, U of
⭘ Blaine Robert Diesslin
Richard H. Lane
⭘ Keith Jerome Sjostrom

Wisconsin-Whitewater, U of
Michael James Devoe

Worcester Polytechnic Inst
⭘ Stephen Edward Bernacki
Stephen Richard Lawry
♦ Clifford Mark Weiner

Wright State University
John L. Hehmeyer
⭘ Kimberly Mae Wiefling

Wyoming, University of
Charles Gregory Bruch
⭘ Hannah Jang-Condell

Xavier University
♦ Austin Church
Arthur D. Foreman
Jeffery T. Grothaus
William Henry Kuhlman
John Swyers
⭘ William M. Zeitz

At Large
Lawrence Alquist
Thomas Bonde
✶ Marc H. Brodsky
✶ James L. Burch
Brenda Cabell
⭘ Elizabeth Dart Caron
♦ Morrel H. Cohen
⭘ Steve Cole
✶ Beth A. Cunningham
♦ H. Frederick and Linda Dylla
✶ Kenneth W. Ford
Mary Gehrke
⭘ J. Andrew Green
⭘ Brian Gulledge
Peter Hakel
✶ Jack G. Hehn
Lee Ann Hennig
Ronald E. Hertel
Kerry Kidwell-Slak
Douglas Warren Lane
⌘ Marvin & Annette Lee
⭘ Alan LeGrand
Glynis Long
Myron Mann
James Martin
Aylin McGough
⭘ Frank Andrew McKay
Robert & Patricia Meyers
⭘ Daniel Miller
George Musser
Tevis Pappas
⭘ George Paulikas
Matthew Payne
Russell Philbrick
⭘ Elizabeth Rogan
David Schaich
Tracy Nolis Schwab
Jeannie Sharp
⭘ William W. Shields
David and Diane Smith
⭘ David Strozzi
⭘ John F. Wilson
David Wright
⭘ Alex Yurchenko
♦ Michael Zitolo

Radiations
American Institute of Physics
1 Physics Ellipse
College Park, MD 20740