PPPL PRINCETON PLASMA PHYSICS LABORATORY
A Collaborative National Center for Fusion & Plasma Research
U.S. DEPARTMENT OF ENERGY
WEEKLY
September 26, 2016

Calendar of Events

THIS WEEK

MONDAY, SEPT. 26

All-Hands Meeting
9 a.m. ◆ MBG Auditorium
Please make every effort to attend for important updates about the Lab. We will be serving coffee and doughnuts starting at 8:45 a.m.

WEDNESDAY, SEPT. 28

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium
Random Organization, Hyperuniformity and Photonic Bandgaps
Paul Chaikin, New York University

UPCOMING

FRIDAY, OCT. 7

American Red Cross Blood Drive
8 a.m.–1 p.m. ◆ American Red Cross Bloodmobile, Lower End Parking Lot

TUESDAY, OCT. 11

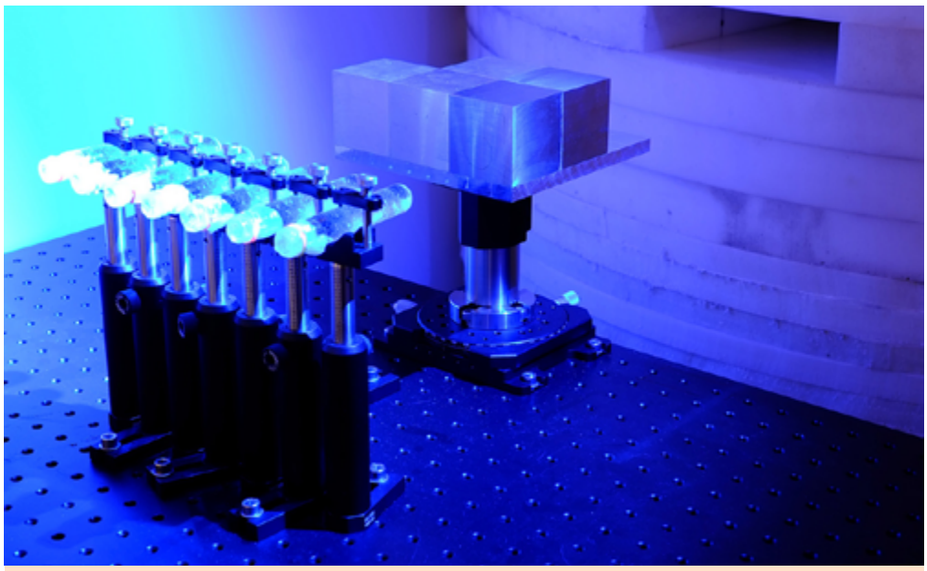
Tour Guide Meeting and Training
9:30–11:30 a.m. ◆ MBG Auditorium
See page 4 for details.

INSIDE

A novel technique that may apply to future nuclear disarmament pacts

By John Greenwald

A system that can compare physical objects while potentially protecting sensitive information about the objects themselves has been demonstrated experimentally at PPPL. This work, by researchers at Princeton University and PPPL, marks an initial confirmation of the application of a powerful cryptographic technique in the physical world.



Experimental setup in a PPPL laboratory. Neutrons beamed from the device at right passed through the arrangement of cubes and were recorded in the bubble detectors at left. *(Elle Starkman)*

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Senior Physicist position recognizes that research doesn't end with retirement

By Jeanne Jackson DeVoe

Physicist Wei-li Lee comes into the office three days a week. An active researcher who won the Dawson Prize for computational physics in 2011, he just published a paper in July in the *Journal of Plasma Physics* and he enjoys talking physics over lunch with his colleagues. In fact, he is so active in giving talks and reviewing manuscripts and proposals that some colleagues never realized he was retired.

Now Lee and four other retired physicists have become the first wave of "senior physicists" at PPPL. It's a new title for an old established practice of physicists continuing to do what they enjoy.

"I have not finished yet," Lee said. "I still enjoy research. I enjoy talking to people here, going to conferences and talking to people and seeing the people I work with. It's really fulfilling."

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Intern helped get robotic arm on PTOLEMY experiment up and running

By Jeanne Jackson DeVoe

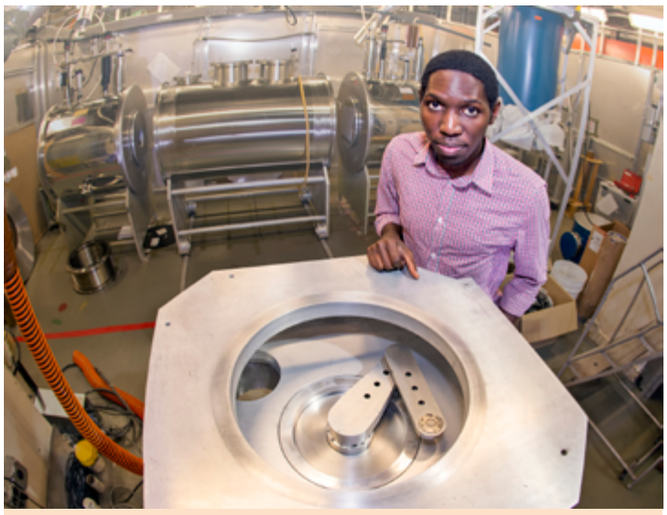
Deep in a laboratory tucked away in the basement of PPPL, intern Mark Thom punched commands into a computer as two other students checked a chamber where a silver robotic arm extended from a small port.

The arm will allow scientists studying neutrinos that originated at the beginning of the universe to load a tiny amount of nuclear material into the device while still maintaining a vacuum in the PTOLEMY laboratory.

Thom, along with high school interns Xaymara Rivera and Willma Arias de la Rosa, worked closely with Princeton University physicist Chris Tully and PPPL engineers to get the robotic arm moving again. The crucial device will load tritium, a radioactive isotope of hydrogen, into PTOLEMY, the Princeton Tritium Observatory for Light, Early Universe Massive Neutrino Yield.

Tritium can capture Big Bang neutrinos and release them with electrons in radioactive decay. The neutrinos can provide a tiny boost of energy to the electrons, which PTOLEMY is designed to precisely measure in the darkest, coldest conditions possible. It is funded by the Mark Simons Foundation and the John Templeton Foundation.

"For me it was just amazing that I actually got onto that project," Thom said. "It's exactly the kind of thing I thought I would like to do, being an engineer working on a high-energy physics project."



PPPL intern Mark Thom with a device containing a robotic arm that will be used with PPPL's PTOLEMY experiment behind him. *(Photo by Elle Starkman)*

The robotic arm, together with the portable container and the computer program to operate it, were recycled from another experiment when Thom and fellow interns Rivera and Arias de la Rosa began the project. Thom was responsible for making the arm operational and altering it so it would fit PTOLEMY.

Handling delicate materials

Tully said the device can safely handle very delicate radioactive materials from DOE's Savannah River National Laboratory. Without the device, scientists would have to shut down PTOLEMY completely twice a day to change the tritium sample, he said. Maintaining a vacuum in PTOLEMY is also necessary for the extremely sensitive sensors that measure the energy spectrum of the electrons emitted from the tritium to function properly.

To make the robotic arm function again, Thom had to analyze why the coding was failing, which meant learning the code for the machine. He had to learn an unfamiliar program and then rewrite it to redirect the arm to handle tritium samples, without having worked on a device of that kind before, Tully said.

The students encountered a setback when the arm stopped working. At first, they thought the device would need a complete overhaul of the motors, which would cost $20,000. It turned out that the culprit was a circuit that would cost just a few dollars to replace. While Tully fixed the computer, Thom took the arm apart and researched how to install magnetic shielding around the motors and sketched a design for that shielding, Tully said. "Mark was quite amazing," he said. "I was very impressed with him."

Thom also designed a cover for one of the ports that would need to be sealed for the robotic arm to work. Rivera and Arias de la Rosa helped him operate and test the robotic arm and wrote procedures for running it. Thom and the other interns also worked with PPPL engineers Charles Gentile and Mike Mardenfeld, along with senior mechanical technician Andy Carpe and lead technician Jim Taylor.

Gentile, who supervised Thom and other engineering interns, said Thom was one of the best interns he has seen in 25 years of supervising more than 200 interns. "He's an excellent mechanical engineer," Gentile said. "He was a hard worker and he came up with innovative solutions to problems."

The arm connects to PTOLEMY through two ports equipped with valves. One valve connects to the experiment. The other connects to a loading chamber where scientists can insert a tiny sample of tritium on a graphene base.

Researchers would create a vacuum in the loading chamber and attach it to the vacuum chamber of PTOLEMY. The robotic arm could then collect the tritium and graphene sample and deposit it into PTOLEMY. Researchers would next retract the arm and close the valve connecting it to PTOLEMY.

Following parents' footsteps

Thom, who is in his final year of master's degree work at Howard University, is from Trinidad. The son of two engineers, he considered becoming a physician and briefly flirted with the idea of being an actor or music producer before choosing to follow in his parents' footsteps.

Thom studied engineering as an undergraduate at Howard. He learned about the internship when Andrea Moten, PPPL acting director of human resources, and engineer Atiba Brereton met him at National Laboratory Day at Howard University in February. The two passed Thom's resume along to Gentile as a candidate for the engineering apprenticeship program.

The graduate student recently celebrated his one-year anniversary with his wife, Sydney, who is also an engineer and is currently teaching at a Kipp DC Middle School in Washington, D.C. Thom commuted to Washington every weekend on Friday nights to see her and then headed back to New Jersey on Monday mornings. "It was challenging at first," he said. "But after a while I got accustomed to it and I actually began to appreciate those drives because it gave me some time to think."

Thom said he enjoyed the laid-back atmosphere at PPPL. He was surprised when Gentile told him he was overdressed on his first day. But he most enjoyed talking to researchers about their work. "I met some really cool people – a bunch of physicists whom I was able to have certain conversations with, just talking about abstract theories. That's the kind of conversation I enjoy," Thom said. "Being able to interact with people like that in that atmosphere was really enjoyable."

The internship gave him a better idea of possible careers as he prepares to graduate, Thom said. "I had a limited view of the engineering world prior to going into this work," he said. "But now I have a better idea of the kind of environment I'd like to be in, so it gives me an idea of what I should do to prepare for that environment."

Zero-knowledge protocol

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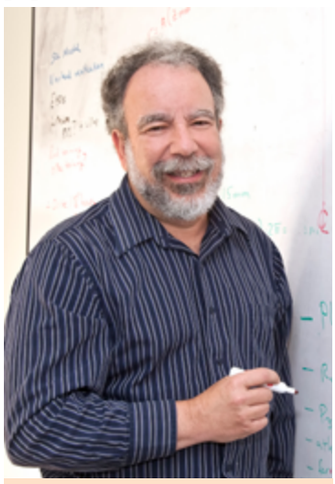
"This is the first experimental demonstration of a physical zero-knowledge proof," said Sébastien Philippe, a graduate student in the Department of Mechanical and Aerospace Engineering at Princeton University and lead author of the paper. "We have translated a major method of modern cryptography devised originally for computational tasks into use for a physical system." Cryptography is the science of disguising information.



Robert Goldston *(Elle Starkman)*

This research, supported by funding from the DOE's National Nuclear Security Administration through the Consortium for Verification Technology, marks a promising first experimental step toward a technique that could prove useful in future disarmament agreements, pending the results of further development, testing and evaluation. While important questions remain, the technique, first proposed in a paper published in 2014 in *Nature* magazine, might have potential application to verify that nuclear warheads presented for disarmament were in fact true warheads. Support for this work came also from the John D. and Catherine T. MacArthur Foundation and the Carnegie Foundation of New York.

The research, outlined in a paper in *Nature Communications* on September 20, 2016, was conducted on a set of 2-inch steel and aluminum cubes arranged in different combinations. Researchers first organized the cubes into a designated "true" pattern and then into a number of "false" ones. Next, they beamed high-energy neutrons into each arrangement and recorded how many passed through to bubble neutron detectors produced by Yale University, on the other side. When a neutron interacts with a superheated droplet in the detector, it creates a stable macroscopic bubble.

To avoid revealing information about the composition and configuration of the cubes, bubbles created in this manner were added to those already preloaded into the detectors. The preload was designed so that if a valid object were presented, the sum of the preload and the signal detected with the object present would equal the count produced by firing neutrons directly into the detectors – with no object in front of them.

Francesco d'Errico *(Courtesy of Yale University)*

The experiment found that the count for the "true" pattern equaled the sum of the preload and the object when neutrons were beamed with nothing in front of them, while the count for the significantly different "false" arrangements clearly did not.

"This was an extremely important experimental demonstration," said Robert Goldston, a fusion scientist and coauthor of the paper who is former director of PPPL and a Princeton professor of astrophysical sciences. "We had a theoretical idea and have now provided a proven practical example." Joining him as coauthors are Alex Glaser, associate professor in Princeton's Woodrow Wilson School of Public and International Affairs and the Department of Mechanical and Aerospace Engineering; and Francesco d'Errico, senior research scientist at the Yale School of Medicine and professor at the University of Pisa, Italy.

Graduate student Sébastien Philippe who led the zero-knowledge protocol experiment. *(Elle Starkman)*

When further developed for a possible arms control application, the technique would add bubbles from irradiation of a putative warhead to those already preloaded into detectors by the warhead's owner.

If the total for the new and preloaded bubbles equaled the count produced by beaming neutrons into the detectors with nothing in front of them, the putative weapon would be verified to be a true one. But if the total count for the preload plus warhead irradiation did not match the no-object count, the inspected weapon would be exposed as a spoof. Prior to the test, the inspector would randomly select which preloaded detectors to use with which putative warhead, and which preload to use with a warhead that was, for example, selected from the owner's active inventory.

Alex Glaser *(Courtesy of Princeton University)*

In a sensitive measurement, such as one involving a real nuclear warhead, the proposition is that no classified data would be exposed or shared in the process, and no electronic components that might be vulnerable to tampering or snooping would be used. Even statistical noise — or random variation in neutron measurement — would convey no data. Indeed, "For the zero-knowledge property to be conserved, neither the signal nor the noise may carry information," the authors write. A necessary future step is to assess this proposition fully, and to develop and review a concept of operations in detail to determine actual viability and information sensitivity.

Important questions yet to be resolved include the details of obtaining and confirming a target warhead during the zero-knowledge measurement; specifics of establishing and maintaining the preloaded detectors in a way that ensures inspecting party confidence without revealing any data considered sensitive by the inspected party; and feasibility questions associated with safely deploying active interrogation

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Zero-knowledge protocol

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measurement techniques on actual nuclear warheads in sensitive physical environments, in a way that provides confidence to both the inspected and inspecting parties.

Glaser, Goldston and Boaz Barak, a professor of computer science at Harvard University and former Princeton associate professor, first launched the concept for a zero-knowledge protocol for warhead verification in the 2014 paper in *Nature* magazine. That paper led *Foreign Policy* magazine to name the authors among its "100 Leading Global Thinkers of 2014," and prompted other research centers to embark on similar projects. "We are happy to see this important field of research gain new momentum and create new opportunities for collaboration between national laboratories and universities," Glaser said.

Seed money for the original work came to Princeton from The Simons Foundation of Vancouver, Canada, through a nonprofit called Global Zero, and from the U.S. Department of State Verification Assets Fund.

Established by Congress in 2000, NNSA is a semi-autonomous agency within the U.S. Department of Energy responsible for enhancing national security through the military application of nuclear science. NNSA maintains and enhances the safety, security, and effectiveness of the U.S. nuclear weapons stockpile without nuclear explosive testing; works to reduce global danger from weapons of mass destruction; provides the U.S. Navy with safe and effective nuclear propulsion; and responds to nuclear and radiological emergencies in the U.S. and abroad. Visit nnsa.energy.gov for more information.

All-Hands Meeting

Monday, Sept. 26 at 9 a.m. in the MBG Auditorium

Please make every effort to attend for important updates about the Lab. We will be serving coffee and doughnuts starting at 8:45 a.m.

Tour Guide Meeting & Training Oct. 11 at 9:30 a.m.

New and experienced tour guides are invited to a tour guide meeting & training on Tuesday, Oct. 11 from 9:30 a.m. to 11:30 a.m. in the MBG Auditorium. Bring your friends! We'll have refreshments, tee shirts for new tour guides, and we'll go over what's new in the tour program. Then we'll have a tour training session on tour demos, highlights of our tours and a tour for new tour guides.

To sign up to be a tour guide or for more information contact Jeanne Jackson DeVoe, jjackson@pppl.gov, ext. 2757.

Senior physicists

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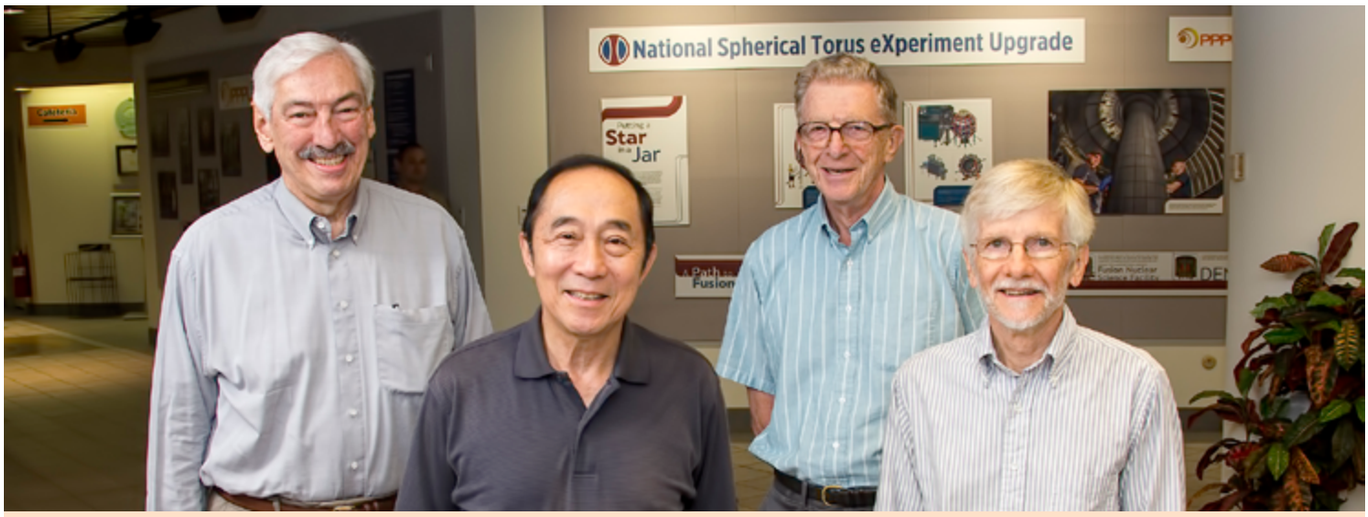
Michael Zarnstorff, deputy director for research, designated the new title to recognize and include physicists who have continued to lend their minds and their time to fusion and plasma research and to PPPL despite not being on the payroll. Lee and physicists Larry Grisham, Dale Meade, Kenneth Young, and Michael Bell were first to sign up.

"It will give some additional recognition to retirees who are continuing to have an impact and continue to play a strong role," Zarnstorff said. "It's something that we do with pleasure in cases where retirees are staying engaged and participating and contributing to the Lab."



Senior physicists, left to right, Dale Meade, Wei-li Lee, Kenneth Young, and Michael Bell. Not pictured: Larry Grisham. *(Photo by Elle Starkman).*

Modeled after Princeton University title

The designation is modeled after a similar title of "senior research scholar" at Princeton University. The title means that "senior physicists" are still considered members of the staff. Perhaps most importantly, they can continue to lead research projects and apply for funding as staff members at PPPL. It is a one-year position, which retired physicists can apply for annually.

Zarnstorff emphasizes that retired physicists who are at PPPL are not required to become "senior physicists." And those who do will not have to meet any requirements other than continuing to contribute to the Lab.

Lee spends two days a week helping his wife Linda take care of their 3-year-old grandson or visiting their granddaughter. But on the other three days, he is back at his office at PPPL. He says he hopes to use the designation to get grants for his research.

Acknowledging retirees' contributions

Another senior physicist is Dale Meade, a former deputy director of the Laboratory who was at the Laboratory for 34 years when he retired in 2005. A well-known and active researcher, Meade is investigating burning plasma issues and "continuing my search for a U.S. path to fusion energy."

Meade said he likes the fact that the Laboratory is following the example of Princeton University in offering an emeritus position and thinks it could help with administrative issues for retirees in the future. "It's a public acknowledgement of the contributions of retirees in the research program," he said.

Kenneth Young, who once headed the Diagnostic Division, and was head of the Collaborations Division when he retired in 2001 after a total of 36 years at PPPL, works at the Laboratory two afternoons a week and often works at home. He collaborates on research on designing a Fusion Nuclear Science Facility. Young is almost finished editing 300 talks and papers from a High Temperature Diagnostics meeting for the *Review of Scientific Instruments* journal. Young said he enjoys coming in and interacting with other physicists.

Emeritus status

Young said he views the "senior physicist" designation as an honorary title. "I just felt that it's sort of an emeritus status and I think that's a bit honorable," he said.

Michael Bell retired in 2012 after 32 years at PPPL where his last position was head of NSTX Experimental Operations. He has remained active at the Laboratory. He recently wrote a chapter on PPPL's Tokamak Fusion Test Reactor in a book published in June entitled "Magnetic Fusion Energy: From Experiments to Power Plants," and edited by Hutch Neilson, head of the Advanced Projects Department at PPPL. (See story on the PPPL website). He was also involved in a review of the NSTX-U coil failure last year. Shortly after retiring, he gave lectures at the International Center for Theoretical Physics in Trieste, Italy. In his spare time, Bell travels, gardens, and has several other activities including American contra dancing and playing the fiddle.

"I care about what the Lab is doing as it enters into a new era," Bell said. "I feel I have contributed in various ways since I've retired and I'd like to maintain that. This seemed like an invitation to play some role in the Lab's life."

Larry Grisham, another senior physicist, retired in February 2014 just shy of 40 years at PPPL. Since then he has continued to do a great deal of unpaid consulting for ITER and has consulted with scientists at PPPL and other laboratories on neutral beams. He was honored at PPPL's Patent Awareness Program dinner last September for his patent on an invention to improve performance in electrostatic acceleration.

In addition to his unpaid consulting work, Grisham works part-time as the director of strategic development with a small local company called Twinleaf that makes atomic magnetometers to measure magnetic fields. Grisham and his wife, Jaqueline, also keep busy with their three young grandchildren.

Grisham said the senior physicist position recognizes a trend over more than a decade. "I think what the Lab did is a very sensible thing of recognizing a long-standing tradition in the field," he said. "In all the sciences, people tend to keep working because you went into an area of science either because it really interested you or because you thought you could really make a change in the world."

Kids sample sciences at PPPL's Community & Staff Day booth

Hundreds of youngsters had fun learning about plasma and how scientists can control it at PPPL's booth for Princeton University's Community and Staff Day at the Princeton University Stadium on Saturday, Sept. 17. Staffing the booth were volunteers Atiba Brereton, Jeanne Jackson DeVoe and Charles Swanson.

Photos by Jeanne Jackson DeVoe.

Atiba Brereton prepares to blow up and shrink marshmallows in a vacuum demonstration.

A boy peers at a plasma ball with a diffraction grating that breaks light into its component colors.

Carolyn Mazzei, a lab manager at the Princeton Baby Lab, has fun with the Van De Graaff generator.

Charles Swanson shows the crowd the vacuum demonstration.

A girl has a hair-raising experience with the Van De Graaff experiment.

Children get ready to watch a half-coated fluorescent tube light up.

Charles Swanson chats with youngsters examining a plasma ball.

New central campus parking option available for PPPL staff

Do you have business or meetings on Princeton University's central campus? PPPL staff members now have use of a limited number of "Official Business Cards" (OBC) that allow two-hour parking in many locations on campus. The locations are:

- Numbered Lots (except restricted lots 8, 9, & 18)
- Front of Dillon Gym
- Brown Hall OBC spaces
- Rear of Edwards Hall
- Visitor spaces behind Baker Rink, Lot 12 (close to MacMillan)

The parking cards can be checked out from Carol Ann Austin in the Director's Office, who will administer the cards.

Here is a link to a map indicating the locations suitable for OBC parking.

Wanted: Undergraduate women interested in physics for January conference

What: Apply now for the 2017 Conference for Undergraduate Women in Physics.

When: Oct. 14 deadline for the Jan. 13–15 conference.

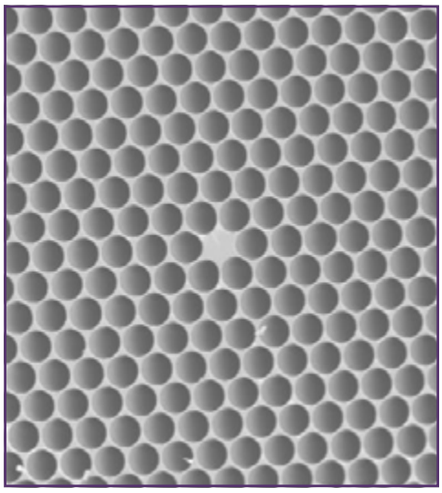
Where: Princeton University

Cost: The conference, lodging and meals are covered. Students pay $45 registration fee and transportation.

Applications and more information: cuwip.princeton.edu
or contact Shannon Swilley Greco, sgreco@pppl.gov, ext. 2208

COLLOQUIUM

Random Organization, Hyperuniformity and Photonic Bandgaps



Paul Chaikin
New York University

Wednesday, Sept. 28
4:15 p.m., M.B.G Auditorium, Lyman Spitzer Building

Boy Scouts STEM Fair, October 22

Volunteers needed

Subject experts in physics and engineering are especially needed to plan workshops.

Please contact Rob Sheneman, rshenema@pppl.gov, ext. 3392, to volunteer.

PPPL Welcomes New Employees!

RAY KRAMER
Lead electrician
Engineering

SHARON LANE
The new nurse at the Occupational Medicine Office
replacing Lacey Wuest

PPPL bids a fond farewell to the following employees:

HENRY CARNEVALE
Lead engineer
Engineering
25 YEARS

TERRY GREENBERG
Administrative assistant
Plasma Science & Technology
36 YEARS

ANTONIO MORGADO
Janitor
Engineering
37 YEARS

Changing of the guard at the cafeteria

MARK GAZO
The cafe manager for four years is retiring to Austin, Texas.

NICK PETTI
PPPL's new cafe manager

American Red Cross Blood Drive

Friday, October 7

8 a.m.–1 p.m.

American Red Cross Bloodmobile
Lower Parking Lot

The need for blood is constant and your donation is important for maintaining a healthy and reliable blood supply. One pint of donated blood can save up to three lives.

Please give blood. All blood types are needed.

To schedule a donation appointment, please contact the OMO at extension 3200.

Thank you.
American Red Cross
Occupational Medical Office Staff

BROCK

MARK GAZO
Chef Manager

Café at PPPL

BREAKFAST ..... 7 a.m. • 10 a.m.
CONTINENTAL BREAKFAST ..... 10 a.m. • 11:30 a.m.
LUNCH ..... 11:30 a.m. • 1:30 p.m.
SNACK SERVICE ..... until 2:30 p.m.

	Monday September 26	Tuesday September 27	Wednesday September 28	Thursday September 29	Friday September 30
COMMAND PERFORMANCE Chef's Feature	**Zesty Orange Chicken** & Broccoli over Rice	**Vegetarian Chili** over Rice with Cornbread	CREATE YOUR OWN **Burrito Bar**	**Baked Macaroni** with Ham served with Stewed Tomatoes	**BBQ Chicken,** Baked Beans & Fried Okra
Early Riser	**Breakfast Club Sandwich**	**Greek Egg White Omelet** with Spinach, Tomato, Peppers & Feta Cheese	**Breakfast Pizza** with Ham, Bacon & Sausage	**Omelet Florentine** with Spinach, Tomato & Mozzarella	**Breakfast Tacos**
Country Kettle	**Mushroom Barley Kielbasa**	**Pasta e Fagioli**	**Chicken & Quinoa**	**Tomato Spinach Lentil**	**Seafood Bisque**
Grille Special	**Colossal Burger** with 2-5.3 oz patties, American Cheese, Lettuce, Tomato & Onion	**Pepperoni Pizza Steak Sandwich** with Fries	**Tuna Melt** on Rye served with Onion Rings	**Taco Dogs**	**Spinach Salad** with Turkey Bacon, Hard-Cooked Egg, Mushrooms & Raspberry Vinaigrette
Deli Special	**Stacked Veggie Sandwich** with Guacamole	**French Dip** with Swiss Cheese, Caramelized Onion & Horseradish Cream served with Potato Wedges	**Prosciutto,** Pesto, Roasted Peppers & Arugula on Ciabatta	**Krabby Kake** on a Kaiser with Lettuce & Tomato	**Buffalo Chicken Wings** with Blue Cheese, Fries & Celery
Panini	**The Cubano**	**Popcorn Chicken & Mashed Potato Bowl** topped with Seasoned Corn & Country Gravy	**Southwest Turkey,** Peppers & Cheddar with Jalapeno Ranch Spread	**Tomato & Fresh Mozz** on Ciabatta with Basil, Red Onion & Arugula	**Turkey French Dip** with Swiss Cheese

MENU SUBJECT TO CHANGE WITHOUT NOTICE

VEGETARIAN OPTION

WEEKLY

Editor: **Jeanne Jackson DeVoe** ◆ Layout and graphic design: **Kyle Palmer** ◆ Photography: **Elle Starkman** ◆ Science Editor: **John Greenwald** ◆ Science Writer: **Raphael Rosen** ◆ Webmaster: **Chris Cane** ◆ Communications Director: **Larry Bernard**

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DEADLINE for calendar item submissions is noon on WEDNESDAY. Other stories should be submitted no later than noon on TUESDAY.
Comments: commteam@pppl.gov ◆ **PPPL WEEKLY** is archived on the web at: http://w3.pppl.gov/communications/weekly/.