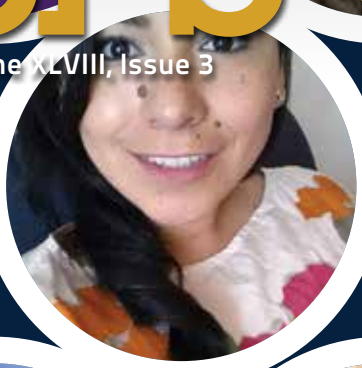
the SPS Observer

Volume XLVIII, Issue 3 Fall 2014






Why Discuss Diversity in a Physics Magazine??







the SPS Observer

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SPS, Diversity, and You

by Sean Bentley,
Director, Society of Physics Students and Sigma Pi Sigma

Photo by Liz Dart Caron.

As I made the transition this summer from 11 years as a college professor and SPS chapter advisor to my new role as SPS director in the SPS National Office, I wanted to make sure I did not lose sight of what first drew me to physics education and SPS, and what to this day I find most rewarding—making a positive impact on students' lives. Because I no longer interact with students on a daily basis, I find that a good way to do this is to assure that each decision I make addresses this question: "How does this benefit SPS members and undergraduate

"This is not a problem that can be solved overnight, but it certainly will not be solved if we do nothing."

I AM SPS

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physics students in general?"

The primary goal of SPS is to help undergraduates in physics, astronomy, and related fields develop into successful professionals and well-rounded members of society. To best achieve that goal, we need to work toward a society with a membership that reflects the diverse student population of the United States. A diversity of cultures, races, genders, and identities leads to a broad range of innovative ideas, allowing the society to be robust and effective in setting the course for the future of physics.

While we focus on improving the representation of different groups within SPS, we must not lose sight of the individual. Percentages are important benchmarks that show us how far we've come and how far we've yet to go, but physics is such a small community that each individual success story is crucial for improving the climate for underrepresented groups in physics and our society.

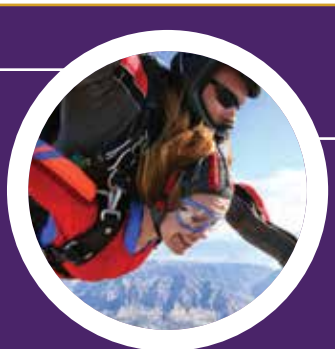
I believe we should strive for diversity not by attempting to ignore differences, but rather by recognizing and appreciating them. The current "I am SPS" campaign (see below) explores some of the things that make each of us, the nearly 5,000 members of SPS, unique. As you read this issue, please consider (and then implement!) ideas you have about what you, your chapter, and SPS as a whole can do to create a more inclusive physics community.

This is not a problem that can be solved overnight, but it certainly will not be solved if we do nothing. //

One of SPS's greatest assets is its diversity. While we're all linked by a common interest in physics, individual members come from all walks of life, and are involved in a broad spectrum of activities that may not be readily apparent.

In this issue, we feature members who shared a fun fact or unique thing about themselves. Go online to tell us about yourself, and you may be featured on the SPS website!

www.spsnational.org/I-am-SPS.html



"I'm a certified scuba diver, and I like extreme sports. I am SPS."
« Kelby Peterson

(continued on p. 13)

ON THE COVER

In this issue, we feature members who shared a fun fact or unique thing about themselves. See "I am SPS" beginning above.

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

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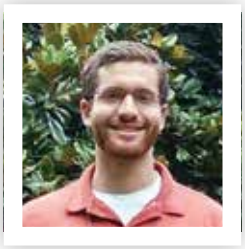
Physics in a Whirl



UNDERGRADUATE RESEARCH PUTS A NEW SPIN ON GYROSCOPES

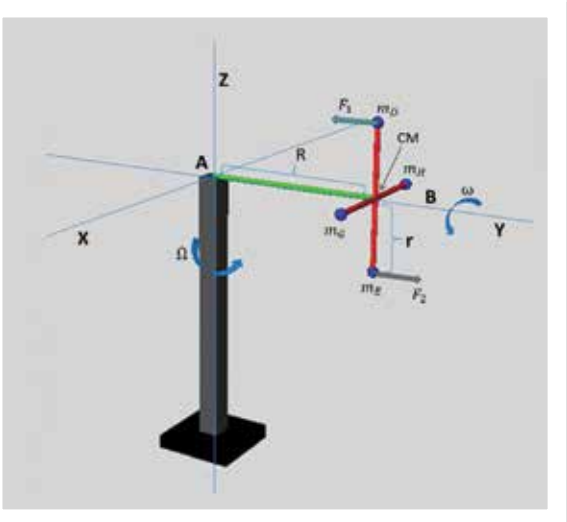
by Harvey Kaplan
Graduate Student, University of Maryland, College Park

Last summer Harvey Kaplan, an SPS member and then-senior at Purdue University in West Lafayette, Indiana, presented a poster on his work modeling a gyroscope at the American Association of Physics Teachers (AAPT) Summer Meeting. He won an SPS Poster Award at the meeting, and went on to publish his work in The Physics Teacher*. We sat down with Kaplan to learn more about his head-spinning work on the motion of gyroscopes.*

A physics professor of mine once explained that physics is the only field that tries to put itself out of business. It was an amusing way to say that every complicated physics concept can be thought of as merely a conglomerate of fundamental physics concepts.

I like this idea in physics and recently applied it to making a computer simulation of a gyroscope. My hope was to explain the behavior of a gyroscope using the basic concepts of linear momentum and force instead of the typical analytical tools of angular momentum and torque, which hide a lot of complexity under the rug. I ended up publishing the work earlier this year in the AAPT peer-reviewed journal *The Physics Teacher*—an appropriate venue for a project that was about looking at a physical system in an unconventional way and presenting the analysis of that system in detail.

> "[E]VERY COMPLICATED PHYSICS CONCEPT CAN BE THOUGHT OF AS MERELY A CONGLOMERATE OF fundamental physics concepts."



As shown in this screenshot, Kaplan's computer simulation illustrates the forces on a model of a gyroscope. Images courtesy of Harvey Kaplan.

The first step was to approximate the structure of the gyroscope. Instead of considering a continuous massive disk that spins about its axis, I started with a simpler radial arrangement of four point masses equidistant from and spinning about a center. This analysis could then be generalized to any number of masses. As the number of masses increased, the masses got closer together, and the approximation approached a continuous gyroscope.

Each mass experienced motion due to precession of the center of mass of the gyroscope and motion due to the rotation of the plane that the point masses defined. I examined how the precessional motion affected the rotational motion of the point masses and how the rotational motion affected the precessional motion of the point masses. These interactions caused "motional" forces which opposed the force on the gyroscope due to gravity and kept the gyroscope upright; more specifically, the torque due to the motional forces countered the torque due to gravity.

My first program simulating these forces allowed the user to vary many parameters, including the gyroscope's physical dimensions, starting position, initial orientation, and rotation rate. But this simplified gyroscope system was not perfect. It did not model higher-order effects in space and time; when the simulation ran long enough, one could see small effects that were not physical, like hints of energy not being conserved. I made another simulation that stepped through single iterations of the program with force and momentum vectors displayed to allow the user to visualize how the system works.

This project pushed me to think about old concepts in a new way and provided for many engaging conversations. I hope the programs I created can continue to inspire conversations as teaching tools for students exploring this type of physics.

I feel very fortunate to have attended and presented my research at a national meeting of AAPT as an undergraduate. I learned a lot from listening to the professors in attendance discuss physics and physics teaching. The recognition from SPS for the work I presented there and then being published in *The Physics Teacher* were important milestones for me; they indicated that I was capable of doing interesting and relevant work in physics. //

SPIN DOCTOR

Read the full research paper by Kaplan and his co-author at http://scitation.aip.org/content/aapt/journal/tpt/52/1/10.1119/1.4849150.

FALL AWARD OPPORTUNITIES FOR Society of Physics Students & Sigma Pi Sigma CHAPTERS




Future Faces of Physics Awards

For projects that promote physics across cultures

Deadline: October 15
Amount: $300

Several awarded annually

The University of Michigan, Ann Arbor SPS chapter received a 2013–14 Future Faces of Physics Award to team up with a middle school that serves underprivileged students and start a new pen pal program with sixth graders. In addition to regular letter exchanges, the chapter visited the school and brought students back to their campus for a demo show and liquid nitrogen ice cream. These events left a lasting impression on the middle schoolers (see the related story on page 8).

Marsh W. White Outreach Awards

For efforts to bring physics to the public

Deadline: November 15*
Amount: $300

Several awarded annually

The Cleveland State University SPS chapter received a 2013–14 Marsh W. White Award to get young students excited about science through an outreach program with a public school. They explored the ways kids encounter physics every day—from refrigeration of milk at breakfast to switching off reading lights at night—by conducting interactive activities once a month during the academic year.

SPS Chapter Research Awards

For SPS chapter physics research projects

Deadline: November 15*
Amount: $2,000

Several awarded annually

The Goucher College SPS chapter received a 2013–14 SPS Chapter Research Award to design and construct a working cloud chamber. Through the project, they developed valuable scientific skills while creating a permanent piece of equipment to be used in the classroom as well as for outreach programs.

Sigma Pi Sigma Chapter Project Awards

For activities that raise awareness of or build community among ΣΠΣ members

Deadline: December 15
Amount: $500

Several awarded annually

The Davidson College ΣΠΣ chapter received a 2013–14 Chapter Project Award to celebrate their legacy as the "alpha" chapter and invite alumni to their induction ceremony, where a lost key belonging to the chapter's 26th member, William Mebane, Jr., '21, was returned by Dr. Toni Sauncy, then-director of SPS and ΣΠΣ.

SOCIETY OF PHYSICS STUDENTS

For details and spring award deadlines, visit www.spsnational.org/programs/awards/.

**When an award deadline falls on a weekend, the deadline is moved to the following Monday.*

Hakeem Oluseyi. Photo by Így működik a Világegyetem.

Thinking Outside the "Box"

A JOURNEY FROM THUG TO THEORETICAL PHYSICIST

by Hakeem Muata Oluseyi
Associate Professor, Florida Institute of Technology, Melbourne

When I look around America, I see thought bubbles. People have stories in their minds about other people, these stereotypes. If you're not careful, these stories can trap you. Don't let that happen.

Today I'm a professor. I've made important discoveries in solar physics and published important work in cosmology. I've worked in Silicon Valley, where I invented a new kind of transistor. I hold a bunch of patents and am a TV personality on shows such as *Outrageous Acts of Science* and *Alien Encounters*.

You might find this hard to believe if you knew about my childhood. My mom worked all the time, and we didn't have much money. We moved almost every year growing up, so I was always the new kid in the bad neighborhood. There were a lot of people who wanted to prey on me. I was fighting and running a gauntlet every day just to get to school. When I was 7 years old and living in LA I had male cousins who were in the Crips gang. So I started saying I was a Crip and stealing.

At the same time I had a set of World Book Encyclopedias that I literally read from A to Z. I was identified as gifted. That was the story of my life back then—academically talented, always in trouble.

For much of my life I acted out what I thought my role was, based on what society told me. I was always hearing sentences that start with "Black folks don't. . . .," as in, "Black folks don't play golf" or "Black folks don't swim." Well, what about "Black folks don't do science"?

When my mom and I eventually moved to rural Mississippi—to a trailer on a dirt road off a dirt road off a dirt road—some professors from a nearby university came to my high school and told us about a science fair. The personal computer had just come out, and my girlfriend's family had one. I taught myself BASIC and coded the effects of special relativity. I ended up winning first place in physics at the science fair.

Looking back on it, those judges must have been so surprised to see this little black kid from an all-black community talking about relativity and coding. Don't get caught in that little black box of who people think you should be. Don't get caught in any box.

I learned this lesson the hard way. I dropped out of Tougaloo College in Mississippi, which was the beginning of a spiral into deep darkness for me. There were a lot of drugs, a lot of guns. Then I was working as a janitor, and there was an opening for a bellhop that I applied for. I didn't get it. My exact thought at that moment was, "I can't even move up from janitor to bellhop? I'm going back to college." To learn math

> "The secret is to jump on every opportunity that comes your way, every moment of serendipity."

I spent every night at a chalkboard in the science building. I did every problem in the calculus book. I ended up double majoring in math and physics at Tougaloo.

At one point my chemistry professor put my name in for a summer research program at the University of Georgia without telling me, and I was selected. I couldn't pay for the plane flight to Athens, GA; I was sleeping in a dorm I broke into because I didn't have money for housing. He bought my ticket.

That summer was a life-changing experience for me. In Mississippi racism had tainted every job I had. I didn't detect any of that in research. This was the life for me!

The secret is to jump on every opportunity that comes your way, every moment of serendipity. While I was in college, students from Harvard and MIT came by and told us about a national conference for black physicists. I went to the conference, and they told me, "Here are the top graduate schools. Here's what you need to do to get in. Here are the recruiters." I got to know the recruiters and applied to graduate school; I was accepted at almost every school where I knew someone.

Don't listen to people who try to stop you from doing what you want to do. While I was a graduate student at Stanford, I learned about classism—even being white wasn't good enough if you didn't talk right and dress right. I wanted to run back to the ghetto. One professor tried to get me kicked out. But I learned how to interact with a new social class. I got mostly A's in my graduate courses. My PhD work won a national award.

In the end I listened to the people who wanted to support me. I decided to change my life and change my name. My new first name, Hakeem, means "wisdom," and my new middle name, Muata, is "He seeks the truth." Oluseyi comes from the West African Yoruba people, and it means "God has done this." //

OLUSEYI speaking at Fellows Talks, TEDGlobal 2012. Photo by Ryan Lash.

Project Physics

Photo by Elena Thompson.

Oluseyi has appeared on TV shows and given talks at various venues, including the popular TED conferences. To learn more about his scientific interests and life story, check out these videos and interviews:

» **Find out how** he scrutinizes the science presented in the Science Channel show *Outrageous Acts of Science* at www.youtube.com/watch?v=oWMqhDdSN0o.

» **Watch a clip** from the Science Channel show *Alien Encounters* at www.sciencechannel.com/tv-shows/alien-encounters?_ga=1.49331107.463615133.1415377872.

» **See him connect** the concept of infinity to the choices we make in a TEDx lecture for inmates at a state prison at www.youtube.com/watch?v=45pTq0ADz6o.

» **Learn what we know** about the big bang in his TEDxOrlando lecture at www.youtube.com/watch?v=wiNnhJZf6Ys.

» **Read more about** his life in this profile published on TEDBlog at http://blog.ted.com/2012/10/05/rise-of-a-gangsta-nerd-fellows-friday-with-hakeem-oluseyi/.

» **Explore** sonic booms and asteroids on a video hosted by the TEDBlog at http://blog.ted.com/2013/02/18/ted-fellow-hakeem-oluseyi-talk-sonic-booms-and-asteroids-on-nbcs-the-ed-show/.

» **You can also follow Oluseyi** on Twitter (@HakeemOluseyi) or Facebook at www.facebook.com/hakeemoluseyi.

Dear **Pen Pal**

CONNECTING MIDDLE SCHOOLERS TO SCIENCE

by Nico Wagner
Graduate Student, Harvard University, Cambridge, MA

The day had finally come! After weeks of hype, 97 sixth graders from Cesar Chavez Academy Middle School (CCAMS) in Detroit made their way to the University of Michigan in Ann Arbor. Waiting for each student was his or her pen pal, a member of our SPS chapter who had been writing notes back and forth to the students since September as part of our Future Faces of Physics project.

I was a senior at the University of Michigan at the time and had not met my two pen pals before that day. Ivan turned out to be a quiet teenager who wanted to be a doctor. Diana, on the other hand, was lively. She had looked up several physics topics to ask me about.

We had a full agenda planned for the students, who were primarily Hispanic, a population often underrepresented in the sciences. They split into groups that rotated through several different stations: a planetarium show, a physics lab tour, a hands-on biology lab experience, and a tour of campus. When the groups reconvened for lunch, they eagerly swapped stories about their adventures. One side of the room chattered about finding stars in the night sky, while the other side buzzed about watching fruit flies under a microscope.

Once everyone settled down, we treated our guests to an all-out demo show. We didn't pick just any demos. For this unique show, we deployed the best of the best: the biggest explosions, the largest sparks, and the loudest demos available to us.

Pop cans exploded and balls flew through the lecture hall. A Tesla coil injected tens of thousands of volts into my body; the students screamed and cheered! Then we kicked things up another gear and fired a jet pulse, which is basically a miniature jet engine, right in front of them.

> "We had truly left a lasting impression."

To finish off the show, we told the audience that we would be setting someone's hand on fire. Little did they know that the "someone" would be their teacher. Accompanied by the loudest cheer imaginable, Brian Wagner made his way to the front and courageously allowed us to light his hand on fire with the help of propane bubbles. Needless to say, that is an image the kids will not soon forget.

When I visited CCAMS in May for Career Day, the kids were still talking about their trip to U of M. Although we had met only the sixth graders on campus, news of the visit had spread to the seventh and eighth graders as well. Everyone was excited for what I, the new "science man," had in store for them. We had truly left a lasting impression. //

SPSer KAT, "the coolest pen pal," received this letter from her middle school correspondent. Photo courtesy of Nico Wagner.

IN THIS DEMO, the hydrolysis of water produces oxygen and hydrogen. The two gases are then mixed and, helped by a spark, transform back into water with a nice little bang. Photo courtesy of Nico Wagner.

Want to Start Your Own **Program?**

Apply for an SPS Future Faces of Physics award. Learn more online at www.spsnational.org/programs/futurefaces/.

Arduino Outreach

STUDENTS HOOKED ON PROGRAMMING AND ELECTRONICS

by Hunter Mills, Kevin Zack, and Benjamin Cunningham
Class of 2014, Sonoma State University, Rohnert Park, CA

Meet Luisa Jojola. Last year she was a third-year biology and mathematics double major at Sonoma State University (SSU) in Rohnert Park, California. She is also a member of the MESA Engineering Program on campus, which supports educationally disadvantaged students pursuing degrees in engineering or computer science. Luisa was one of 15 students who attended a two-day outreach workshop on electronics and programming organized by SSU's SPS chapter and supported by an SPS Future Faces of Physics (FFP) award, with additional support from MESA.

Prior to this event, Luisa had no experience in programming or electronics. She didn't know what to expect at the workshop; programming and electronics can be intimidating, after all. At the end of the first day, she expressed uncertainty about coming back for the second day.

> "Our goal was to introduce students to programming and electronics by skipping straight to the fun stuff."

The hardest step in learning any subject is knowing where to start. Mathematics students start with arithmetic and move on to algebra, geometry, trigonometry, calculus, and so on. The first step in programming is usually to get the computer to output "Hello world!" In electronics the first step is usually to create a basic circuit with a resistor and an LED. These exercises are not particularly rewarding.

Our goal was to introduce students to programming and electronics by skipping straight to the fun stuff: powering sensors and collecting data. Arduino kits made this possible.

Arduino is an open-source hardware device programmed in a language similar to C and designed to streamline microelectronic projects. It masks complex subjects such as communication protocols with simpler, user-friendly commands. Arduino is also supported by an active and open community that continually creates new educational projects and new device-specific libraries that allow information to be logged to an SD card, for instance, or gathered from a GPS unit.

Our two-day workshop started by presenting students with a range of sensors and basic projects. We asked the students to work on whatever they found most interesting. Students could also take the sensors home with them overnight.

Re-enter Luisa. She came back! She decided to take an Arduino home and found that she really enjoyed working with it. By the end of the second day, she had essentially created a backup sensor for a car. Her device included an ultrasonic range finder that found the distance to another device, and an LED she programmed to change color depending on that distance. Luisa has since decided to take an introductory course in C and C++. Not bad for someone with no background in programming or electronics! //

LEFT: Luisa (front) shows the working proximity sensor circuit and program she created.

BELOW: Luisa's project was a success. Images courtesy of SSU.

ABOUT FUTURE FACES OF PHYSICS AWARDS

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 program is to promote the recruitment and retention of people from groups historically underrepresented in physics. Applications are due October 15. For details visit http://spsnational.org/programs/awards/futurefaces.htm.

ABOUT MESA

MESA (Mathematics, Engineering, Science Achievement) is an academic program that supports educationally disadvantaged students as they attain four-year degrees in science fields. MESA Centers are located on college and university campuses across California, and there are also K–12 and community college programs. For details, visit http://mesa.ucop.edu. The California program has been replicated in several other states.

The Magnetic Curlmeter

EXPERIMENTS WITH TOROIDS

by Armian Hanelli and Cyrus Hossainian
Northern Virginia Community College, Annandale

MEMBERS OF THE SPS CHAPTER at the Northern Virginia Community College (NVCC) in Annandale, VA. Third from left: Cyrus Hossainian. To the right of him: Walerian Majewski. Seventh from left: Armian Hanelli. Image courtesy of NVCC.

James Clerk Maxwell, the father of electrodynamics, had a fondness for donuts—more specifically, for donut-shaped objects wrapped in wire.

In 1861 he wrote, "Let there be a circular ring of uniform section, lapped uniformly with covered wire. It may be shown that if an electric current is passed through this wire. . . . the effect will be that of a magnet bent round till its two poles are in contact."

Maxwell's wire-covered ring or its equivalent, a magnet bent into a loop, exhibits a number of interesting properties and rich physics. The current flowing in its windings is characterized by a multipole moment called a toroidal dipole, or an anapole, moment. Toroidal current is the simplest of multipolar currents that produce only finite-range magnetic fields.

Studying toroids has yielded new insights into fundamental physics. Atoms, for example, can behave like miniature toroids. Toroids are also finding applications in electromagnetic media and confining hot plasma in thermonuclear reactors.

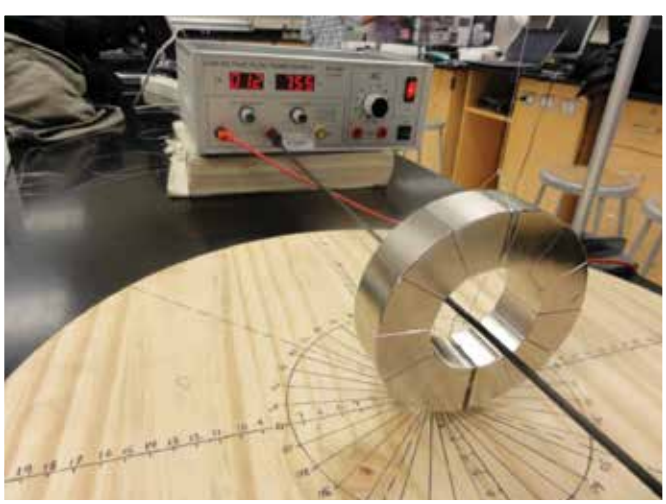
We investigated the simplest toroidal multipole: the dipole. We began by making a "curlmeter" using a magnetic model, a ring of 12 circumferentially magnetized neodymium magnets.

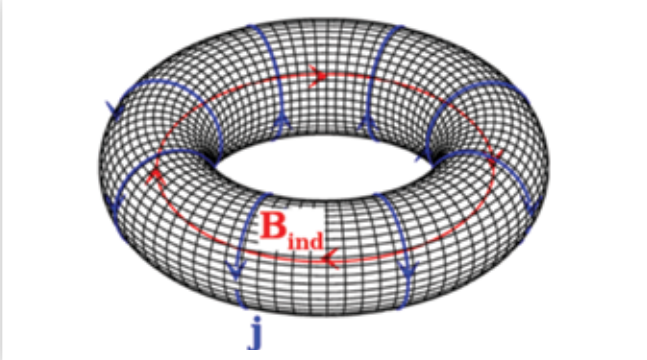
TOROIDAL MOMENT

Just as loops of wire are used as Gaussmeters to measure magnetic fields, toroids may be used as curlmeters to detect the curl of magnetic fields. The curl of a magnetic field **B** is a vector characterizing the amount of circulation, or vorticity, in the **B** field. It is calculated as a vector product of the differential operator ∇ acting on the components of **B** in the Cartesian coordinate system.

$$\nabla = \hat{\mathbf{x}}\frac{\partial}{\partial x} + \hat{\mathbf{y}}\frac{\partial}{\partial y} + \hat{\mathbf{z}}\frac{\partial}{\partial z} \qquad (1)$$

Current flowing in a coil or on the surface of a magnetic torus generates a toroidal moment $\mathbf{t}_m$ directed along the axis of symmetry running through the object's donut hole. This moment **m** is analogous to the magnetic dipole moment produced by current flowing through a loop of wire and interacting with **B** via a torque $\boldsymbol{\tau} = \mathbf{t}_m \times (\nabla \times \mathbf{B})$ with energy $U = -\mathbf{t}_m \cdot \nabla \times \mathbf{B}$. By analogy with the magnetic dipole moment, the toroidal moment of a thin toroid with





LEFT: We passed a linear wire through the hole of our suspended magnetic model to measure its dipole moment.

ABOVE: A magnetization **M** creates a surface current density **J** and magnetic field **B** in a torus, illustrated here. Images courtesy of NVCC.

internal magnetic field $\mathbf{B}_{int}$ should be equal to $\mathbf{t_m} = \mathbf{B}_{int}aA$, where *A* and *a* are, respectively, areas of the torus's "donut" hole and of the cross section of its "limb."

Our magnetic toroid, with approximately circumferential magnetization **M**, has a toroidal dipole moment $\mathbf{t_m}$ that can be written directly in terms of **M** and the position **r** inside the toroid:

$$\mathbf{t_m} = \frac{1}{2}\int \mathbf{r} \times (\mathbf{M})\, dV. \qquad (2)$$

Assuming then that we deal with an almost ideal and small (as compared with the extent of the external field **B**) toroid, its interaction with the curl of **B** means, from the Ampere–Maxwell Law, an interaction with an external current *i*, having current density **J**, and/or interaction with the rate of change of the electric field **E**.

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \qquad (3)$$

Note that Eq. 3 is a differential form of the integral law we see in our textbooks.

$$\oint \mathbf{B} \cdot \mathbf{d}s = \mu_0 i + \frac{1}{c^2}\frac{\partial}{\partial t}\int \mathbf{E} \cdot d\mathbf{A} \qquad (4)$$

OUR EXPERIMENTS

To create a curlmeter capable of interacting with the conduction current density in Eq. 3, we ran a linear wire with current **i** through the hole of our toroid, creating a non-zero curl **B** there. We paramaterized the torque resulting from the interaction of the current density in **i** with the toroid as $\boldsymbol{\tau} = \mathbf{t} \times \mathbf{i}$. It rotated the toroid's axis to align with the wire's current.

To find *t*, "the effective" toroidal moment, we used the method that Gauss used 180 years ago to make the first measurement of the Earth's magnetic field: we measured the frequency *f* of oscillations of our freely suspended toroid under the influence of curl **B**. From the torsional equation of motion of our toroid we found *f* (Eq. 5) as a function of *i*, the torus' moment of inertia, $I = 1.01 \times 10^{-3}$ kg m^2, and the suspension wire's torsional constant *k*:

$$f^2 = \left(t / 4\pi^2 I\right) i + k / \left(4\pi^2 I\right) \qquad (5)$$

We were ultimately able to extract the crucial measurement for our device, the empirical toroidal moment, $t = 1.20 \times 10^{-5}$ Nm/A. Wire currents that did not pass through the donut hole in the torus exerted no torque, in agreement with the theory; from the perspective of our toroid, their fields were curl-less.

We then tried to replicate our findings with electric toroids connected to dc or ac voltage. This proved difficult because the single layer of windings around the toroid created not only a toroidal moment, but also a net magnetic dipole moment. As the current in the linear wire threaded through the toroid's hole increased, the effect of its magnetic field **B** on the magnetic dipole moment of our torus became much larger than the torque on the toroidal moment from curl **B**.

In a future experiment we will try to detect fields that, according to Nobel laureate Vitaly Ginzburg, appear outside of a toroidal dipole immersed in an electromagnetic medium. (No such fields appear in a vacuum.) We also plan to rotate our magnetic toroid around its diameter and observe the toroid's magnetic field (normally locked inside the toroid) escaping outside, creating an electric-dipole-type toroidal antenna. //

This research was funded by a 2013 Sigma Pi Sigma Undergraduate Research Award.

Get Money for Chapter Research!

SPS chapters are eligible for up to $2,000 in funding for research projects through the SPS Chapter Research Award (formerly the Sigma Pi Sigma Undergraduate Research Award). Applications are due November 15th. For details see www.spsnational.org/programs/awards/research.htm.

CORRECTION

"Get Inspired!" on page 17 of the Spring 2014 issue of *The SPS Observer* referred incorrectly to physics demos put on by "Juanita Community College." The actual name of the school is Juniata College, and it is a bachelor's granting institution. We also incorrectly stated that their most popular demo includes smashing a cement block on the chest of a math professor—we should have said a physics professor! We apologize for these errors. See below for the demo in action as college president Jim Troha whacks physics professor and SPS advisor Jim Borgardt. //

JUNIATA COLLEGE PRESIDENT JIM TROHA puts the faculty in line by hitting physics professor James Borgardt with a sledge hammer as SPS students "Danger" Dave Milligan (right) and Caitlin Everhart (left) look on. Photo by Rick Hamilton.

Why Discuss Diversity in a Physics Magazine??

THE IMPORTANCE OF DIFFERENT POINTS OF VIEW

by Geraldine Cochran, Associate Director, Multicultural Center for Academic Success, Rochester Institute of Technology, NY, and Ramón S. Barthelemy, Fulbright Scholar, University of Jyväskylä, Finland

DIVERSITY IS GOOD FOR THE COMMUNITY

Not everyone had the privilege of growing up on Chicago's South Side, as the first author of this piece did. Not everyone had the privilege of living next door to the Great Lakes, as author number two did. Being friends and colleagues, we often share our experiences and different perspectives with one another. Is that diversity? Is that all there is to it?

Two minds are better than one, you've heard. That's true, but people with similar backgrounds and experiences tend to think more similarly than people with different backgrounds and experiences. When problem solving, groups can benefit from having people with diverse backgrounds and experiences because they can offer a variety of perspectives, often leading to a better result. The scientific literature supports this idea; a study published in *Psychological Science* found that the perspectives of minorities in racially diverse groups contributed novelty and helped group members think about complex issues.[1]

The beauty of physics lies in its enduring applicability to new problems and new situations. To solve increasingly complex global problems, we need to bring together people with diverse backgrounds, different perspectives, and a variety of creative approaches. Moreover,

the results of physics research are being used to address problems faced by diverse groups of people. Evidence suggests that diverse teams are more effective at addressing the needs of a diverse population. The first voice-recognition systems, calibrated to male voices, performed poorly in response to women's voices; early car airbags were designed for adult males, "resulting in avoidable deaths for women and children."[2]

THE PHYSICS COMMUNITY IN THE UNITED STATES DOES NOT REFLECT THE POPULATION DISTRIBUTION

Today in the United States, many groups are underrepresented in physics. African Americans and Hispanics made up only 2.1 and 3.2 percent, respectively, of physics faculty in 2012 [3], but they represent over 13 and 17 percent of the population. Women, though 51 percent of the general population, accounted for only 21 percent of instructors or adjunct faculty, 22 percent of assistant professors, 15 percent of associate professors, and 8 percent of full professors in physics in 2010.[4] Statistics on those who identify as lesbian, gay, bisexual, and transgender (LGBT+) in physics are limited and complex, but anecdotes suggest that this group is marginalized in the field of physics. (See Elena Long's story on page 20.)

RECOGNIZING THE REALITIES CAN LEAD TO ACTION

National funding agencies such as the National Science Foundation (NSF) and the Department of Energy have supported programs and research aimed at broadening participation in physics, as well as solicitations that explicitly encourage underrepresented groups and individuals with disabilities to apply for funding. NSF ADVANCE funds projects aimed at increasing the number of women pursuing academic careers in science and engineering. It focuses on transforming institutional structures to reduce barriers to the advancement of women in academia (www.nsf.gov/pubs/2014/nsf14573/nsf14573.pdf).

Physics education research, an interdisciplinary field, has helped us to figure out how to create more equality in the classroom.[5] Just discussing the fact that women are underrepresented in physics, for instance, can encourage women to pursue careers in physics.[6] Barriers to the success of ethnic minorities have also been identified; black women have

WHY IS DIVERSITY IMPORTANT FOR SCIENCE?

by Kendra Redmond, SPS Program Manager

Engaging people from a variety of genders, ethnicities, sexual orientations, perspectives, backgrounds, areas of expertise, religions, cultures, and other variables to participate in science is important for addressing inequities and increasing the size of the scientifically trained workforce. It's also important because it leads to better science! How?

- Scientific progress relies on problem solving and collaboration. Groups composed of people with diverse experiences and areas of expertise tend to be more creative and innovative.
- Asking questions drives science forward, and scientists with different perspectives often ask different questions. Different questions can lead to new insights.
- The ways in which scientists seek answers to questions can be heavily influenced by their values, and new techniques often lead to new knowledge.

For more discussion on this and to see examples of research in these areas, check out the following resources.

- Daryl E. Chubin and Shirley M. Malcom, "Making a Case for Diversity in STEM Fields," *Insider Higher Ed* (October 2008). www.insidehighered.com/views/2008/10/06/chubin
- Kenneth Gibbs, Jr., "Diversity in STEM: What It Is and Why It Matters," *Scientific American* (September 2014). http://blogs.scientificamerican.com/voices/2014/09/10/diversity-in-stem-what-it-is-and-why-it-matters/
- Douglas L. Medin and Carol D. Lee, "Diversity Makes Better Science," *Association for Psychological Science Observer* (May-June 2012). www.psychologicalscience.org/index.php/publications/observer/2012/may-june-12/diversity-makes-better-science.html
- Scott Page, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools and Societies* (Princeton University Press, Princeton, NJ, 2007).

I AM SPS

"I enjoy taking morning jogs to watch the sunrise. I am SPS."
« Tracy Paltoo

"I have been on an Irish hurling team. I am SPS."
« Jacob Ferong

difficulty finding study groups in general, which can be a hindrance to their learning. [7] Psychological interventions can help to address some problems, such as the danger that gender and ethnic minorities will behave like the negative stereotypes they hear about their groups. In one study these interventions reduced gaps between how well men and women did in an introductory college physics course.[7]

Much important, research-based work is being pursued in physics to help diversify our community of practitioners. But what can you do in your daily life to take advantage of the many benefits of diversity? When putting together study groups, picking partners for lab, and electing SPS chapter officers, remember to keep diversity in mind. Don't just pick people off the top of your head; consider students with a variety of backgrounds, skills, talents, and interests. When thinking about who to invite to speak at your next SPS meeting, keep diversity in mind. Look on your department's website—or beyond, to faculty and staff in other departments or alumni—to find people with unique backgrounds and experiences. If you do peer recruiting, think about places on campus and student groups you might not consider otherwise. When you plan outreach events, explore a wide variety of types of places and audiences. Whatever you do, keep diversity in mind. Doing so will strengthen our entire community. //

"When thinking about who to invite to speak at your next SPS meeting, keep diversity in mind."

REFERENCES

1. Antonio, A.L., Chang, M.J., Hakuta, K., Kenny, D.A., Levin, S.L., and Milem, J.F., "Effects of racial diversity on complex thinking in college students," *Psychological Sci.* **15**(8), 507 (2004).
2. Margolis, J. and Fisher, A., *Unlocking the Clubhouse: Women in Computing* (The MIT Press, Cambridge, MA, 2002), p. 3.
3. Ivie, R., Anderson, G., and White, S., "African Americans & Hispanics Among Physics & Astronomy Faculty," American Institute of Physics Statistical Research Center, College Park, MD, July 2014.
4. Ivie, R., White, S., Garrett, A., and Anderson, G., "Women Among Physics & Astronomy Faculty," American Institute of Physics Statistical Research Center, College Park, MD, August 2013.
5. Miyake, A., Kost-Smith, L.E., Finkelstein, N.D., Pollock, S.J., Cohen, G.L., and Ito, T.A., "Reducing the gender achievement gap in college science: A classroom study of values affirmation," *Science* **330**(6008), 12347 (2010).
6. Hazari, Z., *et al., Phys. Rev. Spec. Top.–Phys. Ed. Res.* **9**, 020115 (2013).
7. da Rosa, K. D., "Gender, Ethnicity, and Physics Education: Understanding How Black Women Build Their Identities As Scientists," PhD dissertation, Columbia University, New York, 2013.

I AM SPS

"I lived in the wilderness for 2 months with only what I could carry. I am SPS."
« Wren Gregory

"I sing every chance I get, every day because music is the key to my happiness. I am SPS."
« Deval Mehta

SPS Partners with the National Society of Black Physicists

NEW JOINT MEMBERSHIP PROGRAM AIMS TO PROMOTE LISTENING AND LEARNING

by Paul Gueye
Assistant Professor, Hampton University, VA

A few days ago I was reading a very old story about animals in Africa. In the story all of the animals gather under a tree to identify the youngest and, by their logic, smartest animal. The animals born recently raise their hands, and a discussion ensues. Then suddenly a newborn hare screams from atop a branch just as he comes out of his mother! He obviously wins this challenge.

This story reminded me about how we as physicists sometimes get so caught up in the discussion process that we forget to notice the simple details in front of us. Sometimes we need to take the time to see and listen. Let me explain.

I have been the president of the United States–based National Society of Black Physicists (NSBP) since 2012. For many years our organization and others in the community have been trying various initiatives to address a fundamental issue, namely, the small number of minority students in physics and the sciences in general. Students who are African American, Hispanic, Native American, and female are going into physics in the United States at a much lower level than one would expect based on their college-aged populations.

Over the past two years I have decided to change my way of thinking about this problem. Amidst the good intentions and great ideas, we too often forget one simple concept that would help us to do good—sometimes we need to stop talking and listen. I realized that our initiatives will not work if they do not appeal to their targeted populations. We need to listen to the students, parents, and communities we want to reach.

NSBP and SPS have many of the same goals. We both work to promote the well-being of students within the scientific community and to increase the number of students from underrepresented groups joining the field of physics. To this end NSBP and SPS are pleased to announce a new joint membership program in which student members of either society can join the other at no cost. We hope this partnership will provide more avenues for us to hear from students about their challenges, needs, and achievements, as well as more opportunities for the physics community to learn and respond in meaningful ways.

Exchanging ideas, listening to one another, and working in teams have always been strengths of the physics community. Why can't we succeed in reaching out to underrepresented (and all) populations in ways that are meaningful? If we want to address the issue of underrepresented groups in physics, maybe we should take a lesson from the story of the hare—the youngest, smartest animal in that African story—and try to be smart about addressing diversity by seeing our world with a fresh, new perspective. //

> "We need to listen to the students, parents, and communities we want to reach."

THE JOINT SPS–NSBP MEMBERSHIP PROGRAM

The new SPS–NSBP membership agreement enables student members of SPS to join NSBP for free, and student members of NSBP to join SPS for free. The primary way that SPS members can take advantage of this opportunity is by indicating their desire to join NSBP on the SPS online application form when they join or renew. Current student members of SPS can join NSBP by e-mailing their request to sps@aip.org. Similarly, NSBP student members can take advantage of this joint membership when they join or renew their NSBP membership, or by e-mailing nsbpchapters@nsbp.org.

"I am a former national champion roller figure skater. I am SPS."
« Brandon Laycock

"I have ridden the zero-gravity plane (vomit comet) for NASA research twice. I am SPS."
« Danielle Weiland

A Launching Pad for a Scientific Mind

PHYSICIST STANLEY EDWIN INTEGRATES TRADITIONAL ALASKA NATIVE KNOWLEDGE WITH WESTERN SCIENCE

by Leona Long
Marketing Coordinator at University of Alaska Fairbanks, Interior-Aleutians Campus

> "IN THE ALASKA NATIVE WAY OF KNOWING, nothing stands alone."

When Apollo 13's oxygen tank ruptured, residents of the small Alaskan village of Chalkyitsik gathered in church to pray for the mission's success. Spellbound, young Stanley Edwin huddled with his family by a crackling transistor radio. He wanted to walk on the Moon like astronauts Neil Armstrong and Buzz Aldrin.

"I clearly remember the first Apollo launch, even though I was only about 2 years old," says Edwin. "I was fascinated by outer space and the stars, my ancestors' campfires in the sky."

The 1960s rocket blastoffs propelled Edwin's curiosity. He wanted to know more than what the people around him could explain. His father was a wise man and chief of the Dranjik Gwich'in people, but this wise man's experiences and knowledge were specialized for living and surviving in the boreal forest of Alaska's interior. He could not satisfy his son's questions of why and how.

Decades later, Edwin is finally finding the answers to his childhood questions by studying what he calls "the science of nature," aka applied physics, at the University of Alaska Fairbanks (UAF). His work at the National Center for Atmospheric Research in Boulder, Colorado, won an Outstanding Presentation Award at the 2013 national conference of the

I AM SPS

"I left my 12-year career in the federal government to learn physics and help make people's lives better. I am SPS."
« Austin Bradley

"I once turned down a job as a lounge singer at the MGM Grand. I am SPS."
« Joni Clark

Above: Edwin shows off a rocket model. Photo courtesy of Leona Long. Photo at left by Todd Paris.

Society for Advancement of Chicanos and Native Americans in Science. This summer, he participated in the International Comparative Rural Policy Studies consortium program, which studies rural policy and how to protect rural environments.

"In traditional ways of knowing, we don't break things down and categorize them. We see the interconnection of things and how things affect each other," explains Edwin, who graduated with his bachelor's degree in December 2013. "In the Alaska Native way of knowing, nothing stands alone."

As a member of UAF's SPS chapter, one of Edwin's favorite activities was judging science fairs and performing physics demonstrations for elementary school students. "My own curiosity is always reinforced by the children's inquisitive hunger. They want to know how a demonstration works," says Edwin.

Edwin's path to higher education has been paved with ice. His first winters as a UAF student began at 6 am with a three-mile walk to the university's rural center in Fort Yukon for construction trades technology classes. The bone-chilling temperatures dipped down to 50 below. After his evening classes ended, he walked the three miles back to his home and pondered the questions whose answers had eluded him as a child. This routine continued for several winters until he earned two associates of applied science degrees and a bachelor's along the way.

Now Edwin asks more sophisticated questions during his walk to the university. As a graduate student at UAF's Geophysical Institute, he is continuing his studies in atmospheric science and physics. He is conducting an independent research project at the International Arctic Research Center in Fairbanks, investigating funnel clouds in Alaska, the precursor to tornadoes.

"I always question and seek answers, strive to understand why and how things work the way they do," says Edwin. "Now I am finding answers by integrating the lessons of my father and elders in my work as a scientist." //

Meet Edwin

Check out his Facebook page at www.facebook.com/stanley.edwin.33.

"I'm pretty much a polar bear. I don't get cold! I am SPS."
« Joe Charnawskas

"If you want to mess with a recipe until it doesn't resemble the original but is still delicious, ask me. I am SPS."
« Erin McCamish

"I spent years as a taxi driver before I decided to teach high school physics. I am SPS."
« Eric Clausen

School Ties and Dyes

SPSer HELPS TO FOUND PHYSICS SOCIETY FOR WOMEN

by Robyn N. Smith
Class of 2015, Drexel University, Philadelphia, PA
SPS Associate Zone Councilor for Zone 3

We spent most of the afternoon getting ready. We taped down trash bags to protect the hardwood floor, gathered rubber bands, washed white t-shirts, and mixed hot water with powdered dye. Before we knew it, the third annual "Welcome Back!" tie-dye event of Drexel's Women in Physics Society (WiPS) had begun!

Our apartment was filled with the conversations of 10 young women pursuing bachelor's degrees in physics. Topics of discussion included which classes were hardest, which professors were amazing, and which professors were . . . *well* . . . less amazing. We shared our research interests and our co-op experiences with each other. Someone asked where to buy groceries, and someone else wanted to know the best restaurants in Philadelphia.

The idea for WiPS was born after several women majoring in physics attended a Conference for Undergraduate Women in Physics (CUWiP) in 2011. They wanted to form a student group similar to SPS, but with a specific focus on women. When they needed a treasurer, the final officer position required in order to be recognized as an official student organization, they contacted me. I was in.

We talked to our director of undergraduate studies and together identified retention as an issue in our department. Every department expects some students to switch majors, but our women were leaving in disproportionate numbers.

One problem was that women at different points in their degrees did not have many opportunities to get to know each other; some women felt alone in their physics classes, while the wealth of experience held by the women in upper-level classes went untapped. To bring women together, we began organizing social events such as our tie-dye party.

We then turned our attention to outreach. WiPS often works with Drexel's SPS chapter to supplement traditional outreach events with ones specifically designed for high school girls. Most notably, we have partnered to apply for SPS Future Faces of Physics Awards that have enabled us to build a two-year relationship with a local all-girls high school. Each year, mem-

"Every freshman female physics major last year returned for her sophomore year in physics!"

I AM SPS

"I am a 31-year-old student going back for a second bachelor's degree and a new career. I am SPS."
« Kyle Greene

"I am an international student. I am SPS."
« Dominic Chang

bers of WiPS and SPS set up exciting hands-on demos (such as liquid nitrogen flower smashing!) and teach five physics classes. In every class we discuss college and what it's like to be a woman pursuing a STEM (science, technology, engineering, and mathematics) career.

WiPS also takes professional development seriously. Our members have attended CUWiPs every year since 2011. Upper-level students often present their research, while first- and second-year students are exposed to careers and facets of physics they've never heard of before, including the importance of science policy. Members often tell me that this conference is an extremely encouraging and uplifting experience.

Since the creation of WiPS, the bond between women of all levels in our department has become much stronger. We've successfully increased our retention rate. Every freshman female physics major last year returned for her sophomore year in physics! But we realize we still have a long way to go in improving the culture in physics for women. I encourage you to take a look at your own department and SPS chapter and find ways to support women and other underrepresented groups that will work for your school! //

Left to right: The author, Mary Chessey, and Wendy Harris carve pumpkins at a WiPS event. Photos courtesy of Robyn Smith.

WiPS on the Web

Check out Drexel's WiPS at www.drexel.edu/physics/about/women-in-physics-society/.

"I am doing research on photovoltaics in Luxembourg for a year before going to law school. I am SPS."
« Ashley Finger

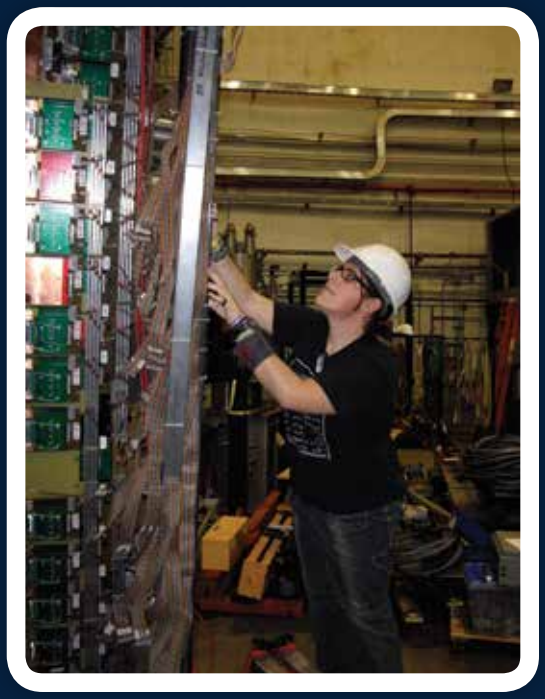
"I want to solve the energy crisis and enable ubiquitous space travel. I am SPS."
« Pierre Avila

"I am the first generation born in the United States on my father's side. I am SPS."
« Kinsey Zarske

Navigating Physics as a Fish out of Water

A TRANS WOMAN'S JOURNEY IN PHYSICS

by Elena Long
Postdoctoral Research Associate, University of New Hampshire, Durham



The author is a user of and research collaborator with the Thomas Jefferson National Accelerator Facility in Newport News, VA. Photo courtesy of Elena Long

In September I visited my undergrad alma mater, where I got my start in physics. The experience caused me to reflect on how far I've come since then.

I wasn't the most traditional physics student. The first person in my family to attend a four-year college, I didn't even realize that grad school was an option when I started my bachelor's degree. As I began my journey to discover the richness of the physical world, I also began another journey: coming out as a queer transgender ("trans") woman.

In college (and later, grad school) I had support for these disparate aspects of my life. At LGBT (lesbian, gay, bisexual, trans) support groups on campus, I met and connected with other students going through similar issues related to gender and sexual orientation. Meanwhile, I continued my physics career, finished my classes, passed my qualifier exams, and had the opportunity to study nuclear physics at an electron accelerator facility.

Extremely excited about the chance to work at a national lab, I packed my bags and moved halfway across the country to a place I had never even visited. If you ever get the opportunity to work at, or at least visit, an accelerator facility, do it. The physics done at the lab captivated me, and just being around the equipment we use to probe the inner structure of protons and neutrons still gives me chills.

As wonderful as the research was, I suddenly found myself a fish out of water in the lab. I was surrounded mostly by straight guys whose gender matched the sex assigned to them at birth ("cisgender"). The culture was one I had never been a part of, and there were no resources for LGBT people. The lab's employment nondiscrimination policy didn't even cover sexual orientation, gender identity, and gender expression.

In my isolation I started looking for resources and someone else who would understand. I Googled every letter of the LGBT acronym soup with "physics." The message repeated over and over again, by everyone from research advisors to fellow students, was, "Shut up and never talk about it, and if you dare

> "No physicist who happens to be a sexual or gender minority SHOULD FEEL ISOLATED AND ALONE."

I AM SPS

"I am a part owner of a professional sports team (the Green Bay Packers). I am SPS."
« Brian Schwartz

"I am a student government representative at Vassar and a spoken-word performer. I am SPS."
« Simon Patane

to talk about it anyway, it will destroy your career." My experiences in the lab were, unfortunately, not unique among LGBT people in physics.

It was around this point that I attended my first large physics conference, organized by the American Physical Society (APS). Figuring that surely someone would know where I could find something, anything, I attended an event focused on women in physics. After the presentation, I gathered all of my courage to ask, "Where can I find resources for LGBT physicists?"

The room went silent. Then someone piped up: "Huh. We never thought of that."

But because I asked the question, people came up to me afterward with suggestions, giving me names of other people to talk to about the topic. We gathered what little we could find on a website and put together the first-ever networking session for LGBT physicists, which took place at another APS conference. We talked about the issues that affected us as LGBT people in physics: the danger of employment discrimination, the value of inclusive health insurance policies, the lack of visibility, the importance of bathroom access, the immense pressure to never talk about our lives, and the culture we were working in that didn't want to admit that we exist.

We were able to bring these issues to the greater physics community at the 2012 APS March Meeting session titled Sexual and Gender Diversity Issues in Physics, thanks largely to the efforts of the APS Committee on the Status of Women in Physics and the APS Committee on Minorities. We posed a question: How could our newly formed LGBT physicists organization help to address the issues we had identified? We then put together a best practices guide, which we keep up to date and expanded in collaboration with the AAS Working Group of LGBT Equality. No physicist who happens to be a sexual or gender minority should feel isolated and alone.

Ten years after my coming out in college, I am struck by how much work we still have to do. To this day, my undergraduate alma mater has taken only one action to address the needs of trans students: turning a men's room into a gender-neutral restroom, a change made only to force a trans woman to not use the women's restroom. Students are still harassed, verbally and physically, because of who they are.

Future physicists continue to be pushed away from the field due to a culture that doesn't want to admit LGBT people exist. We, as physicists, can do so much better for the next generation. //

Continue the Conversation

Check out LGBT+Physicists at http://lgbtphysicists.org and read the group's best practices guide here: http://lgbtphysicists.org/files/BestPracticesGuide.pdf.

APS Creates ad hoc Committee on Lesbian, Gay, Bisexual, and Transgender Physicists

by Arlene Modeste Knowles, APS Diversity Programs Administrator

Five years ago, LGBT advocate Elena Long asked the American Physical Society (APS) for a space at our annual meeting in which lesbian, gay, bisexual, and transgender (LGBT) physicists could meet and network. We were happy to add this to the agenda, and that meeting gave birth to an informal but active group of LGBT physicists. The LGBT+Physicists group, which has grown tremendously, has engaged in outreach, taken on advocacy activities, and gathered resources on their website for LGBT scientists, allies, and the broader science community.

About a year ago, LGBT+Physicists asked to become more formally involved with APS. This fall, with their input, APS Executive Officer Kate Kirby appointed an ad hoc committee to advise APS on the current status of LGBT issues in physics and provide recommendations for greater inclusion. More specifically, the committee will investigate LGBT representation in physics, assess the educational and professional climate in physics, recommend changes in policies and practices that impact LGBT physicists, and address other issues that affect inclusion.

Monica Plisch, associate director of APS Education & Diversity, and I will provide logistical support and advice to the committee. APS will provide resources for them to carry out their charge and continue organizing networking sessions at both the March and April APS meetings. All are welcome to attend these sessions! //

Check out page 10 of the latest *Newsletter of the Committee on the Status of Women in Physics & the Committee on Minorities of the American Physical Society* for more information about the APS Ad Hoc Committee on Lesbian, Gay, Bisexual, and Transgender Issues: www.aps.org/programs/women/reports/gazette/upload/fall14.pdf

"I am a second-degree black belt and a certified instructor in mixed martial arts. I am SPS."
« Brittney Hauke

"I was homeless. I am SPS."
« Cameron Caligan

Female Physicists Address İnequalities

ATTENDING THE 5TH INTERNATIONAL CONFERENCE ON WOMEN IN PHYSICS IN WATERLOO, CANADA, AUGUST 5–8, 2014

by Christine O'Donnell, Graduate Student, University of Arizona, Tucson, 2013 SPS Intern and Toni Sauncy, former SPS Director and Chair, Department of Physics, Texas Lutheran University, Seguin

THE US DELEGATION at the 5th İUPAP İnternational Conference on Women in Physics (İCWİP). Photo courtesy of İCWİP.

İmagine walking into a room of nearly 250 physicists. Everyone is sharing stories about exciting discoveries and classroom experiences while waiting for a world-class plenary lecture to begin.

Now imagine that nearly everyone in the room is a woman.

At the 5th International Conference on Women in Physics (ICWIP5), the scenario described above did not have to be simulated, modeled, or otherwise imagined. It was observed! As she took the stage, conference host Shohini Ghose of Wilfrid Laurier University (WLU) quipped, "Now I know what it feels like to be a man in physics!"

The remark was a well-intended jest, but the reality is that female physicists in the United States and around the world often have no other female colleagues in their departments. While statistics tell us the number of women in physics at all levels is rising, the rise is slow and the overall percentage of physicists who are female remains low.

ICWIP is organized every three years by the International Union of Pure and Applied Physics (IUPAP) Working Group on Women in Physics, formed in 1999 to survey the situation of women in physics, report findings, and suggest means to improve the situation. Over 50 countries were represented at this year's conference, with teams from industrialized countries providing support for attendees from developing nations.

The 2014 conference delivered on its promise of spurring meaningful conversation about a wide range of topics important to physics: research, education, diversity, career development, and more. Distinguished plenary speakers covered a

Physics HERstories

BETH CUNNINGHAM

"I think the thing about physics, what makes it so fun, is every day I get to play. It's like my playground. There are so many neat pieces of equipment that I can use to come up with some great answers to questions that I have about how things work."

FATIMA GARCIA

"If you do have support, I find that you get further along, simply because you build a network of people that are willing to push you forward . . . The knowledge you gather will be amplified by the knowledge you gather from other people."

SILVINA PONCE DAWSON

"I think more women need to go into leadership positions, not to behave as men, but to bring a new way of behaving and [to show] that there is not only one way of doing things, only one way of doing science. There are many ways. They are all very valuable."

CHRISTINE O'DONNELL

"Be yourself. Keep going. It's all worth it, and you're going to have a lot of fun doing it."

Watch the full video at www.youtube.com/watch?v=ofE-mJFJR5w

For more information about the İUPAP Working Group on Women in Physics and the İCWİPs, see http://wgwip.df.uba.ar/.

variety of disciplines, including astronomy, particle physics, solid-state physics, and biophysics.

Participants in breakout workshops at the conference helped to develop new IUPAP resolutions related to gender studies, workplace strategies, professional development, and physics education. These recommendations, prioritized by the conference attendees, will be fine-tuned by the working group for presentation to the IUPAP General Assembly.

The talks, workshops, and sessions offered opportunities for women to learn, expand their professional networks, and have a voice in the activities of the working group. Posters presented by each country detailed both scientific achievements and efforts to attract and retain women in physics. The conference even incorporated cultural events such as an entertaining evening of music provided by WLU faculty.

In addition to its poster, the US team also undertook a video project entitled "HERstories: Wisdom and Encouragement from Women in Physics." Female attendees from across the world were asked to "tell their stories" in video interviews that captured the wisdom, enthusiasm, advice, and spirit of these women. Over 40 interviews were collected. Selected interviews were compiled into a video released in mid-October 2014. By presenting a diverse range of success stories tied to the common experience of being a woman, the project aims to engage, recruit, and retain young women interested in physics (see "Physics HERstories").

ICWIP5 was a unique and life-enriching experience that added new chapters to the stories of those who participated. We hope the outcomes of the conference will inspire even more women! //

A Glimpse of the Future of Biophysics

ASPIRING COMPUTATIONAL NEUROSCIENTIST ATTENDS GORDON RESEARCH CONFERENCE ON PHYSICS RESEARCH AND EDUCATION IN SOUTH HADLEY, MA, JUNE 8–13, 2014

by Mallory Tackett, University of Missouri, Kansas City

"Excuse me," I said, approaching a pair of researchers talking about some recent advancements in neuroscience. "I couldn't help but overhear your conversation."

It was my second day at the conference, and I was the only undergraduate there. I felt like an annoying tick on the backs of these great scientists. Expecting to be written off, I continued. "I'm an undergraduate hoping to do computational neuroscience research. Can you tell me more about your work?"

Surprisingly, one of their faces lit up, and we dove into a long and winding conversation. We talked about electroencephalography data analysis, mammalian olfactory patterns, and the neural circuitry of vocal learning in songbirds.

This was only one of many conversations I'll remember for years from my recent trip to Massachusetts for a Gordon Research Conference, supported by SPS and the National Science Foundation. The goal of the Gordon Research Conferences is to bring together scientists from many disciplines to discuss research at the frontiers of physics, biology, and chemistry. This particular conference had caught my eye because it focused on intersections

continued on page 25

Photo courtesy of AIP.

« EMMA MCKAY

"When I was 12 years old I picked up a copy of *Discover* magazine that my mother had gotten as a subscription for my older brother, and I read about Albert Einstein and the twin paradox. I thought it was amazing that we could know so, so much about the world. I told my mom that I wanted to be a physicist, and she said, 'Oh, if you'll be a physicist you'll be stuck all day in a room with a bunch of nerdy boys.' I [said], 'You know, I don't know who you think I am, Mom, but I'm pretty sure I'm the biggest nerd ever.'"

ANNE COX

"I walked into my introductory physics course . . . My professor, who was old and male, looked at the room [of 12 students] and said, 'Physics is something few men and no women understand.' And that was enough motivation for me to try to prove him wrong. And so by the time I got to my senior year I was the only physics major left out of that group of 12.'" //

"'Meet people, do physics, exchange knowledge' was the motto of the conference."

Die Physiker ("The Physicists") in Heidelberg

PRESENTING AT THE 29TH INTERNATIONAL CONFERENCE OF PHYSICS STUDENTS IN HEIDELBERG, GERMANY, AUGUST 10–17, 2014

by Helen Meskhidze, Class of 2016, Elon University, Elon, NC

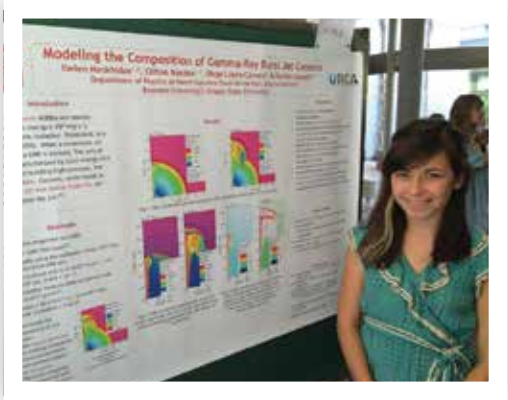
The opening ceremony of the 29th International Conference of Physics Students (ICPS) took place inside a castle. Hundreds of students from all around the world had gathered for this conference. We were each given a physics-related card depicting anything and anyone from Newton to a spiral galaxy. Our task was to find our match in the crowd and claim our prize. It was a great way to start a conversation; my card partner and I (who found each other nearly instantly) really enjoyed our small prize of German gummy bears.

The first of many guest lecturers was Metin Tolan of the Technical University of Dortmund, who discussed the physics behind James Bond films—the accuracy of Bond's free falls, the possibility of Bond watches, and Bond's questionable use of women as mirrors. His lecture was a hit with the young, eager, excited physics students in the audience. Other lectures I enjoyed covered the Higgs boson, simulations of the Milky Way on a supercomputer, and an astronaut's experiments in space.

I presented my own research on gamma-ray bursts (see "Modeling the Com-

MODELING THE COMPOSITION AND EMISSIONS OF GAMMA-RAY BURST JET COCOONS

by Helen Meskhidze



The author stands beside her poster at the poster session. Photo by Zoey Warecki.

Massive stars end their lives with powerful supernova explosions that, in extreme cases, may produce a gamma-ray burst. The driving mechanism of these bursts is jet-containing material that is moving close to the speed of light (relativistic jets) through a dense, rapidly rotating star. Previous studies have examined the general formation and radiation of the cocoons of these jets. However, the structure of the cocoon and the effects of cocoon composition on the creation of gamma-ray bursts have not yet been determined. In this study, we present the results of numerical simulations aimed at determining the composition and mixing of the cocoon material in gamma-ray burst progenitors and study how mixing affects the emitted radiation. We do so by adding tracer particles to hydrodynamic simulations to follow the mixing of matter within the cocoon as it evolves. Using this data, we compute the radiation of cocoons from different progenitor stars with varying amounts of cocoon mixing. These simulations will enable us to understand the total energy emitted by a star and the radiation properties of the cocoon. When compared to observations, our calculations may put constraints on the progenitor star structures that produce gamma-ray bursts. //

position and Emissions of Gamma-Ray Burst Jet Cocoons") at the student poster session, which was a great opportunity to discuss research with others in similar fields and learn about concepts I had never encountered before. A student from Finland doing galaxy merger research talked with me about computational astrophysics. A fellow American described the construction of a transmission electron microscope in his lab.

While in Heidelberg, I visited the Karlsruhe Institute of Technology as well as the Max Planck Institute for Astronomy. The main building of the astronomy institute was shaped like a spiral galaxy! The conference also featured a slew of cultural events, including a costume party, an evening in which delegates shared foods from their home countries, and a performance by Die Physikanten, a German group known for hilarious presentations of spectacular experiments. The audience couldn't stop laughing!

"Meet people, do physics, exchange knowledge" was the motto of the conference. It truly lived up to that motto and proved to be an experience I will not forget. The physics presented at the conference was interesting, the lecturers were great, and the cultural experiences were phenomenal. //

Left: The view from the castle of Heidelberg. Below: Heidelberg University's historical prison. Photos by Helen Meskhidze.

MORE INFORMATION

Helen Meskhidze received an all-expenses-paid trip to ICPS as a winner of the 2014 SPS Award for Outstanding Undergraduate Research, along with fellow winner Zoey Warecki of Towson University in Maryland. You can read their full meeting reports online at www.spsnational.org/programs/awards/2014/OSA/index.htm. Interested in applying for the 2015 SPS Award for Outstanding Undergraduate Research? Visit www.spsnational.org/programs/awards/student.htm; applications are due March 15, 2015.

The next ICPS will take place August 12–19, 2015, in Zagreb, Croatia. For more information see http://icps2015.unizg.hr/en/. All physics students are invited; you do not have to win the SPS Award for Outstanding Undergraduate Research to attend!

Biophysics *(continued from page 23)*

between biology and physics. I got so much out of speaking to individuals who were in the position I intend to be in some day. At one point I hopped on a bus to go hiking and check out the downtown area with graduate students who gave great advice about classes that I had yet to take and told me about how they had started doing research and publishing papers.

> "I got so much out of speaking to individuals who were in the position I intend to be in some day."

In addition to time for leisurely socializing, the conference featured many great talks. One of my favorites was given by Wonmuk Hwang, a Texas A&M professor who studies motors and filaments. His presentation was fast paced but included great pictures, models, and videos illustrating the formation of collagen fibers and motor protein function. I was amazed by how he had used his programming skills to make intricate biological models.

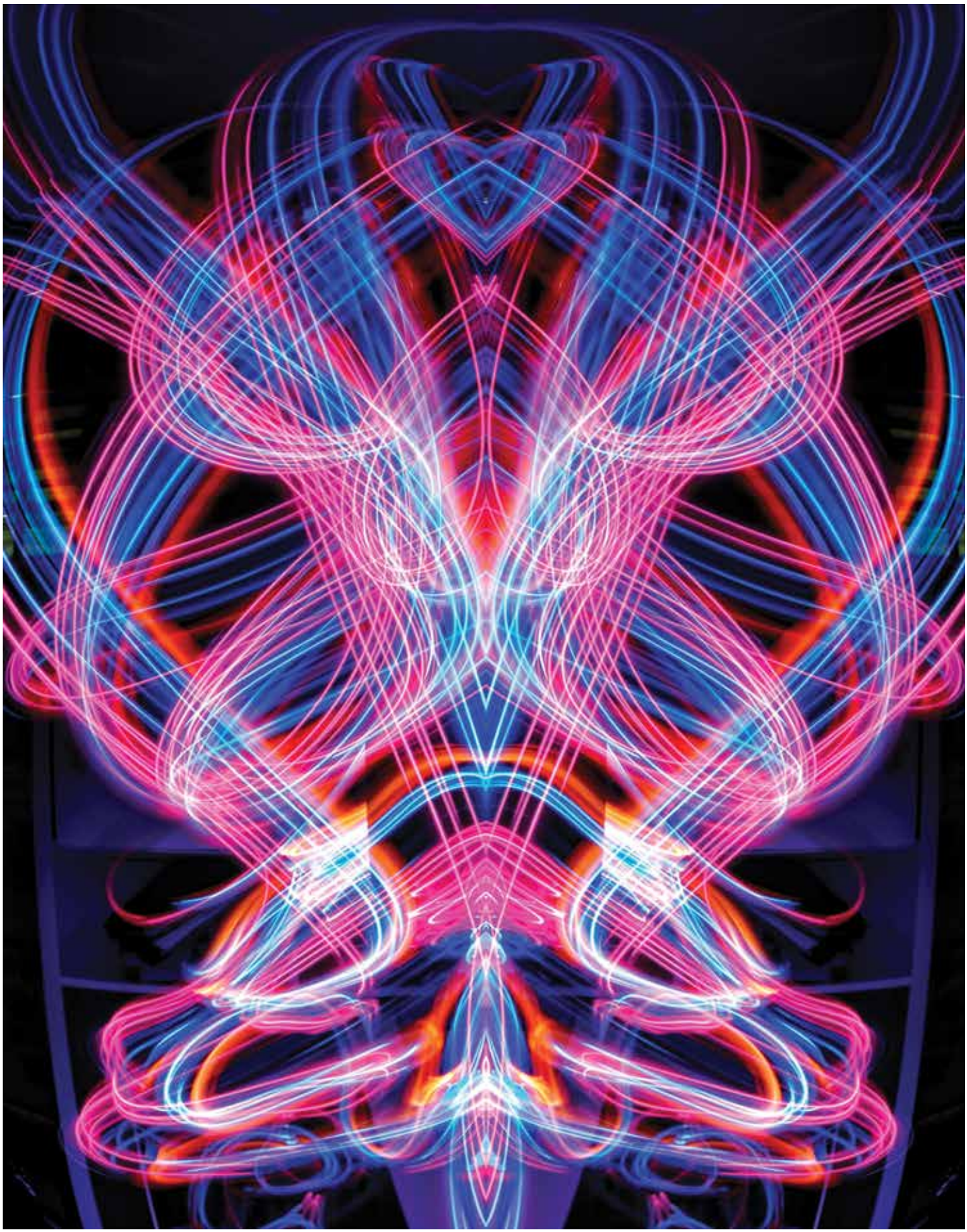
I had the good luck of sitting with him during lunch one day and found that what he had to say in person was just as motivating as his lecture. He and the other attendees encouraged me. "You'd be a good fit for our program!" and "I know someone who's doing research you'd like to look into" were things that I heard often.

The theme of every activity seemed to be that physicists have much to learn from biologists, and vice versa. By the last day, the typical greeting question had evolved from "Do you work mainly in the field of physics or biology?" to "Are you a biophysicist?" Highlighting the benefits of both fields appeared to have helped bridge the gap between them. Not only was the conference a great success for me in terms of networking, but it was also an inspiring look into the integrated field of biophysics. //

NEXT UP

Peruse upcoming Gordon Research Conferences at www.grc.org/.

STEVE VOGEL from Duke University leads an informal GRC discussion about what topics in physics might matter to the contemporary biologist. Photo courtesy of Mel Sabella.



"LIGHT PAINTING CAN BE FUN," by William Cho. Created using blue, orange, and violet cellophane wrapped around a flashlight during a 30-second exposure. Made available under an Attribution-NonCommercial-ShareAlike 2.0 Generic license.

The Museum of Light

by Dwight E. Neuenschwander,
Southern Nazarene University, Bethany, OK

Forty thousand years ago the bear and the boar were painted on cave walls by torchlight. Two hundred years ago Lakota grandchildren gathered around campfires under starry skies to listen as grandfathers told tales of the Star People. *The Odyssey*, the *Principia*, and *Eine Kleine Nachtmusik* were written by flickering candlelight. By sunlight or by lamplight, in a world lit only by fire, for ages beyond memory humanity worked *by* light.

"By sunlight or by lamplight, in a world lit only by fire, for ages beyond memory humanity worked *by* light."

In a world now lit by dynamos and quanta, we also work *with* light. Precise and powerful, versatile and beautiful, light has been shaped to fit our grasp. Radar and lasers, CDs and DVDs and LEDs, spectroscopy, adaptive optics, medical imaging, optical computers—light reads bar codes, analyzes stars, opens doors, guides missiles, and attaches loose retinas. The signal fire has become the satellite array; light carries voices across continents through wispy fibers of glass. Light delivers an image of the Earth, our blue speck, as seen by Voyager from beyond the orbit of Pluto.

Light heals and informs. Light is also a weapon and a trespassing pollution, which says little about light itself but much about human fear and desire. In literature, light and darkness set the mood. In the sacred books of ancient wisdom, light symbolizes insight and serenity. To walk in the light is to bring out the best in our humanity.

Creation mythologies begin with light, but light as a tool is our creation. As we begin 2015, designated the International Year of Light and Light-Based Technologies by the United Nations, let us celebrate the physics of light and the technologies it spawns. May we be sufficiently enlightened to look beyond ourselves, to use the power and promise of light with care and responsibility. While it cuts steel and sends messages, may light be a tool used always for enhancing our humanity.

I am the one who openeth his eyes, and there is light; When his eyes close, darkness falleth.

—Utterance of the Egyptian god Ra, Turin papyrus, ca. 1300 BC.

The lights of nature and of mind entwine within the eye and call forth vision. Yet separately, each light is mysterious and dark. Even the brightest light can escape our sight . . . . Two lights brighten our world. One is provided by the sun, but the other answers to it—the light of the eye. Only through their entwining do we see; lacking either, we are blind.

—Arthur Zajonc, *Catching the Light: The Entwined History of Light and Mind* (Oxford University Press, Oxford, UK, 1993), pp. 1–3.

In the forward of the book of photos by Páll Stefánsson, *Light: Images of Iceland*, (Iceland Review, Reykjavik, Iceland, 1987), the editor quotes Genesis 1:1, then says:

The light was good. And over the aeons since creation, everything has changed but the light, that remains good as ever. Man, too, has worshipped the light since time immemorial, as everything in nature does in its own way. In his unceasing quest

WHITE LIGHT goes through a prism lying on a black background, refracting into spectral colors. Photo by iStock.com/joephil.

back to himself and his origins, rational man has followed paths through the valley of darkness. Yet he knows that eternal truth cannot be found in the dark. Symbolically, man is always searching for the light. Truth is within the light- because life itself is light . . . A vital urge leads Man to bask in the light. . . .

What is Life? It is a flash of a firefly in the night. It is the breath of a buffalo in the winter time. It is the little shadow which runs across the grass and loses itself in the Sunset.

—Crowfoot, warrior and orator of the Blackfoot Confederacy (1821–1890), spoken in the last hours of his life. Source: Ethel Brant Monture, *Canadian Portraits: Brant, Crowfoot, Oronhyatekha—Famous Indians* (Clarke, Irwin, & Co., Ltd., Toronto, p. 120, 1960).

. . . Then Allan a Dale came forth and tuned his harp, and all was hushed around, and he sang in his wondrous voice songs of love, or war, of glory, and of sadness, and all listened without a movement or a sound. So Allan sang till the great round silver moon gleamed with its clear light amid the upper tangle of the mazy branches of the trees . . .

—from Howard Pyle, *The Merry Adventures of Robin Hood of Great Renown in Nottinghamshire* (Scribner's Sons, New York, 1883).

. . . But the strangest thing about it was, that from the crown of its head there sprung a bright clear jet of light, by which all this was visible; and which was doubtless the occasion of its using, in its duller moments, a great extinguisher for a cap, which it now held under its arm . . . Perhaps, Scrooge could not have told anybody why, if anybody could have asked him; but he had a special desire to see the Spirit in his cap; and begged him to be covered.

"What!" exclaimed the Ghost. "Would you so soon put out, with worldly hands, the light I give? Is it not enough that you are one of those whose passions made this cap, and force me through whole trains of years to wear it low upon my brow!"

—from Charles Dickens, *Christmas Stories by Charles Dickens* (Nelson Doubleday, Garden City, NY, 1955).

This master, meanwhile, bending over a vast manuscript adorned by grotesque paintings, appeared to be tormented by an idea which incessantly obtruded itself upon his meditations . . .

"Yes, so Manou asserted and Zoroaster taught. The sun is the offspring of fire, and the moon of the sun; fire is the soul of the universe. Its elementary atoms are incessantly overflowing and pouring upon the world in innumerable currents. At the points where these currents intersect one another in the atmosphere they produce light; at their points of intersection in the earth they produce gold. Light, gold—the same thing! . . . But how is science to set about detecting the secret of this general law? Why, this light which floods my hand is gold! These same atoms, which expand according to a certain law, need but be condensed according to a certain other law. How is this to be done? Some have proposed to effect it by burying a ray of the sun. Averroës—yes, it was Averroës—buried one under the first pillar on the left, in the sanctuary of the Koran, in the grand mosque at Cordova; but the vault must not be opened to see whether the operation has been successful for the space of eight thousand years. . . ."

"Others have thought," continued the archdeacon, "that it would be better to operate upon a ray of Sirius. But it is very difficult to obtain one of his rays pure, on account of the simultaneous presence of the other stars, whose light mingles with it . . ."

—from Victor Hugo, *The Hunchback of Notre Dame*, translated by Walter J. Cobb (New American Library, New York, 1965), pp. 264–265.

Then I placed another Prisme . . . so that the light . . . might pass through that also, and be again refracted before it arrived at the wall. This done, I took the first Prisme in my hand and turned it to and fro slowly about its Axis, so much as to make the several parts of the Image . . . successively pass through . . . that I might observe to what places on the wall the second Prisme would refract them.

When any one sort of Rays hath been well parted from those of other kinds, it hath afterwards obstinately retained its colour, notwithstanding my utmost endeavours to change it.

—Isaac Newton, *Optiks* (1666).

The light of the Sun appears to be yellow. Thus it is necessary that the Sun projects by its nature more yellow rays than others, ... Mr. Newton has shown in his *Optics*, page 216, that sunlight is abundant in this kind of ray.

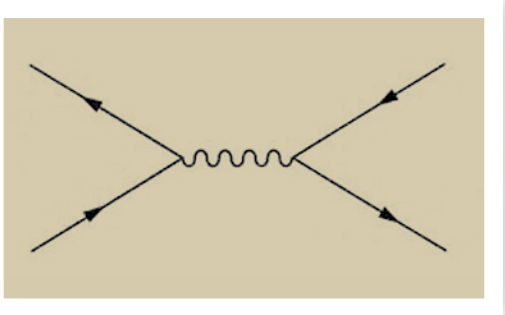
It is very possible that in other systems, there are suns which project more rays of red, green, etc. and that the primary colors of suns that we never see are different from ours, and that, in short, there are in Nature other colors than those that we know of in our world.

—Gabrielle-Emilie Le Tonnelier de Breteuil, Marquise du Châtelet, *Pièces qui ont remporté le prix de l'académie royal des sciences de Paris* (1738), pp. 165-166. Later published in *Dissertation sur la Nature et la Propagation du Feu* (1744).

All the fifty years of conscious brooding have brought me no closer to the answer to the question, "What are light quanta?" Of course today every rascal thinks he knows the answer, but he is deluding himself.

—Albert Einstein, 1951

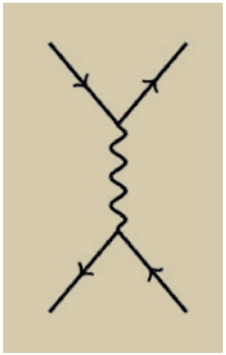
It would appear that, since the electron and positron are distinguishable, the Pauli principle would not require the interchange diagram, leaving as the only one [the following].



A FEYNMAN DIAGRAM illustrates the interactions of subatomic particles. Public domain image.

But it is still possible by the same phenomenological reasoning to conceive of the [next diagram], which would represent virtual annihilation of the electron and positron, with the photon later creating a new pair. It turns out that it is necessary to regard an electron–positron pair as existing part of the time in the form of a virtual photon in order to obtain agreement with experiment.

—Richard Feynman, *Quantum Electrodynamics* (W. A. Benjamin, New York, 1961).



ANOTHER FEYNMAN DIAGRAM. Public domain image.

Even Light itself, which every thing display,
Shone undiscovered, till his brighter mind
Untwisted all the shining robe of day;
And, from the whitening undistinguished blaze,
Collecting every ray into his kind,
To the charmed eye educed the gorgeous train
Of parent colours.

—James Thomson, "A Poem Sacred to the Memory of Sir Isaac Newton."

There are two ways of spreading light . . .
To be the candle, or the mirror that reflects it.

—Edith Wharton, "Vesalius in Zante," *Artemis to Actaeon and Other Verse* (Scriber, New York, 1909).

Seeing into darkness is clarity. Knowing how to yield is strength. Use your own light and return to the source of light. This is called practicing eternity.

—Lao-tzu, *Tao Te Ching*, translated by Stephen Mitchell (Harper & Row, New York, 1988), p. 52.

When the rainbow, opposite the sun
A thousand intermingled colors throws
With saffron wings then dewy Iris flies
Through heaven's expanse, a thousand varied dyes
Extracting from the sun, opposed in place.

—Virgil

Nothing can dim the light which shines from within.

—Maya Angelou

Nay then, the sun shall bide behind my shoulders!
The cataract, that through the gorge doth thunder
I'll watch with growing rapture, 'mid the boulders
From plunge to plunge down-rolling, rent asunder
In thousand thousand streams, aloft shower
Foam upon hissing foam, the depths from under.
Yet blossoms from this storm a radiant flower;

The painted rainbow bends its changeful being,
Now lost in air, now limned with clearest power,
Shedding this fragrant coolness round us fleeing.
Its rays an image of man's efforts render;
Think, and more clearly wilt thou grasp it, seeing
Life in the many-hued, reflected splendour.

—J. W. von Goethe, *Faust*, translated by Albert G. Latham (E. P. Dutton, New York, 1908), Pt. II, p. 15.

. . ."And you, Ring-bearer," she said, turning to Frodo. "I come to you last who are not last in my thought. For you I have prepared this." She held up a small crystal phial: it glittered as she moved it, and rays of white light sprang from her hand. "In this phial," she said, "is caught the light of Eärendil's star, set amid the waters of my fountain. It will shine still brighter when night is about you. May it be a light to you in dark places, when all other lights go out. Remember Galadriel and her Mirror!"

Frodo took the phial, and for a moment as it shone between them, he saw her again standing like a queen, great and beautiful, but no longer terrible. He bowed, but found no words to say . . .

. . . At length they came to the door upon the outer court, and they halted. Even from where they stood they felt the malice of the Watchers beating on them, black silent shapes on either side of the gate through which the glare of Mordor dimly showed. . . . Sam drew out the elven-glass of Galadriel again. As if to do honour to his hardihood and to grace with splendour his faithful brown hobbit-hand that had done such deeds, the phial blazed forth suddenly, so that all the shadowy court was lit with a dazzling radiance like lightning . . .

The will of the Watchers was broken with a suddenness like the snapping of a cord, and Frodo and Sam stumbled forward. Then they ran. . . .

—J.R.R. Tolkien, *The Fellowship of the Ring* (Houghton Mifflin Company, Boston, MA, 1965) and *The Return of the King* (Houghton Mifflin Company, Boston, MA, 1965).

We've all got both light and dark inside us. What matters is the part we choose to act on. That's who we really are.

—J.K. Rowling, *Harry Potter and the Order of the Phoenix* (Scholastic, New York, 2003).

On the first morning of his imprisonment when he got up early, went out of the shed at dawn and saw the cupolas and crosses of the Novodevichy convent, still dark at first, and saw the hoarfrost on the dusty grass, the hummocks of the Sparrow Hills, the wooded banks above the winding river vanishing into the purple distance; when he felt the touch of the fresh air and heard the jackdaws flying from Moscow across the fields; and when later the light gushed out of the cloud and the cupolas, crosses, hoarfrost, the river and the distant horizon all began to sparkle in the joyous light—Pierre experienced a new feeling he had never known before of strength and exultation in life.

—Leo Tolstoy, *War and Peace,* translated by Ann Dunnigan (New American Library, New York, 1968), p. 1209.

It is well known that Maxwell's electrodynamics—as usually understood at present—when applied to moving bodies, lead to asymmetries that do not seem to be inherent in the phenomena. Take, for example, the electrodynamic interaction between a magnet and a conductor. The observable phenomenon here depends only on the relative motion of the conductor and the magnet, whereas the customary view draws a sharp distinction between the two cases, in which either the one or the other of the two bodies is in motion . . . Examples of this sort, together with the unsuccessful attempts to detect a motion of the earth relative to the "light medium," lead to the conjecture that not only the phenomena of mechanics but also those of electrodynamics and optics will be valid for all coordinate systems in which the equations of mechanics hold . . .

—Albert Einstein, "Zur Elektrodynamik Bewegter Körper," *Annalen der physik* **17**, 1905; English translation, "On the Electrodynamics of Moving Bodies," edited by John Stachel, Forward by Roger Penrose, *Einstein's Miraculous Year: Five Papers that Changed the Face of Physics* (Princeton University Press, Princeton, NJ, 1998), pp. 123–124.

The wave theory of light, which operates with continuous spatial functions, has proved itself superbly in describing purely optical phenomena and will probably never be replaced by another theory. One should keep in mind, however, that optical observations refer to time averages rather than instantaneous values; and it is quite conceivable, despite the complete confirmation of the theory of diffraction, reflection, refraction, dispersion, etc., by experiment, that the theory of light, operating with continuous spatial functions, leads to contradictions when applied to the phenomena of emission and transformation of light. Indeed, it seems to me that the observations of "black-body radiation," photoluminescence, production of cathode rays by ultraviolet light, and other related phenomena associated with the emission or transformation of light appear more readily understood if one assumes that the energy of light is discontinuously distributed in space. According to the assumption considered here, in the propagation of a light ray emitted from a point source, the energy is not distributed continuously over ever-increasing volumes of space, but consists of a finite number of energy quanta localized at points of space that move without dividing, and can be absorbed or generated only as complete units.

—Albert Einstein, English translation, "On the Heuristic Point of View Concerning the Production and Transformation of Light," edited by John Stachel, Forward by Roger Penrose, *Einstein's Miraculous Year: Five Papers that Changed the Face of Physics* (Princeton University Press, Princeton, NJ, 1998), p. 178.

I spent 10 years of my life testing [the photon concept and] the 1905 equation of Einstein's, and, contrary to all my expectations, I was compelled in 1915 to assert its unambiguous experimental verification in spite of all its unreasonableness since it seemed to violate everything we knew about the interference of light.

—R. A. Millikan, "Albert Einstein on his seventieth birthday," *Rev. Mod. Phys.* **21**, 343–345 (1949).

Since the presence of fire-corpuscles alone does not suffice to excite heat, but their motion is needed also, it seems to me that one may very reasonably say that motion is the cause of heat. . . . But I hold it to be silly to accept that proposition in the ordinary way, as if a stone or piece of iron or a stick must heat up when moved. The rubbing together and friction of two hard bodies, either by resolving their parts into very subtle flying particles or by opening an exit for the tiny fire-corpuscles within, ultimately sets these in motion; and when they meet our bodies and penetrate them, our conscious mind feels those pleasant or unpleasant sensations which we have named heat, burning, and scalding. And perhaps when such attrition stops at or is confined to the smallest quanta, their motion is temporal and their action calorific only; but when their ultimate and highest resolution into truly indivisible atoms is arrived at, light is created.

—Galileo, "The Assayer," *Discoveries and Opinions of Galileo*, translated by Stillman Drake (Doubleday & Co., New York, 1957), p. 278.

Let me imagine, and at the moment it is nothing but imagining, an idealized, abstract physical situation in which I will create a particle [at the position x at time t] . . . And let me describe this act of creation . . . by a creation operator [this is labeled by the space-time point xj and that operates on this state]. An operator because it symbolizes a physical property but something beyond what we are accustomed to thinking of, and an operator because it acts on a state, the state being the state in which nothing is present, or physically a vacuum. We now transfer our attention to this operator as the basic physical object. And this is what I mean by the quantized field because it is on the one hand a field; it is a mathematical quantity which varies continuously in time and space. On the other hand, it is certainly not a classical field, because these as operators are not things that can be measured simultaneously, and [also because] in the operator character . . . we have the elements of discontinuity which is essentially the particle concept.

—Julian Schwinger, quoted by Silvan Schweber, *QED and the Men Who Made It: Dyson, Feynman, Schwinger, and Tomonaga* (Princeton University Press, Princeton, NJ (1994), pp. 362–363.

. . . . According to this hypothesis, then, an atom is a sort of infinitesimal solar system whose members, the electrons, are no bigger with respect to the diameter of the atom than is the earth with respect to the diameter of the earth's orbit. Furthermore, according to this hypothesis, it is the vibrations of these electrons which give rise to light and heat waves . . .

This theory undoubtedly contains many germs of truth. As yet, however, it is in the formative stage and ought to be regarded as a profoundly interesting speculation brought forward by men high in authority in the scientific world, rather than as an established doctrine. However, that such things as negatively charged corpuscles exist, and that they have a mass which is much smaller than that of an atom is now universally admitted . . .

. . . X rays are like cathode rays in producing fluorescence, . . . [and] X rays are not deflected either by a magnet or by an electrostatic charge, nor do they carry electrical charges of any sort. Hence it is certain that they do not consist, like cathode rays, of streams of electrically charged particles. Their real nature is still unknown, but they are at present generally regarded as irregular pulses in the ether, set up by the sudden stopping of the cathode-ray particles when they strike an obstruction.

—Robert A. Millikan and Henry G. Gale, *A First Course in Physics* (Ginn & Company, New York, 1906), pp. 474–475.

. . . For several years after the laser's invention, colleagues used to tease me about it, saying, "That's a great idea, but it's a solution looking for a problem." The truth is, none of us who worked on the first lasers imagined how many uses there might eventually be.

—Charles H. Townes, "The Light That Shines Straight," *Beamline*, Summer/Fall 2000.

Every picture has its shadows
And it has some source of light

—Joni Mitchell, "Shadows and Light" (1990).

And when the night is cloudy,
there is still a light that shines on me.
Shine until tomorrow,
let it be.

—John Lennon and Paul McCartney,
"Let it Be" (1970).

//

INTERNATIONAL YEAR OF LIGHT 2015

www.light2015.org

the SPS Observer
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Meet your 2014-15 SPS National Council

THE 2014–15 SPS NATIONAL COUNCIL and the 2016 SPS Congress Planning Committee stand in front of the American Center for Physics in College Park, MD, in late September. Photo by Matt Payne.

The SPS National Council is the governing body for the Society of Physics students and Sigma Pi Sigma, the physics honor society. Each fall, elected faculty members (zone councilors) and students (associate zone councilors) from each of the 18 regional SPS zones gather to conduct society business face-to-face. The council continues to meet via phone and web throughout the year in committees and as a whole group to address issues of concern to the society. If you have ideas or concerns related to SPS, please contact the representatives from your zone! You can meet them and find their contact information online at www.spsnational.org/governance/council/.

SPS NATIONAL COUNCIL

SPS NEEEDS YOU!

The SPS National Council is looking for good candidates for SPS president, zone councilors and associate zone councilors. Is that you? Is that your fellow student? Is that your advisor? Details at:

www.spsnational.org/governance/elections/

Nominations are due February 15, 2015.