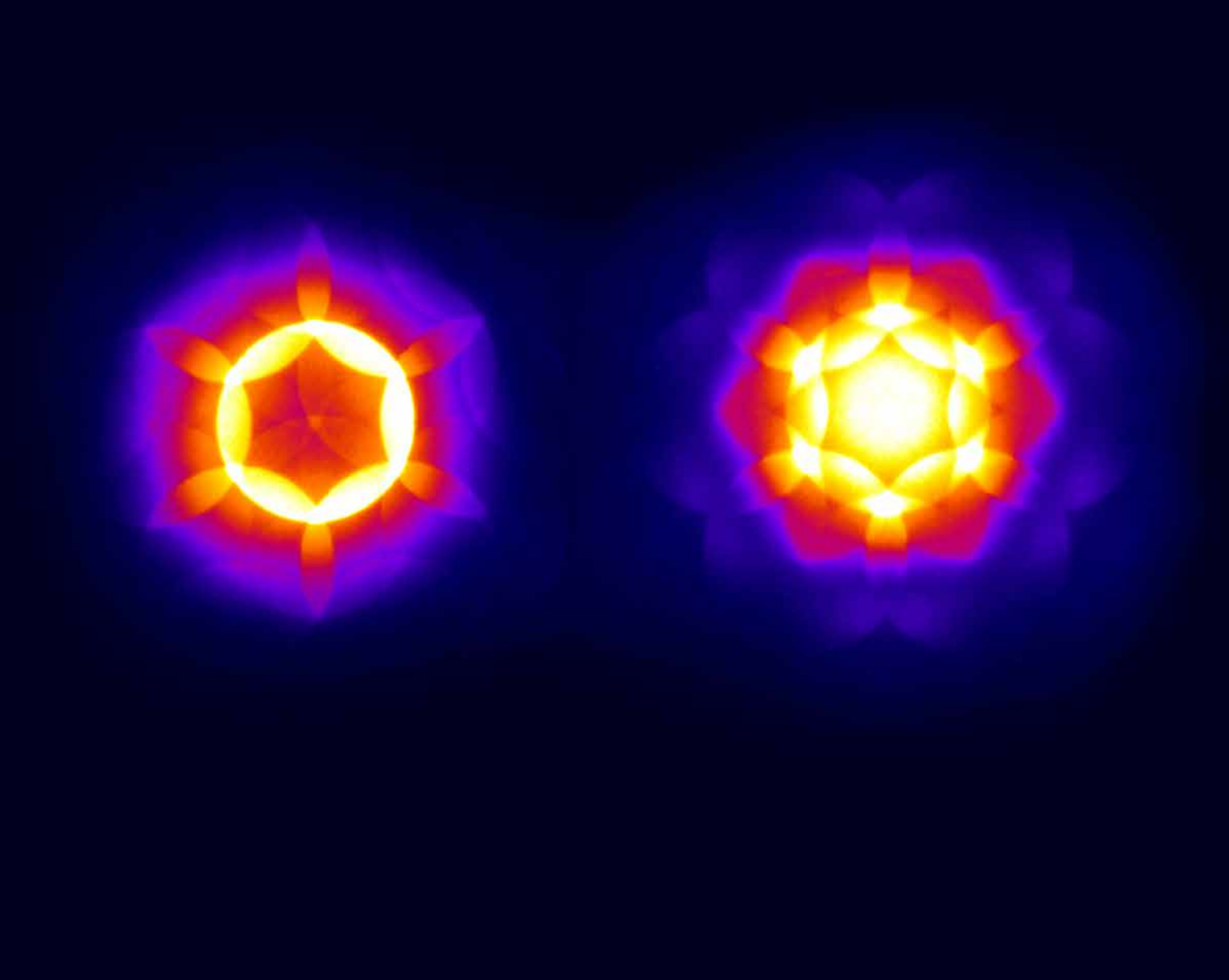
Cornell Engineering
Applied and Engineering Physics

AEP

Newsletter
Fall 2016



MESSAGE FROM THE DIRECTOR

DEAR FRIENDS OF AEP,

We are delighted to share news from AEP through this newsletter. Since our last communication, we celebrated with our 2016 graduates, their families, and friends. Our ceremony was joyful and, thankfully, indoors. Who said it never rains on Cornell's commencement? In this issue, we highlight our newest alums, and others in the news. You can also read about recent additions to the faculty. Stay tuned for more new faces in the next issue.

Graduates, recent or more seasoned, we wish you well and remind you to stay in touch. We want to hear from you.

All the best,
Lois Pollack
Professor and Director

Left to Right: Tayler Hebner, REU student, University of Minnesota Duluth; Michael Zachman, graduate student, Cornell, AEP; Benjamin Savitzky, graduate student, Cornell, Physics; Arthur McCray, REU student, Carleton College.

ABOUT THE COVER

Provided courtesy of AEP's Kourkoutis Electron Microscopy Group, this issue's cover is an image of false color convergent beam electron diffraction patterns of the layered transition metal dichalcogenide TaS_2 (Tantalum(IV) sulfide).

The subtle contrast variations provide direct information about the crystal's thickness and symmetries.

At left, undergraduate and graduate students from the Kourkoutis Group work on the newly installed Scanning Transmission Electron Microscope in the basement of the Physical Sciences Building. A similar instrument was used to record the diffraction pattern displayed on the cover.

Congratulations 2016 AEP GRADUATES!

STAY CONNECTED

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GUILLAUME LAMBERT

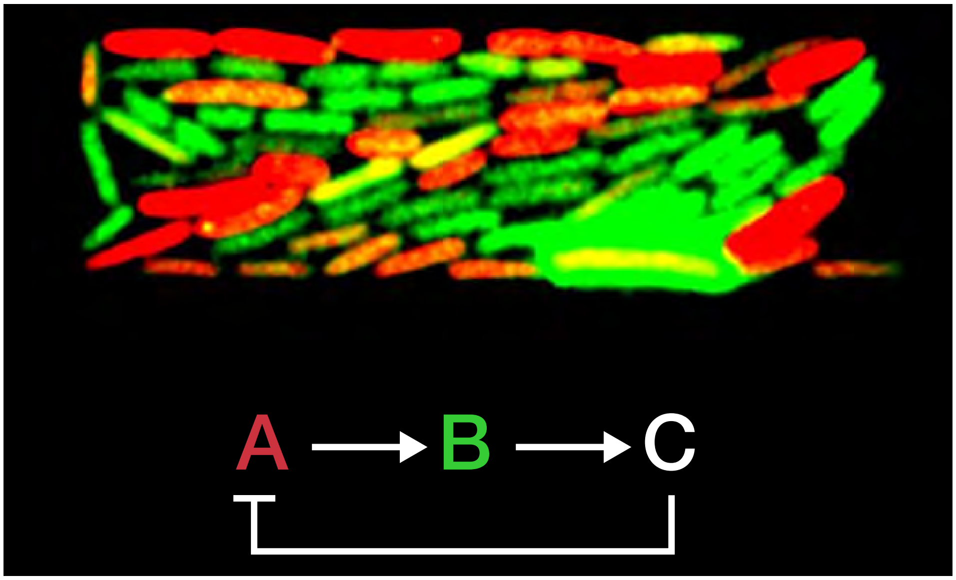
Assistant Professor Guillaume Lambert studies the internal machinery of cells, with the vision that one day he may synthetically design organisms with novel functions that will be controlled by scientists as if they were operating a computer. Ultimately, he explains, this technology aims to allow researchers to detect viruses with greater speed and efficiency in order to develop living diagnostics (e.g., a pill that detects pathogens in the body when ingested) and possibly lead to cures for genetically-based diseases.

Lambert's research crosses disciplines through the combination of nanoscale science, microsystems engineering, and biotechnology. "I am physics because I use tools—microfluidics, circuit-based approach, nanofabrication," he explains. "but the problems I attack are in biology."

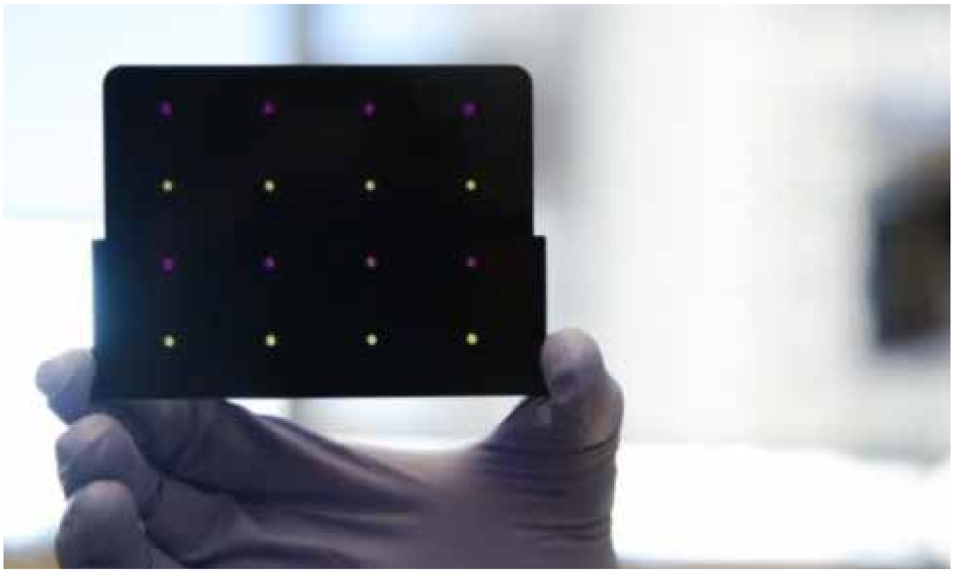
Lambert grew up on a dairy farm in Saint Agathe, Canada, a village of some 2,000 people 50 miles south of Quebec City. The youngest of four boys, he recalls how his family embodied the spirit of engineering, as innovation was often required to fix and construct things on the farm. His interest in physics was sparked by his father, who read lots of science fiction and avidly watched documentaries. During car rides to and from hockey practice, Lambert and his father would talk about outer space, quantum mechanics, and theories of physics. "I wanted to be like Stephen Hawking," he said. As time went on, however, he realized that he enjoyed working in the lab far more than writing and studying equations. This eventually led Lambert to study physics at McGill University in Montreal.

Later, during his Ph.D. studies at Princeton, Lambert reconnected with biology and biophysics; having found a curiosity in biology's mysteries just as he once was intrigued by the mysteries of quantum mechanics and astrophysics. In the lab, Lambert used microfluidics to study how bacteria move and swim. He created v-shaped nanostructures that act similarly to fish- or fly-traps to redirect bacteria and force them to move in a particular direction. Favorable conditions for the bacteria existed on one end, and less-favorable conditions were on the other, and the funnel-shaped structures concentrated the cells away from the more favorable area. Lambert wanted to know whether we could use these structures for specific purposes—to selectively remove bacteria from an infected site, for example. Thus it was a battle of physics versus biology, to see what would ultimately dominate.

Although the cells were competing against a physical force, Lambert explained, bacteria have had billions of years to evolve very sophisticated machinery to go where there is food, and to search for a better environment despite obstacles. In the end, they were able to swim against the structure to reach the more beneficial environment.



In the image above, fluorescent protein oscillations spontaneously emerge in an engineered gene circuit that contains a negative feedback loop.



A black cartridge containing a paper-based diagnostic for detecting Zika. Areas that have turned purple indicate samples infected with Zika, while yellow areas indicate samples that are free of the virus.

It was during this time that Lambert first became acquainted with Cornell, as he and some fellow lab members traveled to Ithaca to use the renowned Cornell Nanoscale Science and Technology Facility (CNF). The beauty of the campus, the magnificent gorges, and the friendliness of Ithacans resonated with him for years to come, he said.

After obtaining his Ph.D., Lambert worked a postdoctoral position for one year in the Department of Biology at New York University, followed by three years as a Chicago Fellow in Biology at the University of Chicago, where part of his research was supported by grants from the Chicago Biomedical Consortium. His most recent appointment, prior to accepting his new position at Cornell, was as a visiting scholar at the Wyss Institute at Harvard, where he worked in the laboratory of Dr. Jim Collins with a team that designed a "toggle switch" to program functions in cells. Using this new technology, he explained, cells can be triggered to go from one biological state to another on command. "Synthetic biology is a relatively new field," says Lambert. "It's the engineering of biology—creating organisms and bacteria that do what you want them to do. Something never before seen in life, we design it to do it."

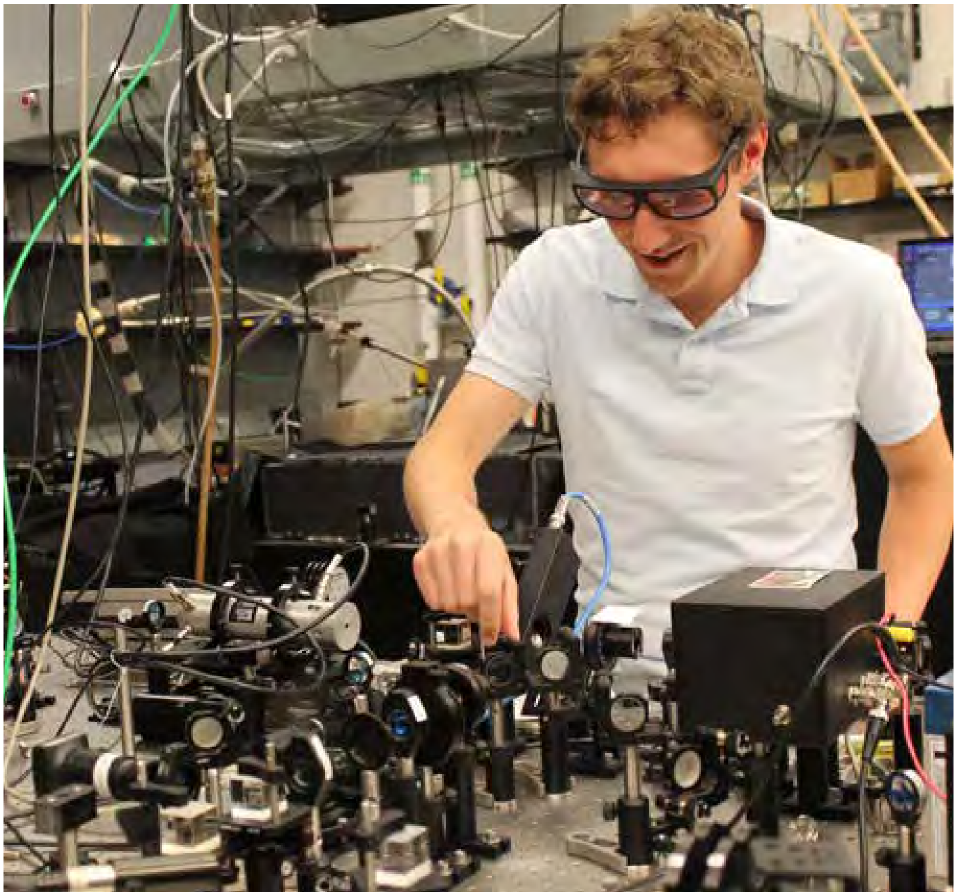
Also at the Wyss Institute, he helped to develop a breakthrough low-cost, rapid paper-based diagnostic method for Zika virus detection, with the goal that it could be used in the field to screen blood, urine, or saliva samples. In the near future, it is hoped that this new system will help reduce major outbreaks of Zika and other viruses by being able to identify them more immediately and at a very low cost.

Now at Cornell, in his first semester as the Gordon Lankton Sesquicentennial Faculty Fellow in Applied and Engineering Physics, Lambert plans to further his research by studying biological systems at the single-cell level to gain insight into physical and biological principles and develop new biomedical and diagnostics applications. Using microfluidics, he is able to study the responses of a single cell, rather than a test-tube with billions. "For example," he said," perhaps there is a new drug developed that kills 99.9 percent of the bacteria. We look at what happened to the .01 percent of the population—how is it resistant, how is it special? Then we work to program cells to kill these unwanted bacteria." Lambert also describes an outside challenge within the field: "There are a lot of fears with biotechnology because we wouldn't want bacteria that is programmed to be harmful to get into the wrong hands. Therefore, as we engineer cells we make sure that we create organisms that do not live past a certain time frame, or cannot survive outside the laboratory conditions." Furthermore, he emphasizes that the drive of his research is to benefit humankind by finding better ways to prevent, detect, and cure diseases.

When not in the lab, Lambert and his wife enjoy traveling. This past March they went to Tanzania to climb Mount Kilimanjaro, where they accompanied a team of 14 people—cooks, guides, etc.—for eight arduous days to reach the summit. Last year, their expedition was in Iceland (a "frozen Hawaii," as Lambert describes it) where they spent a few days walking on glaciers, spending time in thermal springs, and touring the dramatic landscapes of the island. An adventurer at heart, in his research and in the broader world, the School of Applied and Engineering Physics is pleased to welcome Guillaume Lambert to the faculty. ■

JASON BARTELL

Hometown: State College, Pa.
Program: Ph.D. in Applied and Engineering Physics
Research Lab: Fuchs Group: Spin Dynamics at the Nanoscale



Jason Bartell in the Fuchs Optics Laboratory.

AEP: How did you become interested in engineering?

JB: I was always interested in technical things. My grandfather was a metallurgist, and my parents encouraged me to go into something technical, and I enjoyed it, so I kept with it.

I studied physics as an undergraduate at Penn State, because I liked the idea of being able to understand how things work and then apply them, and that's ultimately what led me to pursue a Ph.D. in Applied Physics. I like the idea of better understanding why things happen so one can more efficiently engineer them.

What are your research passions?

I work on magnetic materials and devices in the Fuchs Group. I, along with another student, Darryl Ngai, who graduated last year, built up a microscopy technique for studying magnetic devices using thermal gradients. We were able to publish on that, and since then it's been exciting to use our microscope to see things people have not seen before. I also enjoy finding new ways to use our technique through collaboration with other groups, particularly Bob Buhrman's group in AEP and Dan Ralph's group in Physics.

How does your research apply to the outside world?

Magnetic materials and devices are best known for their use in memory storage, such as hard drives (although they're used in many different applications). With the technology that enabled hard drives also came some other ideas for how to apply magnetic materials to make electronics more efficient by using the angular momentum component of an electron, its spin, in addition to the charge. This area of research is known as spintronics and the goal is to do some signal processing or memory storage in a way that is faster and more energy-efficient than we currently do it.

In everyday applications this science would be used for information storage and transfer. It's a field where there's lots of early research and you don't know what's going to pan out. But some real technological advances and technologies have come out of this area of research so I'm excited to see where it goes next.

One thing that people are trying to do is make fast, low-energy memory storage. Right now hard drives do a good job at storing a lot of information, but they have moving parts and are slow. So for instance, your smartphone doesn't have a hard drive, it has a solid-state memory. The idea is to move to a solid state form of magnetic memory storage, because it generally takes less energy to keep the information stored, and is less volatile than our current memory storage options.

What are some of the influences that have directed your research?

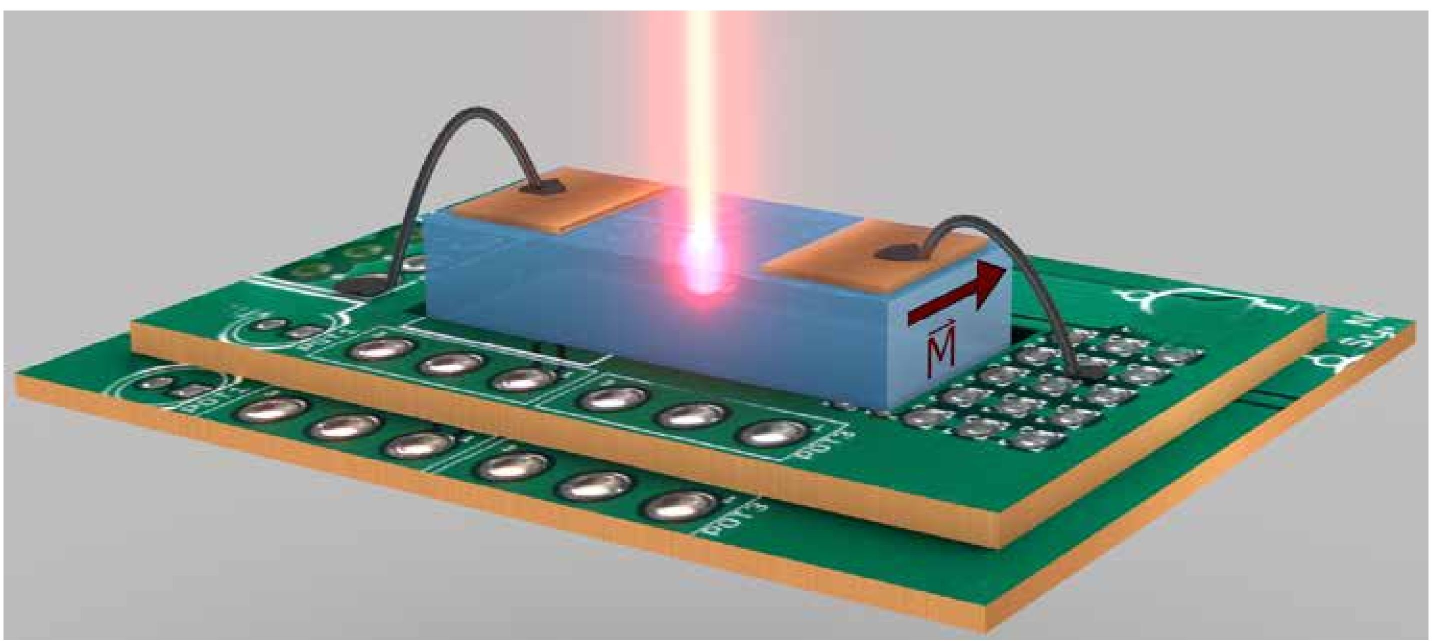
A couple years into the work Darryl and I were doing, we noticed that laser heating of our samples produced a voltage. Professor Greg Fuchs suggested that this might be a way to do high-resolution imaging of magnetization dynamics, something that currently takes very expensive equipment at dedicated facilities. We did our literature research and there were a couple papers published on that idea, so we decided to see if we could build on what they did but with a key difference, using a pulsed laser instead of a continuous wave laser (a laser that's on all the time, and is always heating up your sample). We demonstrated that the pulsed laser heating allowed us to stroboscopically sample magnetic dynamics and has the potential for high resolution. This was an exciting change in our research —to move from all optical techniques to do this combination of optics and heating and electronics. That allowed me to learn many different things and also do something new. The realization that we could take something that previously we thought was an artifact and turn it into something useful, was the biggest "ah- ha!" moment I've had in grad school so far.

Outside of the lab, what is your favorite thing at Cornell?

On campus, I really enjoy the plantations. They do *Shakespeare in the Park* every year, which is really fun. I like Ithaca in general. My wife and I live in Fall Creek, so we can easily get to things and it makes for a nice community down there.

What is your most memorable AEP moment?

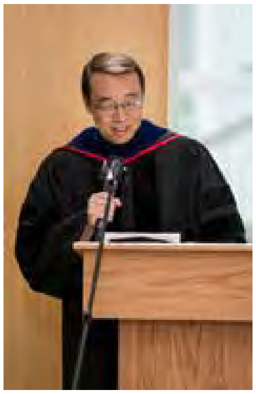
Physics and applied physics are intimately connected. And so taking the qualifier exam was probably the most memorable AEP-specific thing, because the qualifier in applied physics is very different than the one they give in physics, and it's a very big event, as anyone who has done the Ph.D. program in applied physics knows. It's two days of six-hours of testing, and you have to do a lot of studying for it—and they could test you on anything. It's a difficult test and it's a good demarcation of moving from the classwork-centered mindset during your first year of grad school into a more research-based mindset. ■



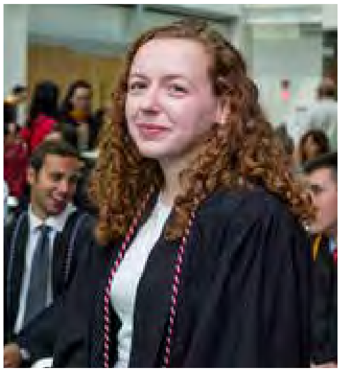
Representation of the thermal gradient microscopy technique developed in the Fuchs Group called time-resolved anomalous Nernst effect (TRANE) microscopy. Image credit: Isaiah Gray

AEP
COMMENCEMENT 2016











See more photos on our Facebook Page

facebook.com/CornellAEP





Applied and Engineering Physics students and faculty during the 2016 commencement celebration.
Photos by Gary Hodges, www.garyhodgesphoto.com

2016 GRADUATION AWARDS

ALBERT M. PARK

David Delano Clark Award for Best Master of Engineering Project

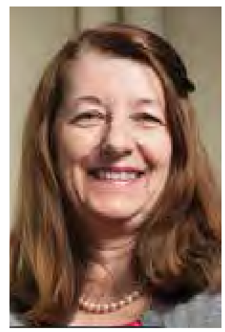
JOVANA ANDREJEVIC

SUK HYUN SUNG

Dorothy and Fred Chau Award for Excellence in Undergraduate Research in Engineering Physics

NICK JUNGWIRTH

William Nichols Findley Award for Outstanding Graduate Research Paper



LENA KOURKOUTIS

Assistant Professor, AEP

PAULETTE CLANCY

Professor, CBE

Dorothy and Fred Chau Project Supervision Awards

NAJVA AKBARI

Trevor Cuykendall Award for Most Oustanding Teaching Assistant

ALEJANDRO A. CARDERERA

Henri S. Sack Award for Top Academic Performance by an M.Eng. Graduate

JOVANA ANDREJEVIC

NINA ANDREJEVIC

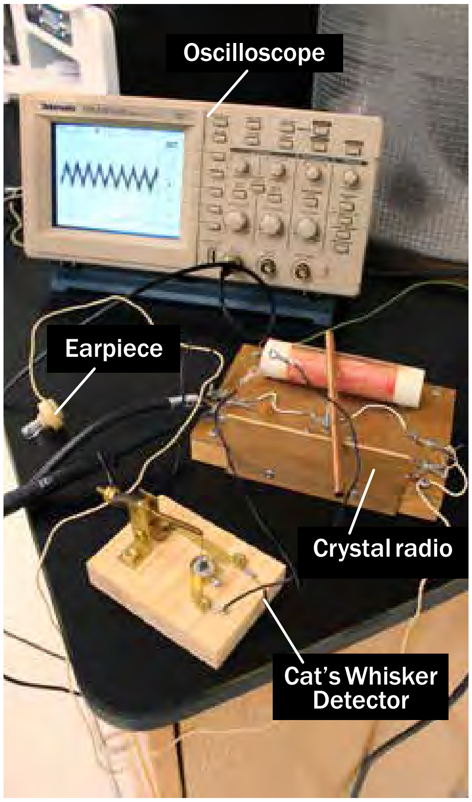
Paul Hartman Award for Excellence in Experimental Physics (Undergraduate)

JUN WEI LAM

Trevor Cuykendall Award for Most Oustanding Academics (Senior)

AEP
STUDENT AWARDS & NEWS

2016 NATIONAL SCIENCE FOUNDATION (NSF) GRADUATE RESEARCH FELLOWSHIPS were awarded to Engineering Physics graduating seniors (left to right) Christian Zollner, Jovana Andrejevic, Mallika Bariya, to Applied Physics Ph.D. student Aaron Hui, and AEP alumnus Bryan Anthonio '15 (not shown). NSF Fellowships are given annually to individuals across the nation who have demonstrated their potential for significant research achievements.



THE WISE RESEARCH GROUP hosted a 4-H activity this past July, where they showed the young 4-H members how to construct crystal radios in the Freshman Nano Lab. At left is a functioning crystal radio, attached to an oscilloscope and a cat's whisker detector, one of the first semi-conductor diodes used in radio production. The thin wire creates a connection with the crystal galena (lead sulfide), conducting electrical current in one direction.

NINA ANDREJEVIC was named a Merrill Presidential Scholar, one of the highest honors for undergraduates at Cornell. Merrill Scholars rank among the top one percent of the class in their respective colleges and only 35 students are chosen each year. The program also recognizes the teachers who have played a significant role in ensuring their success. Each scholar is given an opportunity to recognize the high school teacher who most inspired his or her scholastic development and the Cornell faculty member who most significantly contributed to his or her college experience. Andrejevic acknowledged high school teacher Mark Buesing of Libertyville High School, (Libertyville, Ill.), and Professor David Muller.

ZACHARY ZIEGLER was one of four Cornell students in the class of 2017 to receive a Barry Goldwater Scholarship, the premier undergraduate award of its type, given annually for merit in the fields of mathematics, science and engineering.

AEP FACULTY AWARDS & NEWS

HAROLD CRAIGHEAD, Charles W. Lake, Jr., Professor of Engineering, was inducted into the **National Academy of Inventors**. NAI selects fellows based on their excellence in academic invention.

CRAIG FENNIE, Associate Professor has been elected a **Fellow of the American Physical Society (APS)**, and was recognized during the APS meeting in Baltimore on March 15. The criterion for election is exceptional contributions to the physics enterprise, such as outstanding physics research, important applications of physics, leadership in or service to physics, or significant contributions to physics education.

LENA KOURKOUTIS, Assistant Professor, is one of 105 researchers to receive a **Presidential Early Career Award for Scientists and Engineers (PECASE)**, the highest honor bestowed by the U.S. government on science and engineering professionals in the early stages of their careers. Kourkoutis, the James C. and Rebecca Q. Morgan Sesquicentennial Faculty Fellow, received funds and was nominated by the U.S. Department of Defense. Her work focuses on understanding and controlling nanostructured materials, from complex oxide heterostructures to materials for battery and photovoltaic applications to biological systems.

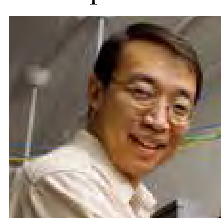
DAVID MULLER, Professor, is the recipient of the **2016 Peter Duncumb Award from the Microanalysis Society.** This award recognizes outstanding achievement in the field of microanalysis through technical accomplishment, leadership, and educational and professional activities. It is awarded annually to an individual currently active in his or her career through nomination by the MAS membership and selection by MAS Council. Muller was presented with the award at the annual meeting in July.

GENNADY SHVETS joins the School this semester. Stay tuned for a feature article about Shvets in our next issue.

CORNELL**NEURO**TECH

This past fall, a multi-million dollar gift from the Mong Family Foundation launched the creation of Cornell Neurotech, a collaborative program between the Colleges of Engineering and Arts and Sciences. Cornell Alumnus Stephen Mong '92 MEN '93 MBA '02, the primary donor to Cornell Neurotech, said the initiative is meant to expedite and expand the ongoing neurological research in Cornell's laboratories, with the goal of solving the mystery of the brain and how it produces our behavior, thoughts and feelings, giving the foundation to understand profound behavioral deficits from Alzheimer's disease, schizophrenia and autism disorders.

AEP professor **CHRIS XU** is co-director of the program. "Developing new scientific tools is critical to understanding the brain and the neurological illnesses that affect it," he said. "New technologies and discoveries are waiting to be realized, and I couldn't be more excited about the prospect this gift brings to our interdisciplinary research collaborations here at Cornell. I'm honored to help lead this innovative program that the Mong Family Foundation has made possible."



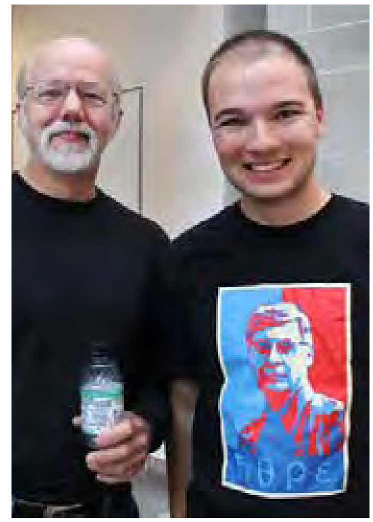
Excerpt adapted from articles in the Cornell Chronicle and Cornell Daily Sun.
Read more at: aep.cornell.edu/aep/news/

SAVE THE DATE…

…our next alumni breakfast is *June 10, 2017*

…and we hope to see you there!

Applied and Engineering Physics alumni and faculty gather for the 2016 Reunion Breakfast, held this past July in the Clark Atrium of the Physical Sciences Building.



2016 REUNION BREAKFAST

MANSI KASLIWAL '05: ASTRONOMICAL AMBITIONS OF AN AEP ALUMNA

Dr. Mansi Kasliwal, Assistant Professor of Astronomy at Caltech, displays one of the 16 large-format detectors that will be part of the Zwicky Transient Facility (ZTS) camera mosaic. Working in collaboration with the surveys at Palomar Observatory and the Advanced LIGO, which "hears" gravitational waves, it is hoped that eventually the ZTS will see the light from the binary neutron-star merger. Dr. Kasliwal earned a B.S. in Engineering Physics with Honors from Cornell University in 2005.

Raised on a farm in Indore, India, Dr. Mansi Kasliwal ('05) grew up dreaming of one day becoming a scientist. Even at a very young age she conjointly demonstrated a strong interest in science and an aspiration for discovery. Recognizing this inquisitive passion, Kasliwal's parents encouraged her to study abroad, and at the age of 15 she headed off to the United States.

Kasliwal first came to Cornell to participate in the six-week Exploration in Engineering Seminar for high school students. Prior to attending this workshop, she explains, "I knew I wanted to be a scientist, but I didn't know what that meant." The seminar exposed her to several engineering fields where she gained hands-on experience in weekly labs and worked on design projects aimed to introduce concepts of the engineering design process. Following that summer experience, Kasliwal had her heart set on Cornell.

As an undergraduate at Cornell University, Kasliwal affiliated with Applied Engineering and Physics (AEP) and consequently developed an affection for astronomy. She joined the Infra-Red Astronomy Group, working under Professors Richard Lovelace, Terry Herter, and the late Jim Houck. "Studying under these professors opened a corridor into the universe for me for the first time—that's when I knew I wanted to be an astronomer, as crazy as that was," said Kasliwal. "AEP gave me the confidence that this wild dream was possible. They showed me what it meant to be an astronomer."

Today, Kasliwal is Assistant Professor of Astronomy at Caltech, where she also completed her doctoral work. She has been a part of the team at the Laser Interferometer Gravitational-Wave Observatory (LIGO), a large-scale physics experiment founded in the 1980s as a means to detect gravitational waves—a goal which was achieved this past September, when LIGO detectors in Livingston, La., and Hanford, Wash., observed a ripple in the fabric of spacetime, generated from a cataclysmic event in the distant universe: the collision of two black holes. A truly momentous occasion in astronomy, the discovery at LIGO this past fall confirms a major prediction of Albert Einstein's 1915 general theory of relativity, opening up an unprecedented new window into the cosmos.

In addition to her work with LIGO, Kasliwal is also leading the Caltech effort to look for the electromagnetic counterparts to gravitational waves known as astrophysical transients. Astrophysical transients, she explained, are astronomical objects or phenomenons, the most common of which are novae and supernovae. Novae and supernovae are detected through telescopes as flashes of light that appear when stars become a million to a billion times as bright as our sun, then quickly fade away. As a result of these transients, most of the chemical elements that we observe around us are synthesized, she said. Scientists try to capture the light from the flash and disperse it. Once they extract a spectrum, they can identify what sort of elements the transient is made of.

The collision of two black holes—an event detected for the first time ever by the Laser Interferometer Gravitational-Wave Observatory, or LIGO—is seen in this still from a computer simulation. LIGO detected gravitational waves, or ripples in space and time, generated as the black holes merged. The simulation shows what the merger would look like if we could somehow get a closer look. The stars appear warped due to the strong gravity of the black holes. Visit: *www.ligo.caltech.edu* to see the video.

During her Ph.D. work at Caltech, Kasliwal explained that she was part of a team that found a rare class of events that generates about half of the calcium in the universe. This discovery set in motion her current research aimed at discovering the cosmic mines of the heavy elements—specifically, gold and platinum. To date, she said, astronomers have a general understanding as to what is required to make these elements, yet no one has identified the event in action.

"Astronomy," she says, "is the oldest discipline yet it is also the youngest, because there are so many unknowns —we have to look in a new regime to discover new things."

To future AEP students, Kasliwal encourages them to dream big. "AEP gives a very strong foundation in physics, math and engineering—it's a basis you can use in many ways. Don't be afraid to dream crazy dreams." She thanks AEP for giving her the foundation to rise to where she is today. ■

ALAN ALDA, actor and science advocate, presented a public talk at Cornell's Bailey Hall on May 16, 2016. His talk, **"Getting beyond a blind date with science"** emphasized the importance of conveying science and scientific research in plain language in order to be clear to the public. This lecture was sponsored by the Kavli Foundation and was part of an intensive three day faculty workshop on communicating science. In the photo above, Alda is seen at right with David Muller, AEP Professor and Co-Director of the Kavli Institute at Cornell.

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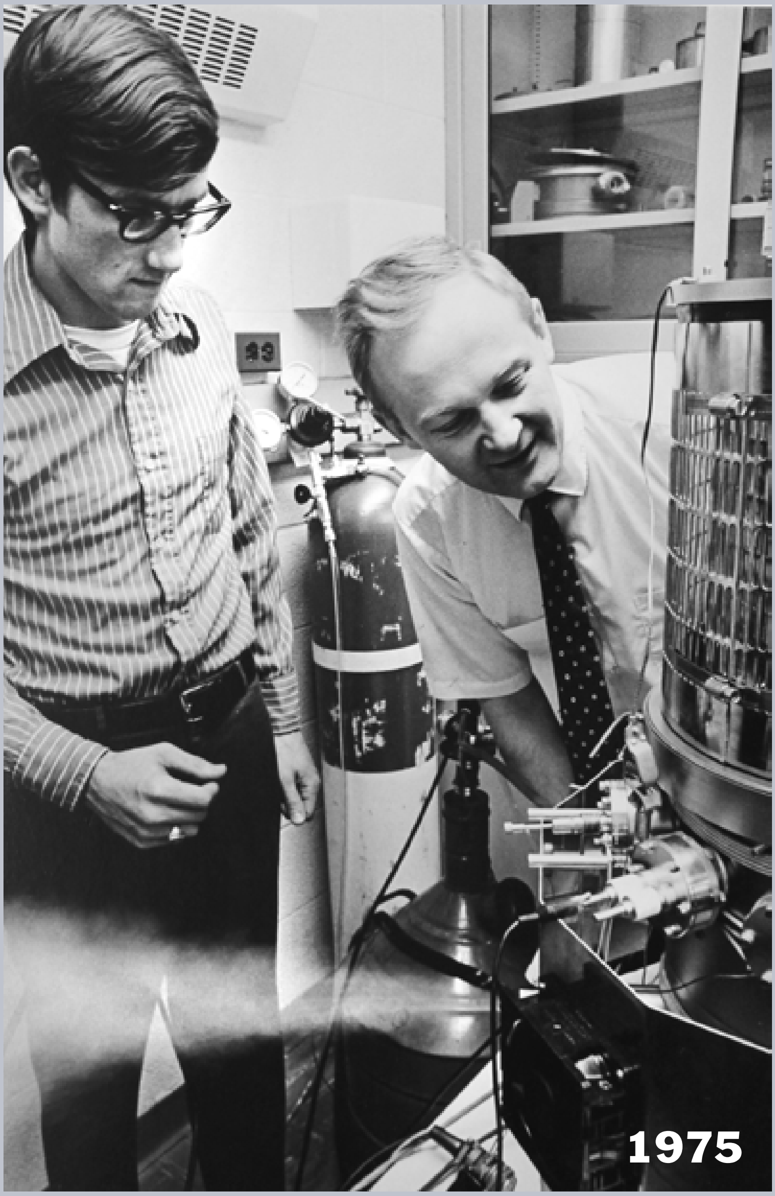

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BLAST FROM THE PAST

At left is AEP alumnus Phil Batson, EP' 70, Ph.D.'76, with Professor John Silcox (now Professor Emeritus) examining an evaporation chamber for making and imaging nanoscale-sized particles. The instrument allows researchers to evaporate hot aluminum atoms into a cold non-reactive gas (such as helium), resulting in the formation of nano-sized aluminum particles that can then be examined. In the background is a gas cylinder and beside the machine, a cryogenic dewar of liquid nitrogen, which would have been used to cool the gas to a low temperature. Around the base of the vacuum chamber are electrical leads needed for heating metallic sources of atoms.

Following his graduation from Cornell and two years spent at Cambridge University, Dr. Batson joined the IBM Watson Research Center and began investigation of the properties of small particles. Some of his initial studies were spent with a new electron microscope at Cornell in what is now the Cornell Nanoscale Science & Technology Facility (CNF).

Toward the end of the millennium he motivated the formation of the Nion company (a world-class developer of advanced scanning transmission electron microscopes) by providing funds for the construction of an aberration-corrected electron lens, a technology that made it possible to identify individual atom columns with unprecedented clarity. Later on at Rutgers University, Batson successfully competed for funds to enable NION to build a 100 keV microscope with a spatial resolution of 1 Angstrom (1 / 100,000,000 cm) and an electron energy analysis resolution of 10 meV, permitting very high spatial and energy resolution.