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APS physics

For more from the APS March Meeting, see pages 3 and 5.

Applied Physics at the APS March Meeting

By Michael Lucibella

APS March Meeting, Denver This year's March Meeting included physics with big commercial potential. Here are just a few highlights of the research presented with serious industrial applications.

Automotive Thermoelectrics

Thermoelectric generators can convert waste heat into electricity and are poised to make a big splash in the green-energy industry. Gregory Meisner of General Motors Global R & D in Warren, Michigan is developing a device to harvest waste heat from auto exhaust systems. Meisner and his team received a four-year Department of Energy (DOE) grant in 2012 to develop a workable prototype that can increase the fuel economy of a vehicle by 5%.

"If we can convert heat to electricity, we can improve vehicle economy," Meisner said. "This will be the first application of high-temperature thermoelectric materials for high-volume use." Thermoelectric generators use materials that convert temperature differences into an electric potential.

Meissner said that earlier devices simply bolted onto the exhaust pipe, away from the heat of the catalytic converter. His first prototype, still a bolt-on device, was able to convert about 2.5% of the heat it absorbed into electricity. He is planning future prototypes that will be "more integrated into the system."

Thermoelectrics could have a big impact on the auto industry. As much as 75% of the energy generated by a car's internal combustion engine ends up lost as waste heat.

"Thermoelectrics have been around for more than 100 years," Meisner said, adding that NASA has been using the technology for decades to power its space probes [see page 2]. "It's only been relatively recently that the performance of thermoelectric materials entered the range of significant power generation."

Though Meisner hopes to have a working prototype by 2016, it would likely still take several years of commercialization before cars start rolling off the lot with these generators.

Faster 3D Printing

The 3D printing revolution is just beginning and physicists are finding ways to speed up the process.

Most 3D printers squirt a thin layer of resin onto a surface, then add more layers on top of it until the object is printed. Printers creating metal objects work essentially the same way, but produce a jet of

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Neutrinos and National Security

By Michael Lucibella

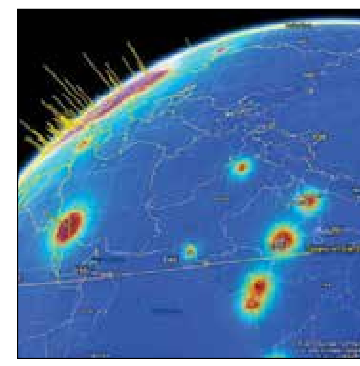

Photo courtesy of Glenn Jocher and John Learned, University of Hawaii

Global map of reactor neutrino emission.

APS March Meeting, Denver The Department of Energy (DOE) is funding WATer CHerenkov Monitor of AntiNeutrinos (WATCHMAN), a prototype neutrino detector that can monitor whether a nuclear reactor 400 kilometers away is enriching the raw material for nuclear weapons. If successful, the WATCHMAN Collaboration's research could make it nearly impossible for countries to hide their illicit nuclear enrichment. It also marks the start of the neutrino's transformation into a practical tool for uses outside of basic research.

"This would be the first really applied use of neutrinos," said Mark Vagins of the University of California Irvine and member of the collaboration.

All nuclear reactors emit radiation and antineutrinos. While radiation can be blocked with a few feet of soil or concrete, antineutrinos pass unimpeded through hundreds of miles of solid Earth.

"That's the beauty of this signal–you won't be able to stop it or shield it," said Adam Bernstein of Lawrence Livermore National Labs and head of the WATCHMAN Col-

NEUTRINOS continued on page 7

Hydrodyamic Forces to Blame for Glacial Earthquakes?

By Calla Cofield

APS March Meeting, Denver Massive icebergs that break off from their parent glaciers might be responsible for earthquakes detectable from thousands of miles away, sometimes reaching 5 on the Richter scale. How this happens could depend on the way the icebergs slosh around in seawater and release energy against the glacier wall.

At the March Meeting, Justin Burton presented results from his laboratory at Emory University, where he and his colleagues are looking at iceberg calving events. Burton added evidence to the case that hydrodynamics is a crucial part of how the icebergs are able to create significant seismic events in their parent glaciers.

In the early 2000s, Douglas MacAyeal at the University of Chicago and colleagues made the connection between glacial calving and earthquakes. Several studies have shown that the events are well correlated, and scientists want to use the seismic data to keep track of calving activity and track details about the icebergs, like their size. But to do that, they need to work out the mechanisms causing the seismic activity.

Icebergs that break off from glaciers are often (but not always) gravitationally unstable: They are tall and skinny and occasionally break off so that the taller side is pointing down into the ocean (imagine a book-shaped ice cube trying to float with its cover vertical). An iceberg with this arrangement will flip 90-degrees (so the cover of the "book" goes from vertical to horizontal).

In a particular fjord on the west coast of Greenland where this phenomenon has been extensively stud-

QUAKES continued on page 7

Photo courtesy of Jason Amundson, Emory University

Icebergs form at Ilulissat glacier, Greenland.

Wisconsin Synchrotron Center Goes Dark

By Michael Lucibella

Photo courtesy of Synchrotron Radiation Center, University of Wisconsin

Construction of the 1.0 GeV Aladdin electron storage ring in 1981.

In mid-March one of the country's remaining synchrotron light sources switched off for the last time. The Synchrotron Research Center (SRC) at the University of Wisconsin-Madison shut down after thirty years of use when funding for its continued operation failed to emerge.

"It's not that we're a sleepy little institution waiting to be turned off. We were producing real world-class science here," said Joseph Bisognano, the director of the synchrotron center.

The $5 million center is home to the Aladdin storage ring with twenty-one attached beamlines. The compact machine's specialty was ultraviolet and soft X-ray research, and recently the facility installed an infrared beamline.

Berkeley's Advanced Light Source is the only other major source of soft X-rays in the United States. The closure of the SRC represents the shuttering of roughly 40 percent of the nation's soft X-ray and ultraviolet beamlines.

Following a review panel's recommendations, the National Science Foundation (NSF) announced in 2011 that it would soon stop funding the center. NSF provided about two years worth of bridge funding for the university to operate the machine while searching for new revenue sources.

"In the end, nothing materialized," said Steve Ackerman, the associate dean for physical sciences at the university.

Guebre Tessema, the program director for NSF's Division of Materials Research who led the review panel, said that they reached their decision partially based on the budget constraints, but primarily on the desire to prioritize the development of new tools and techniques over long-established facilities.

"It's a period where fundamental changes are taking place with third-generation light sources coming online [and] fourth generation light sources in development. In that context, NSF had to think strategically," Tessema said.

The matter essentially came down to a choice between Wisconsin's SRC or the Cornell High Energy Synchrotron Source, and NSF ultimately opted for the latter.

"This was a competitive process and the decision was made to give an award to a competitor," said Mary Galvin, NSF's director of the Division of Materials Research.

Bisognano said that he felt that the decision was influenced by political pressure for NSF to reduce its budget. He said that the lab was being shut down despite having received several excellent NSF reviews in recent years.

"We're large enough to count [for closing] but small enough to not create a lot of political repercussions," Bisognano said. "That's all I can figure because it was a very cost-effective facility at $5 million a year."

Galvin disagreed. "They really are science decisions, trying to optimize the science that we can get," Galvin said. "We have a lot of proposals that get very positive assessments that we don't fund."

The synchrotron's last run was on March 7. The university will

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Members in the Media

"A lot of people think we need scientists to deal with the science issues–the funding for NASA and things like that. I'm not worried about that. It is the countless other things that come before us that have scientific components that are ignored."

***Rush Holt**, U.S. House of Representatives,* The Washington Post, *February 18, 2014.*

"If we build three east-west great walls in the American Midwest....one in North Dakota, one along the border between Kansas and Oklahoma to the east, and the third one in south Texas and Louisiana, we will diminish the tornado threats in the Tornado Alley forever."

***Rongjia Tao**, Temple University,* USA Today, *February 26, 2014.*

"It could mean that we have to change quantum theory, the fundamental theory governing matter. Or it could mean that there could be weird activity in the very earliest moments of the Big Bang."

***David Kaiser**, Massachusetts Institute of Technology, on testing the quantum implications of loopholes in Bell's theorems,* NBCNews.com, *March 5, 2014.*

"The idea was just to trust that nature has designed a good way to do this."

***Kerstin Nordstrom**, University of Maryland, on designing the RoboClam, a smart anchor that burrows like a clam,* The Los Angeles Times, *March 5, 2014.*

"Elastic threads are everywhere in our daily lives–from hair and textile yarns to DNA and undersea broadband cables. Even the honey you pour on your toast."

***Pierre-Thomas Brun**, École polytechnique fédérale de Lausanne, describing his research on the physics of lassos,* BBCNews.com, *March 6, 2014.*

"Our first suspicion was that this has to be a mistake…. We did many tests to try to rule out these spurious effects, and so far we have failed."

***Troy Shinbrot,** Rutgers, on his team's discovery that fractures in granular material can generate voltages,* The Washington Post, *March* 6, 2014.

"I actually don't constrain myself personally with the practical applications at this point…. We don't have to get a home run here."

***Omar Hurricane**, Lawrence Livermore National Laboratory, on the NIF's incremental approach to achieving ignition,* The New York Times, *March 17, 2014.*

"Inflation–the idea of a very big burst of inflation very early on–is the most important idea in cosmology since the big bang itself… If correct, this burst is the dynamite behind our big bang."

***Michael Turner**, University of Chicago,* The Washington Post, *March 17, 2014.*

"Yeah, I ordered it 30 years ago…. It finally arrived."

***Andrei Linde**, Stanford, one of the theorists behind cosmic inflation, when asked if he had ordered something after being surprised at his front door with the news of the findings from the South Pole,* The Los Angeles Times, *March 18, 2014.*

"Certainly everything in the universe that we see now, at one time before inflation, was smaller than an electron…. And then it expanded during inflation at faster than the speed of light."

***Kent Irwin**, Stanford,* CNN Tech, *on his team's discovery of evidence for cosmic inflation, March 18, 2014.*

"The most prized component we can be having here is a failed part [so future parts won't fail]."

***John Hurrell**, The Aerospace Corporation,* National Public Radio, *March 18, 2014.*

We Want your Nominations for Historic Sites

Please submit nominations via
http://www.aps.org/programs/outreach/history/historicsites/nomination.cfm

This Month in Physics History

April 3, 1965: Power in the Sky

In a letter to his patrons about the aboriginal people he encountered on his first voyage to the New World, Christopher Columbus wrote "They know neither sect nor idolatry with the exception that all believe that the source of all power and goodness is in the sky...." [1]. He was referring to the beliefs of the natives, who thought that he, his companions, and his ships must have come from some extraterrestrial place. More than 500 years later, we have become voyagers in a new world, through the solar system and into deep space beyond.

Columbus had the wind to propel his ship, the stars to guide him, and the muscles of his crew to keep the ship under control. Space vehicles in Earth orbit have solar cells to provide the energy needed for communication and instrumentation. At the planets beyond Earth, and in deep space, solar radiation is too weak for solar cells to provide the power needed to guide space vehicles and communicate with them.

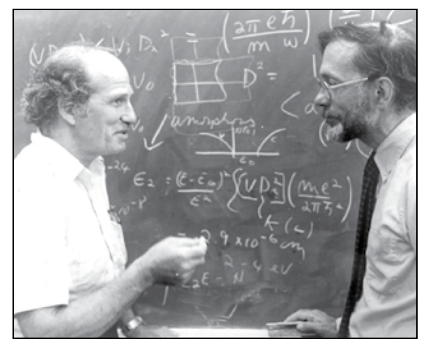

Photo courtesy of George Cody.

Ben Abeles (left) and George Cody (right) in 1972. The two physicists invented the silicon-germanium thermoelectric generator used on numerous space missions.

An invention from the 1960s made it possible to provide this power, and has been a key factor in the success of these space voyages. It is the radioisotope thermoelectric generator (RTG) that supplies the electric power needed for guidance, communications, and all the other power needs of the space vehicles. The RTG contains a radioactive source, plutonium 238, which emits primarily ~5 MeV alpha particles and has a half-life of 87.7 years. The alpha particles are absorbed within a short distance inside the radioactive plutonium oxide, heating it to as high as 1000° C. The RTG design places this heat source in contact with two side-by-side semiconductor elements, one N-type and one P-type. These must be stable at 1000° C, have high electrical conductivity and, especially important, low thermal conductivity. The only readily available material that satisfied all these requirements was an alloy of silicon and germanium. Fifty years later, no better material has yet been found.

Physicists George Cody and Ben Abeles discovered the unique properties of this material in the early 1960s. Working as part of a research team at RCA Laboratories in New Jersey, they attacked the difficult problem of measuring thermal conductivities at 1000° C. This is complicated by thermal radiation and other sources of error, so they started with measurements on iron, which provided some basis for comparison. They used an elegant method that eliminates the effects of radiation losses, first reported by Swedish physicist, Anders Ångström in 1861 (better known for the length unit bearing his name). They were able to measure the thermal conductivity of iron up to 1000° C and found good agreement with published results.

Cody and Abeles then went on to the silicon-germanium alloys, which were available at RCA Laboratories, and known to be stable at 1000° C in vacuum, to measure the thermal conductivity over a range of alloy compositions. At the optimum composition, 60 at.% silicon, the thermal conductivity was unexpectedly low, lower than that for other materials known at the time. Other members of the group supplied material with the needed electrical conductivity by suitable doping, and also solved problems of lattice strain at elevated temperatures and metallurgical difficulties of also maintaining good electrical contact.

This appears to be just good physics research, made possible by institutional patience with solid work, and it is. But it resulted in the key invention that has made all the planetary and deep-space missions possible. Cody and Abeles applied for a patent in October 1962, which was granted on October 18, 1966: US 3,279,954, *Thermoelectric Device Having Silicon-Germanium Alloy Thermoelement*.

The earliest use of the invention on a space vehicle was SNAP-10A (SNAP = System for Nuclear Auxiliary Power). Heat from a nuclear reactor core was transferred to the thermoelectric generators by a molten sodium-potassium coolant. This vehicle was launched on April 3, 1965 in a 700-mile-high orbit. Performance of the silicon-germanium thermoelectric material in SNAP-10A was so outstanding that it was chosen to be the power source for subsequent deep-space missions.

Later vehicles included the Voyager I and II unmanned spacecraft launched in 1977 for their rendezvous with the giant outer planets, and the Galileo spacecraft mission to Jupiter launched in 1989. In 1990, Ellis Miner at the Jet Propulsion Laboratory noted that "when future generations look back, Voyager's epic journey to the four giant gas planets [Jupiter, Saturn, Uranus, and Neptune] of our solar system may stand as one of humanity's most productive exploratory missions. These findings include information on the individual planets' atmospheres, thermal properties, ring systems, satellite surfaces as well as bulk properties. Barring unforeseen catastrophic failures, the power...resources should keep both spacecraft collecting... data until the year 2015" [2]–almost 40 years after their launch and a credit to the performance and reliability of the silicon-germanium RTG.

More recently, the Curiosity Mars Rover and the earlier Rovers, Spirit and Opportunity, were outfitted with silicon-germanium RTGs that provide enough power for all communications, processing the important signals with the crucial information needed to land safely with all their equipment intact. But that is only the beginning. There is then enough power to move a vehicle nearly as large as a small

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Diversity Corner

APS to form ad hoc committee on LGBT issues

In response to a formal request from the LGBT+ Physicists, APS will form an ad hoc committee to investigate the status of physicists who identify as Lesbian, Gay, Bisexual, Transgender (LGBT), and other sexual and gender minorities. Little is known about the numbers of LGBT+ physicists and there has been no systematic study of the issues they face. The LGBT+ Physicists have organized networking events and roundtable discussions at APS meetings, and held an invited session on Sexual and Gender Diversity Issues in Physics at the 2012 APS March Meeting. They have also put together a best practices guide for physics departments, which is available along with other resources at http://lgbtphysicists.org

APS Bridge Summer Meeting

June 25-27, 2014 - College Park, MD

http://www.apsbridgeprogram.org/conferences/summer14/index.cfm

The APS Bridge Program Summer Meeting will bring together experts to discuss efforts to increase the number of underrepresented minorities (URMs) who receive PhDs in physics. This year's conference will focus on exploring and understanding the role of the MS degree in promoting URMs in physics. Workshops, panel discussions, and presentations will address topics including

- Establishing relationships among MS-granting and PhD-granting institutions
- Role of master's degrees for URM students
- Barriers to student advancement to the PhD
- Mentoring
- Non-cognitive admissions measures

Who should attend: faculty, students, and administrators interested in increasing the number of underrepresented students pursuing PhDs in physics. Registration is now open.

APS CSWP Climate for Women in Physics Site Visit Program Inspires Astronomy Community

At the American Astronomical Society (AAS) meeting in Indianapolis in June 2013, the AAS Council approved a proposal by the Committee on the Status of Women in Astronomy to implement Climate Site Visits for astronomy departments. These site visits are modeled on the highly successful visits done by the APS Committee on the Status of Women in Physics (CSWP) for physics departments. More details are available at: http://womeninastronomy.blogspot.com/2014/01/cswa-climate-site-visit-program-for.html

PhysTEC Conference Offers Travel Support for Minority-Serving Institutions

Registration is now open for the PhysTEC Conference in Austin, Texas on May 19-20, held in conjunction with the UTeach Conference. The registration rate for PhysTEC member institutions is $150 and the non-member rate is $295; registration closes on May 1, 2014. Travel stipends of up to $800 are available to a limited number of minority-serving institutions.

The PhysTEC Conference is the nation's largest meeting dedicated to physics teacher education. This year's conference theme is "Building Leadership" and the conference features workshops, panel discussions, presentations by national leaders, and a contributed poster session. There will be a PhysTEC-UTeach joint plenary session by Arthur Levine, Woodrow Wilson Foundation. Other plenary speakers include Nicole Gillespie, Knowles Science Teaching Foundation; David E. Meltzer, Arizona State University; and Susan Singer, National Science Foundation Additional conference information can be found here at: http://www.phystec.org/conferences/2014

Graphene, Paper, Scissors

By Calla Cofield

APS March Meeting, Denver Melina Blees, a graduate student at Cornell University, is dabbling in kirigami, a form of origami that mostly involves cutting paper rather than folding it. Through specially placed cuts, a sheet of paper becomes a spring, a pyramid, a net, or any number of other shapes.

But Blees is working with 10 micron squares of graphene, which is a single layer of carbon atoms. At the APS March Meeting in Denver, Blees showed videos of the structures she has created. They flex, bend, twist and stretch almost exactly the way they would if they were cut from paper.

"I knew, just from the numbers, that graphene should behave like this," said Blees. "But to actually feel like you are pulling it and playing with it, and it's resilient–it's kind of incredible."

The use of origami in physics is not new–another meeting session focused on its many applications. And the idea that changing the physical structure of a material can also alter its properties is of course familiar in mechanical engineering and metamaterials. But applying these concepts to graphene has been nearly impossible: it tends to stick to substrates and to itself, and tears easily when pushed or pulled, almost like wet tissue paper.

A few years ago, Blees and other researchers in Paul McEuen's lab at Cornell found they could apply gold tabs to make "handles" to grab the graphene. They first transfer graphene to an aluminum film on glass, then use a photolithography process to deposit the gold tabs, and at the same time make the kirigami cuts. The aluminum is then removed with a mild hydrochloric acid etch.

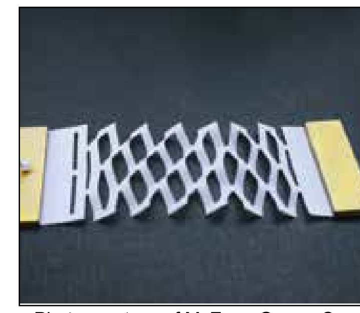

Photo courtesy of McEuen Group, Cornell University.

New techniques enable elaborate graphene structures.

Blees remarks that she can pick up and manipulate these "cantilevers," but only if they are suspended in water. She and her colleagues suspect that as the aluminum is removed, the water gets between the graphene and the glass substrate, preventing sticking. In most cases, graphene sticks to the resting surface so well that trying to pick it up with the gold tabs would only cause it to tear.

This allowed the researchers to measure the bending stiffness of the graphene directly. "It's not an easy thing to measure because usually graphene is suspended and under tension, and then that changes what you're measuring," said Blees. "So it's a different situation when you can pick it up and it's fairly free."

Blees can cut a spring pattern out of the graphene, allowing it to stretch to nearly twice its resting length. For this reason, graphene could find its way into touch-screen technology, which is one place that this kind of flexibility might be useful.

Biophysics applications are attractive. In a group of connected cells, like a network of neurons, the graphene could serve to probe the cells individually.

"These [graphene nets] are really soft so they're bio-friendly. You could just drape a net over a cell, measure some electrical properties, and get real time read-outs of exactly what kind of neural firing is going on in a specific location within an entire network," said Blees. "We're just starting to think about going in that direction…trying to see what we can measure electrically with graphene in solution."

McEuen, in an interview, added that the goal of the kirigami research is to assist in creating machines at the microscopic level.

"Feynman, 50 years ago said, 'There's plenty of room at the bottom.' He said we should miniaturize electronics, which we've done; information, which we've done; and machines, which we haven't done," said McEuen."To attack this problem of how to make nanoscale machines, we're borrowing ideas from kirigami and origami. That's the 10,000 foot view, and these are the very early steps in that process."

Profiles In Versatility

Physicists in International Aid: Developing Careers that Serve Humanity

By Alaina G. Levine

As a PhD student in cosmology at UC Davis, Augusta Abrahamse said she "got tired of programming all day on a very small set of problems that was only relevant to a small group of people." So she took a year off from grad school and volunteered in Nicaragua and Bolivia on energy and rural development projects. Her time in Latin America opened her eyes to an entirely new ecosystem of challenges that as a physicist she was poised to conquer: issues pertaining to international aid, development, and even scientific diplomacy. She returned to the States, refreshed. She finished her doctorate while taking classes on international development project design and then went back to Bolivia for a faculty position at the Universidad Privada Boliviana in Cochabamba.

Photo courtesy of Augusta Abrahamse

In a class on alternative energy taught by physicist Augusta Abrahamse, students participate in a solar car race at Universidad Privada Boliviana in Cochabamba, Bolivia.

Abrahamse knew she wanted to advance her expertise in international aid and policy. Selected for the American Association for the Advancement of Science (AAAS) Science & Technology (S&T) Policy Fellowship, she was placed in the U.S. Agency for International Development (USAID). She was lucky to come to the Agency during the fall of 2013, while it was expanding its science and technology portfolio. She was assigned to the data and analytics team.

By coincidence, she was paired with another physicist, Eric King, who is also an AAAS S&T Policy Fellow. King, who received his PhD in planetary physics from UCLA in 2009, "always had a taste for difficult problems," he says. "I was always interested in doing something to make people's lives better here on Earth." Frustrated after the Sandy Hook school shootings by Congressional inaction on identity checks prior to firearms purchases, King launched a non-profit, GunByGun.org, to support community gun buy-back programs.

The two physicists are essentially "data evangelists," says King. "We are trying to promote and fa-

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pickup truck over rough terrain, dig into the surface, take and analyze samples, and communicate the results back to Earth.

The RTG in Voyager 1 is still producing power after 36 years. Its instruments and communication equipment continue to function well. Voyaging on alone, it left our solar system on August 25, 2012 and will go on into interstellar space.

George Cody and Ben Abeles received the Stuart Ballantine Medal of the Franklin Institute in 1979 for "the contribution their invention made to space communication and reconnaissance"; have been honored as "Inventors of the Year" for their silicon-germanium RTG by the International Thermoelectric Society; and admitted to the New Jersey Inventors Hall of Fame after the Galileo launch in 1989.

References

1. http://www.ushistory.org/documents/columbus.htm
2. *Physics Today* 43, 40 (July 1990).

Editor's Note: This column was written by guest author Richard Williams.

Letters

Readers are welcome submit letters to letters@aps.org. APS reserves the right to select letters and edit for length and clarity.

Neutrinos and Cosmic Rays

We were gratified to see the IceCube Neutrino Observatory labelled a "Physics Newsmaker for 2013" (*APS News*, February, 2014, page 1).

However, we were confused by the second half of the discussion, "In August, researchers using data from IceCube's surface detectors, IceTop, confirmed that, as scientists had long suspected, supernovaes are among the main sources of the high-energy protons known as cosmic rays." IceCube has not made any conclusions about the sites of cosmic-ray acceleration.

Spencer Klein
Berkeley, CA

Olga Botner
Uppsala, Sweden

Francis Halzen
Madison, Wisconsin

Tom Gaisser
Newark, Delaware

Editor's note: *The quoted section should have read "Then in August, researchers from the Fermi Large Area Telescope collaboration confirmed that, as scientists had long suspected, supernovae are among the main sources of the high-energy protons known as cosmic rays." We apologize for the error.*

Women and the Nobel Prize

Congratulations for recognizing the gender imbalance in Nobel Laureates in Physics since their inception in 1901 ("This Month in Physics History," *APS News*, December 2013). As of now, the Nobel Prize in Physics has been awarded to two women and 193 men.

In addition to the three women mentioned, Lise Meitner, Chien-Shiung Wu, and Vera Rubin, whose contributions merited Nobel Prizes, there are others. For example, Marietta Blau, who pioneered the development of nuclear emulsions, the immensely important photographic method of studying particle tracks; Inge Lehmann–discoverer of the Earth's inner core; Cecilia Payne-Gaposchkin–chemical composition of stellar atmospheres; Kathleen Lonsdale, who demonstrated benzene ring structure and that the molecule is planar and hexagonal; Katharine Blodgett–first monomolecular films on solid surfaces.

References to the original published papers and biographical data on these and other important female physicists can be found at the website http://cwp.library.ucla.edu. Scientific accounts and biographies of 40 distinguished and important 20th century female physicists can be found in the volume: *Out of the Shadows, Contributions of 20th Century Women to Physics,* N. Byers and G. Williams (eds.), Cambridge University Press, 2006.

Nina Byers
Los Angeles, California

Digital versus Analog

In "Digital versus Analog" (Letters, *APS News*, February 2014), Victor Alpher contests David Lide's description of the telegraph as a digital instrument.

As Alpher stated, the *Oxford English Dictionary* indeed defines a digital signal as one that is "expressed as a series of the digits 0 and 1…." He failed to note, however, that the dictionary also defines a telegraph to be "a system for transmitting messages from a distance along a wire, especially one creating signals by making and breaking an electrical connection." This binary demarcation of an open (0) or closed (1) circuit is just what Oxford demands for a technology to be digital. Thus, Lide was correct in labeling the telegraph as a digital instrument.

Evan MacQuarrie
Ithaca, NY

Report to Set Particle Physics Priorities

By Michael Lucibella

Now nearing completion, the upcoming Particle Physics Project Prioritization Panel (P5) report will recommend which experiments to do and what research to fund at the Department of Energy over the next decade.

"There is extreme interest in what's going to happen. And whatever happens is going to have a big impact on what [DOE is] going to do," said Patricia Dehmer, the deputy director for science programs at the DOE's Office of Science, speaking at March's High Energy Physics Advisory Panel meeting.

The panel will release its proposed roadmap on May 22. It builds on the APS-sponsored Snowmass high-energy physics planning meetings held over the summer in Minneapolis.

The report comes at a critical time for the field. Budgets since the last P5 report ten years ago have been smaller than expected, and the president's 2015 federal budget request released in early March included a 6.6% cut to high energy physics.

"There is still time to influence the 2015 budget that is on the Hill," Dehmer said. "Things tend to be budgeted when they're compelling, the science will be impactful…and there's complete alignment from the community on up through the administration."

Administrators from DOE urged the physics community to back whatever final form the report takes.

"The office expects the community to fully support the result of the P5 and Snowmass deliberations," said James Siegrist, associate director of the DOE Office of Science. "Bickering scientists get nothing."

Siegrist also urged researchers to temper some of their expectations because his office is expecting only modest funding growth in the near future.

"The P5 budget is extremely tight, so it's very likely that your favorite project did not get the priority you hoped," Siegrist said. "You must suppress any feeling of entitlement that the budget scenarios are too austere for a field as glorious as high energy physics.… The global high energy physics program is at stake, not just your research or feelings."

Undocumented Students Eligible to Receive APS Support

By Bushraa Khatib

In June 2012, the U.S. Department of Homeland Security announced that it would consider deferring deportation proceedings for students and young people brought to the US as children, assuming they meet specific requirements. This classification, called "Deferred-Action," allows APS to provide support for students who might otherwise be ineligible, and who typically have few resources to attend college.

In a 2012 press release, then-Secretary of Homeland Security Janet Napolitano explained that U.S. immigration laws "must be enforced in a firm and sensible manner," and that they are "not designed to remove productive young people to countries where they may not have lived or even speak the language."

In response, the APS Committee on Minorities (COM) considered these changes during a recent January 23 meeting and recommended that APS provide support for deferred-action students in Society programs designed to encourage underrepresented minority students to pursue careers in physics.

Successful applicants to the federal program will receive deferred-action status for two years, which can be renewed, and will be eligible to apply for work authorization.

To be eligible, individuals must have come to the US under the age of sixteen; have continuously lived in the US for at least 5 years prior to June 12, 2012; currently be in school, graduated from high school, or have obtained their GED; have

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INSIDE THE Beltway

Science Futures: Buy or Sell?

by Michael S. Lubell, APS Director of Public Affairs

Unless you're a political junkie or have nothing better to do with your time than watch Fox News or MSNBC, you probably haven't heard the name David Jolly before. There's no reason you should have. But you should be concerned about the impact his March 11 special election victory could have on science.

Jolly, a Republican lobbyist with no campaign experience, poor name recognition, and little early campaign cash, upended Alex Sink, a well-funded, well-known Democrat who had narrowly lost Florida's last gubernatorial election. Jolly, helped by a flood of outside money, pulled off his narrow victory by running hard against big government programs in general and Obamacare in particular.

Although Republican Bill Young had represented Florida's 13th district for 42 years until his death in 2013, the area anchored by Tampa had voted for President Obama in both 2008 and 2012. That history has prompted analysts to label the special election a bellwether for the upcoming 2014 congressional elections. If they're right, Jolly's successful campaign could have national ramifications for both political parties. But that's not all.

In a previous *APS News* column (October 2013), I wrote about the squeeze healthcare spending is creating for science budgets at both the national and state levels. But Jolly's successful use of an anti-big government campaign theme suggests a further, existential threat to federal science programs.

Although the turnout demographics in a special election may not mimic the demographics in a general election, Jolly's message that Washington is not to be trusted seems to have resonated well in a true swing district, especially among independent voters.

Based on the Florida 13th result, Republicans undoubtedly will continue to use the limited-government message in the 2014 congressional campaigns. Democrats will be on the defensive, and if the Jolly-Sink contest is a reliable predictor, their attempt to defend government may well be a losing proposition.

If shrinking government really does become a winning populist theme in November, the Tea Party will have a much larger choir singing its anti-Washington refrain. Should that happen, science budgets would be faced with a very challenging landscape, beginning as early as next year.

Last December's Ryan-Murray budget deal restored most sequestration cuts in fiscal years 2014 and 2015, but unless Congress strikes a new bargain after the November elections, those across-the-board reductions will kick in once again in fiscal year 2016.

Despite its general bipartisan appeal among lawmakers, science could then become the exemplar of collateral damage in a fight between Democrats focused on preserving the social safety net and Republicans fixated on reducing the scope and budget of the federal government. Making the case for science will be difficult but not impossible.

There are a number of arguments that could resonate with both sides of the aisle. Here are just a few.

Fact One: The National Science Board's recently released "Science and Engineering Indicators 2014" provides the following attention grabber. Between 2001 and 2012, our nation's worldwide share of research and development fell from 37 percent to 30 percent. **Message One: In an era of increasing global high-tech competition, we cannot afford to cede any further ground**.

Fact Two: As the economy continues to recover, the Congressional Budget Office predicts that deficits will continue to shrink as long as corporate profits grow and corporate income tax revenues increase. **Message Two: Science and technology are the acknowledged primary drivers of the 21st century American economy, and federal support of long-term research has proven to be a major catalyst of innovation and entrepreneurial ventures.**

Fact Three: The workforce of the 21st century will have to be far more science and tech-savvy, and today we have far too few well-prepared science teachers to educate our students. **Message Three: Investing in science education at the federal and state level is essential for developing a 21st century science teacher corps.**

Fact Four: In the physical sciences and engineering, foreign students fill more than half the slots in advanced degree programs, and more frequently than in the past, foreign PhD recipients are returning

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APS physics MARCH MEETING 2014

More Highlights from Denver

Preservationists hope this is the year for the Manhattan Project Historic Park

By Michael Lucibella

An arduous effort to preserve the history of the Manhattan Project in the form of a National Park (at several different locations) may be close to fruition, said the head organizer at a recent session of the APS March Meeting in Denver.

Cynthia Kelly, founder of the Atomic Heritage Foundation, remarked that legislation this year might clear the way for the National Park Service (NPS) to take over the birthplace of the atomic bomb.

"These buildings embody this history in a way that nothing else does," Kelly said. "The Park Service will do what they do best. They're America's storytellers."

The Obama administration must formally transfer control of the land from the Department of Energy (DOE) to NPS before the park can move forward. A bill authorizing the transfer got through the House in 2013, but was dropped in the Senate. It would have transferred sites in Hanford Washington, Los Alamos, New Mexico and Oak Ridge, Tennessee to NPS.

"It's been almost five years since any park legislation has passed," Kelly said. "It's been very difficult in this congress to get the votes we need."

Facilities picked include the "V-site," a cluster of buildings at Los Alamos where physicists assembled the first atomic bomb, the B-reactor and its control room at Hanford, which produced the first plutonium, and one of the calutrons at Oak Ridge for separating uranium.

But in a setback, the giant mile-long K-25 plant which produced most of the uranium used in the "Little Boy" bomb was demolished in December. "I tried very hard to get one sliver saved," Kelly said.

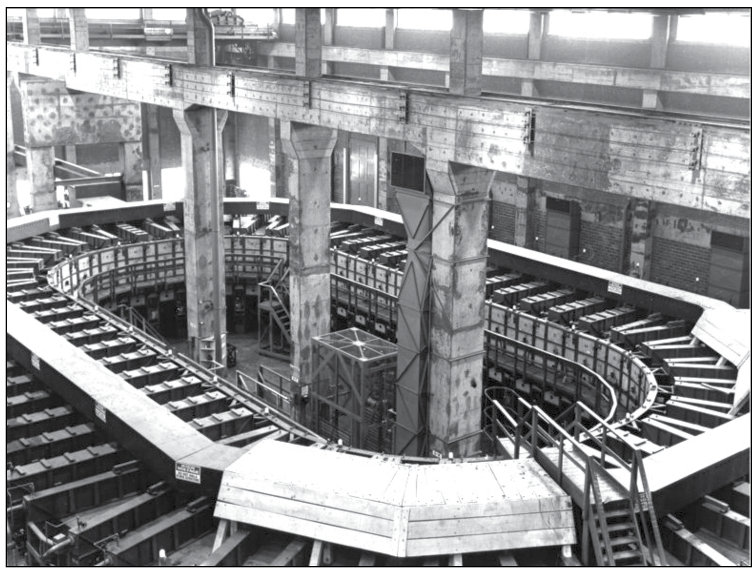

Photo courtesy of the US Department of Energy

Calutron used in the mid-1940s for uranium enrichment at the Oak Ridge Y-12 plant, one of the sites marked for preservation by the Atomic Heritage Foundation.

Downtown Los Alamos ("outside of the fence" to the locals), is also home to other historic parts of the Foundation's grand plan.

"You can go to Oppenheimer's house," Kelly said. "We were able to get this donated from the couple that had been living there for the last 50 years."

Next door is the house where physicist Hans Bethe once lived. It will be converted into the "Harold Agnew Cold War Museum" in honor of the former director of Los Alamos.

Even after the land is transferred, it could be several years before the sites are ready for the public as refurbishment and cleanup continues.

Security and environmental concerns have also played a role in delaying the process. Several of the buildings in Oak Ridge are located near sensitive weapons storage areas, making opening the site to the public tricky. In addition, concern about radioactive contamination prompted several environmental reviews.

The path to preservation has been long and tortuous. Kelly's efforts started in 1998 when she worked at the DOE. The lab had just slated some of the old, dilapidated structures at Los Alamos for demolition.

"The Los Alamos National Lab was going to raze or destroy all of the Manhattan Project buildings that were behind the fence," Kelly said.

She brought in the Advisory Council for Historic Preservation, which advises Congress and the administration. They helped prevent the immediate destruction of the sites. Kelly then left the department to found the Atomic Heritage Foundation to lobby and raise money for the park.

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Controlling Magnets with Heat

By Michael Lucibella

Researchers from the University of California, San Diego, have found that in a narrow temperature range, some nanomaterials suddenly and dramatically become more resistant to changes in their magnetic orientation. The team, led by Ivan Schuller, discovered previously unseen spikes in this behavior in bilayers of nickel and vanadium oxide.

"It's the control of magnetism without a magnetic field," said Schuller, speaking at the APS March Meeting. "We can control it just by changing the temperature."

Coercivity is the quantity that marks how resistant a ferromagnetic material is to having its magnetic orientation changed by a nearby magnetic field. In most materials, the hotter they are, the easier it is to change their magnetic directions, and the lower their coercivity.

Schuller's team found a narrow temperature range where the coercivity of a 10 nm layer of nickel mated with a 100 nm layer of vanadium oxide unexpectedly jumps several hundred percent.

"It changes by a factor of five. It's a huge effect," Schuller said. "It's significant because it provides a new control mechanism for the magnetism."

The effect occurs at the temperature where the oxide goes from being an electrical insulator to a conducting state. The nickel-plus-$V_2 0_3$ nanomaterial shows spikes between 160 and 180 kelvin, while nickel with VO_2 peaks around 340 kelvin.

Because the effect is so new, its potential applications are still unclear. Schuller speculated that this kind of manipulation could be used in the future to make longer-lasting magnetic memory, or build an electrical transformer that loses its conductivity when it starts to overheat.

"It's an automatic fuse that doesn't burn. Something that you wouldn't have to go and replace," Schuller said.

He added that he expected to see similar effects in other materials, and his group plans to find out if there is some way also to mimic the effect using different voltages and currents.

The team's research was published in *Applied Physics Letters*.

Better Visa Policy for Scientists

By Calla Cofield

At the APS March Meeting, the Society's Forum on International Physics hosted a session titled "Visa Policies for the 21st Century." In a first, a representative of the U.S. State Department's Visa Office spoke at the Meeting and answered questions from the audience. Kathie Bailey, director of the Board on International Scientific Organizations of the National Academy of Science (NAS), spoke about the Academy's effort to assist visa applicants who are experiencing delays with their application. Al Teich, former Director of Science Policy and Programs at the American Association for the Advancement of Science for 30 years, and now a professor at George Washington University, spoke about legislation that would help foreign scientists and students coming to the U.S.

"This session was not another rehashing of the horror stories of who has had a visa problem," said the session chair Amy Flatten, Director of International Affairs at APS, in an interview after the session. "We wanted this session to be about solutions. This discussion was focused on the things we can do moving forward."

Matthew Gillen, the State Department's chief of the Bureau of the Consular Affairs' Visa Offices Coordination and Screening Division, opened his presentation by asking how many of the 30 or so audience members were born outside the United States. Nearly every attendee raised his or her hand. He then invited the audience members to shout out questions during his talk, stating, "I want to make this very interactive."

Many of the audience members asked specific questions about their own visa situations. Gillen answered many of these, but also emphasized that visa holders should visit the foreign office at their institution with further questions. He said that the amount of misinformation that circulates by word of mouth is a big problem. Many of the questions posed by audience members were with phrases like "I heard that..." or "A friend told me…" to which Gillen replied "Stop listening to your friends. Go ask an expert."

Gillen's presence at the Meeting may be a sign of the increased transparency from the State De-

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The Growing Network of APS Local Links

By Michael Lucibella

The newest APS networking effort for early career scientists debuted at this year's March Meeting. The Denver area APS Local Link held its inaugural meet-up, setting the tone for more groups to come.

"[These are] networking meetings that would occur on a regular, monthly, basis," said Crystal Bailey, the careers program manager at APS. "It would encompass students, postdocs, and early career physicists working in industry, national labs, and academia."

One of the central recommendations of the early career task force, formed in response to the APS Strategic Plan, is to establish a number of local networks for physicists to meet informally. The hope is that the groups bring different physicists together across a region, which could encompass several universities or labs.

"It's all about building partnerships," Bailey said. "We want the industry people to be invested in coming because it will give them an opportunity to recruit for their companies and build partnerships with local institutions."

Links are separate from established APS sections both in size and formality. Local Links will bring physicists together from a smaller area, while sections cover multiple states. In addition, section meetings are essentially small science conferences, whereas Local Links are designed to be more casual and up to the group itself as to how they're organized.

"These will be totally informal, networking meetings," Bailey said. "These are truly grassroots groups. APS does not dictate the structure or the activities of the group."

In Denver about 60 people

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Photo by Ken Cole

APS March Meeting attendees engage in local networking.

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In 2004, Congress commissioned a study weighing the feasibility of a Manhattan Project historic site. Finished in 2011, the study recommended that NPS should administer the historical structures, while DOE will continue to manage the now-obsolete reactors.

The Atomic Heritage Foundation has also collected numerous historical documents and oral histories of the Manhattan project from the people working there. In addition, the Foundation is also putting together a traveling exhibit for 2017 highlighting the supplementary innovations that came out of the Manhattan project.

"We're going to tie some of the inventions then to inventions today," Kelly said.

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fine metallic grains and fuse them together with a powerful laser.

These printers can take many hours to fabricate an object. The time could be shortened by increasing the flow rate with smaller grains, but small grains also have a propensity to clog at the printer's nozzle, known as a hopper.

Guo-Jie Gao of Osaka University said, "We can reduce the jamming probability and increase the flow rate, if we put an occlusion in the hopper."

It sounds counterintuitive, but Gao found that he could reduce jams by controlling the flow with a strategically placed obstacle right in front of the nozzle. The blockage redirects the granular flow around it so particles don't clog at the narrow bottleneck.

Gao simulated the dynamics of a hypothetical material, and is planning next on investigating the properties of actual grains used in 3D printing.

"We want to study the effect of the friction constants of different materials," Gao said.

De-Icing Wind Turbines

Snow and ice hamper a turbine's ability to harvest wind energy. The trick to efficiently clearing ice off a wind turbine might be to keep its surfaces just a little bit wet. Researchers have developed a coating for metal that traps nano-sized air and water bubbles so that ice slides off with almost no effort.

"Our strategy is inspired by ice skating," said Jianjun Wang from the Chinese Academy of Sciences. He added that ice skaters slide along a thin layer of liquid water underneath their blades. "Could we introduce such a water layer under the ice?"

Wang and his team created a coating from hygroscopic polymers, materials that absorb water. The trapped water droplets stay liquid, creating a thin wet layer that easily sloughs off ice.

"Hygroscopic polymers will absorb and hold water, thus an aqueous lubricating layer forms," Wang said.

Wind turbine companies have already started inquiring about applying the team's coating even though the researchers have only carried out preliminary proof-of-concept tests.

Better Flexible Solar Cells

Researchers found that a dose of graphene improves the efficiency of flexible solar cells. They were able to almost triple the energy conversion efficiency of a solar cell made of polymers by mixing the right concentration of nano-sized graphene flakes into the solar cell.

"Graphene is a promising additive to a polymer solar cell," said Yan Jin of the University of Cincinnati.

Polymer solar cells have huge commercial potential because of their flexibility and durability compared to silicon cells, but have been held back because of their low energy-conversion efficiency.

Jin and her team extracted the graphene flakes from graphite and then mixed them in with the polymer that makes up the cell's active layer, which converts light into electricity. She found that the optimal mix of graphene is about 0.1 milligrams per milliliter of the solar cell polymer.

"We expect that it can also be used for other systems," Jin said.

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cilitate the use of quantified evidence for decision-making" in funding and other programmatic opportunities within the agency. To that end, "we are examining innovative sources of data we haven't tapped for development purposes before," explains Abrahamse.

Social media is at the top of the list. "If we can use social media to better understand conditions that might affect populations," she says, this will improve deployment of resources to endangered communities. For example, the team is considering how twitter could be used to mine data in an emergency, such as a tsunami or earthquake, or Google searches about flu-like symptoms could pinpoint where an outbreak might be occurring.

Ali Douraghy, another AAAS S&T Policy Fellow, came to a career in international development through his love of languages. While an undergraduate in biomedical engineering at UC San Diego, he took a year off to study Arabic at the American University in Cairo. "This changed everything," he says, recounting how he traveled across the Middle East and even into Pakistan. When he returned stateside, he pursued a PhD in biomedical physics at UCLA while furthering his studies in Arabic. Upon graduation, he headed to the United Arab Emirates on a Fulbright Fellowship to help the nation improve their medical imaging capabilities by adopting technology such as PET scans. "I was itching to get back to the Middle East," he says.

When President Obama delivered his "New Beginning" speech at Cairo University in 2009, in which he discussed how the US was going to use science and technology as a new tool for engaging the Middle East, it resonated with Douraghy. "I knew I wanted to be part of this new policy," he says. He soon landed a Fellowship at the National Academy of Sciences Office of the Foreign Secretaries, which enabled his segue into the AAAS program.

As an AAAS Fellow, USAID created a new position for Douraghy, allowing him to engage in science diplomacy and create conduits for better cooperation specifically with the Middle East. His projects have included working with the joint science and technology fund between the U.S. and Egypt to enable bi-national scientific collaboration. More recently, as a Science Diplomacy Fellow based at the US mission in Jakarta, Douraghy helps connect US and Indonesian researchers, oversees funding initiatives between scientists in the two countries, and serves as a policy advisor on science and technology issues.

Of course there are many paths to a career in international development. Alan Hurd, for example, currently serves as an executive advisor to Los Alamos National Lab and also consults for the UN International Atomic Energy Agency (IAEA). "The IAEA's mission is to help countries that choose to develop nuclear energy," he describes. "It is truly uplifting to work with people from Uganda or Nigeria, for example, to help them improve their peaceful nuclear technology capabilities."

These benefits are outcomes of effective science diplomacy, in which "science can provide advice to inform and support foreign policy objectives," and "diplomacy can facilitate international scientific cooperation." Hurd became excited about science diplomacy as a Franklin Fellow at the Department of State and continues that interest by serving as the Chair of the APS Committee on International Scientific Affairs. Recently, he had the opportunity to review IAEA developments of Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), a third-generation synchrotron light source under construction in Jordan (see also the Back Page, p. 8). Its research partners include Israel, the Palestinian Authority, Pakistan, Iran, and other nations, and the collaborations have been completely harmonious. "Everyone checks their politics at the door," he says. "Only scientists could pull this off."

Some of the physicists were surprised that their educational background served as a successful platform on which to craft a career in international relations. "I thought I would feel like a fish out of water as a physicist in a government agency, but this is not true," says King. In fact, they all agree that physics has given them an advantage in making a significant impact in this new arena. "Physics has given me a foundation to understand a little bit of everything," says Abrahamse. King sees parallels in his physics studies with projects in international development, as both are "really big and complicated, with a lot of moving parts and elements that can't ever be accounted for," he says. "You have to be open to different mechanisms to solve really complex problems" in both worlds. And Douraghy agrees that science diplomacy in particular is like a complex system. "It is very rare that things unfold in a linear fashion," he says.

The work is incredibly rewarding, the physicists say, because they know they are making a difference on the ground with individual scientists and communities and in international accord through their impact on policy. Douraghy says that the best part of his job is "helping to advance development in critical areas for Indonesia, while helping to create more avenues of collaboration" like student exchanges and research partnerships between Indonesia and the United States.

For scientists interested in pursuing careers in international development and science diplomacy, Abrahamse suggests getting involved with organizations like the AAAS and Engineers Without Borders, which she participated in as a graduate student. Join relevant committees in APS and start networking, adds Hurd. "We have an obligation to work across borders," he adds. "Every interaction of that sort helps reduce global tension and promotes economic stability. And every scientist is doing this even if they don't realize it. We're all diplomats."

Alaina G. Levine is the author of Networking for Nerds *(Wiley, 2014) and President of Quantum Success Solutions, a science career and professional development consulting enterprise. She can be contacted through www.alainalevine.com, or followed on twitter @AlainaGLevine.*

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VISA continued from page 5

partment's visa office, compared to past decades. Gillen outlined ways that the State Department has improved communication with visa applicants, and how it has worked to recover from the major delays that occurred in the four years immediately following 9/11. According to Flatten, wait times for visa processing at any consular office in the world can be found at http://travel.state.gov. Bailey's advice: "Apply early," at least three or four months prior to travel.

The second key resource cited by Flatten is the website (http:/nationalacademies.org/visas) of the International Visitors Office (IVO) which is part of the National Academies. The website features a questionnaire for scientists whose visa applications are delayed beyond the standard time window, or who are 14 days from an event and do not yet have a visa. Information from the questionnaire will be reported by NAS to the state department. In one instance, the IVO discovered that multiple delays were taking place at one particular embassy, and alerted the State Department to that finding.

Much of the audience was dealing with visa problems rooted in legislation. Examples of legislation changes that could assist people working in the STEM fields were addressed by Al Teich, who has a long list of suggestions of how to improve visa policy to benefit people in STEM fields. (See Teich's article in the March issue of *APS News* for more details).

Many challenges remain for scientists and students in the STEM fields when it comes to gaining entry to the U.S. for school, work, meetings or collaborations. Flatten says she was pleased with the State Department Visa Office's presence at the session, noting that "not only did they speak to our scientists, I think more importantly they heard from our scientists."

LINKS continued from page 5

showed up at the Sheraton hotel to meet, share a drink, and network. Already there are other pilot Links gearing up in the Tampa Bay and San Francisco Bay areas.

"Those three places already have a fairly strong infrastructure of students who were willing to begin organizing events," Bailey said. She added that students play a major role in putting these groups together, and it only takes one or two motivated people to get a group going.

Because the Links are new, APS is staying flexible about how they're organized and what it can do to help. The Society is able to provide some funding, advertising, and network-building to get new Links off the ground, and is in the process of putting together a list of best practices based on the successes of these first meet-ups to help new groups get started.

Members interested in starting their own Local Link can contact Jon Burkin at burkin@aps.org or visit the website at http://www.aps.org/membership/locallinks/index.cfm.

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not been convicted of a felony or threaten national security or public safety in any way; and cannot be above the age of 30.

And to support students who are often without resources to study in this country, long-time APS member Robert Stanek recently made a significant bequest to APS that will provide support for underrepresented students who would like to study physics in this country. His preference is that the funds be used to help undocumented students, and may help deferred-action students in the future.

More information is available at www.aps.org/programs/minorities, and on the U.S. Citizenship and Immmigration Services website, www.uscis.gov/childhoodarrivals.

ANNOUNCEMENTS

Correction

In the correction on page 7 of the March 2014 issue of *APS News*, Charles Kaufman's name was misspelled. We doubly apologize for this error.

QUAKES continued from page 1

ied, the largest of these icebergs may be up to about one kilometer tall, two kilometers wide, and 500 meters thick as they break off from the glacier. According to work published in 2012 in the *Journal of Geophysical Research: Earth Surface*, Burton et al. show that the iceberg takes a few minutes to make the 90 degree adjustment, but in that time it will release the energy equivalent to two Hiroshima nuclear bombs, or 40 kilotons of TNT.

There are multiple forces at work when an iceberg forms. As the bottom half swings up, the top half exerts a contact force against the glacier. But Burton and his collaborators have shown that the contact force on the glacier is larger when hydrodynamic forces are included in the calculation. This is due to various effects of the water on the system. For example, the iceberg's rotation away from the glacier creates suction between the two surfaces, creating a force in the opposite direction from the contact force.

Other scenarios may be involved. A group at Harvard University, led by James R. Rice, showed that it is possible to replicate the seismic signals without hydrodynamic forces, but it requires that the iceberg push off of other icebergs, which must lie directly in front of it.

Burton is now investigating how the sea waves created by this violent rotation may also contribute to seismic activity. In work he is preparing for publication, Burton says his laboratory experiments suggest that the period of the waves created by a calving iceberg could match the period of the seismic data. While the calving of a large iceberg may last a few minutes, seismic events often continue long after that. This longer time period could be explained by the waves.

Minor seismic activity can be detected as a result of waves pounding on shores, so the idea is not unfounded. In addition, the setting is unique: The glacier is a straight cliff face, stretching roughly a kilometer down into the ocean. Waves striking the vertical face could potentially transfer their energy directly into the glacier, as opposed to a horizontally inclined shore, where the wave would be broken up and the energy would be more dispersed.

"I guess it's just really surprising if an ocean wave like this can produce seismic waves that are detected globally," said Jason Amundson, a glaciologist at the University of Alaska Southeast and an occasional collaborator with Burton. "On the other hand, this is a wave hitting a vertical face, so it's a different type of problem than seismologists usually think about."

If Burton's hypothesis proves correct, it would be a situation where water waves cause seismic waves. "Which is weird," he says, "because it's usually the other way around."

The scientists studying iceberg calving are primarily glaciologists and seismologists. For that reason, a discussion of the hydrodynamics involved in this process has had to come from outside sources, such as physicists like Burton.

"Nobody knew how to think about [the hydrodynamics] and it really took these experiments to figure out that they were important," said Burton in an interview. "In fact we didn't know that they were important until we just couldn't model the data without turbulent forces in the water. So most people would agree that they're important."

GOES DARK continued from page 1

soon start to disassemble the machine after workers finish cataloguing and locating buyers for some of the more valuable parts.

"There are a few instruments that we hope to send to a happy home," said Mary Severson, the center's beam manager

Many of the Center's technicians like Severson are staying on to help the decommissioning process. However in a few months everyone employed by the center will have to start looking for new jobs.

"Closure of the facility was a possibility but not a certain thing until this month," said Ken Jacobs, the head of the accelerator development division and a 12-year veteran of the lab. He's been looking around for somewhere in the Madison area to go next, but there's a limited number of places where he can apply his expertise.

"It's sort of a highly specialized field and there aren't very many accelerators around," Jacobs added.

FUTURES continued from page 4

to their home countries. **Message Four: We must make graduate education more attractive to American students by providing the funds required for world-class university research programs and science instrumentation.**

Having the messages is essential, but having messengers who can communicate them is just as important. Unfortunately, all too often, scientists who are at the top of their game in the laboratory are woefully lacking in basic communication skills. But there is hope.

As the Alan Alda Center for Communicating Science at SUNY-Stony Brook has shown, scientists can learn those skills with proper training. They may not become stars of stage and screen in the Alda tradition, but they can up their game dramatically.

NEUTRINOS continued from page 1

laboration. "Neutrinos have no nationalities."

Giant neutrino detectors could be built within the borders of a country to keep tabs on the reactors of a nearby nation hostile to inspections. Based on the detected neutrino signature, monitors can discern what is happening inside of that nation's reactors.

"If an unfriendly nation is producing plutonium, they will typically run their reactor in a specific cycle," Vagins said. "What we want to really determine is how well we can see this on-off cycle."

Because neutrinos only weakly interact with matter, nonproliferation monitors will need massive water detectors to analyze reactors at long distances. When an antineutrino strikes an atomic nucleus, it emits a tiny flash of light, which propagates through the clear water and can be picked up by sensitive photodetectors. But this is rare, so large volumes of water are needed to see the effect at all.

The prototype the collaboration hopes to complete by 2016 will use a few thousand tons of water spiked with gadolinium to observe reactors a dozen kilometers away. They predict that detectors engaged in nonproliferation monitoring would need about a million tons of water to observe reactors 400 kilometers away.

The collaboration hopes to build the prototype at the Fairport Salt Mine outside of Cleveland, Ohio, once the home to the world's first water neutrino detector.

"The mine is still active. The area used by scientists, the instrumented cavern, has remained unused for many years," Vagins said.

The Perry Nuclear Power Plant 12 kilometers up the road offers the ideal source of nearby reactor neutrinos. The mine also extends under Lake Erie, keeping atmospheric backgrounds to a minimum.

WATCHMAN builds on a series of recent experiments at the San Onofre nuclear power plant in California. There, smaller detectors adjacent to the reactor units proved it was possible to see inside a reactor core from its neutrino emissions.

Though primarily backed by the National Nuclear Security Administration, the collaboration hopes DOE's Office of Science will pick up between about 25 to 45 percent of the roughly $40 million bill.

"If we build a detector of this scale, at a kiloton, you can do science with that," Vagins said. "We don't really have a supernova detector in America, and this would be a very capable one."

The collaboration also hopes to use it for basic particle physics, in particular the hunt for hypothesized sterile neutrinos that do not interact with matter in the usual ways, except gravitationally. So far, administrators from the Office of Science haven't committed any funds, but have expressed some interest in the Watchman science program.

"Right now we're exploring it. Our interest isn't exuberant, but we're certainly looking," said Alan Stone at the Office of Science. "We're looking at all opportunities and looking to see what we can do with limited budgets."

A final decision from the Office of Science will likely come sometime after May when the Particle Physics Project Prioritization Panel (see page 4) delivers its final recommendations for the department's future plans.

The Back Page

International Science Changes the Scientific Discourse

By Esen Ercan Alp

When we think of large-scale international scientific facilities, CERN comes to mind as a prime example. The discovery of the Higgs boson captured the imagination of the general public worldwide. However, this particular success of CERN may overshadow the success and importance of many other national and international large-scale facilities, which are changing the scientific practice and discourse in a fundamental way. Several examples come to mind, including established photon and neutron sources in Europe, and notably the first synchrotron light source in the Middle East, SESAME in Amman, Jordan. Furthermore, many of the national facilities, such as the one I work at in the US, have considerable international participation and collaborations that make them truly international facilities. All have been responsible for big changes in the way scientists work with each other.

Multidimensional in many ways

Research teams that form around these billion-dollar facilities almost always are multinational and multidisciplinary, bringing in their talents, skills and knowledge obtained in different parts of the world. Large accelerator facilities are typically conceived and designed by the users of the previous generation machines. Planning for such facilities involves international collaboration of hundreds of scientists, engineers, representatives of funding agencies, diplomats, and politicians. It takes a decade or two from the original idea to operation, but these projects are almost always very successful, despite initial difficulties. Another common aspect of these facilities is that they exceed the performance of their predecessors by several orders of magnitude in terms of number of photons, neutrons, protons, or ions on the sample, in terms of their frequency range, and in terms of other aspects like spatial and temporal coherence, pulse duration, and polarization.

Several factors play a role in the success or failure of these facilities. Each new generation machine has to be built quickly enough so that there is continuity between the young and the old researchers, and yet late enough to capture substantial technological and theoretical advances that have taken place. There is a need to have a wide and competent scientific user community to invent new techniques and explain the scientific and societal needs for a new generation machine. Along the way, old rivalries, perceived national competition, and the sheer ambition and determination of a few individuals all influence the process.

Reaching consensus about international facilities

The need for new-generation synchrotron radiation and neutron sources has been articulated several times in recent years in scientific case reports [1-4], as well as in national strategy documents [5-6]. However, to reach a consensus about what kind of machine to build, there is an interesting and complex process, which is not always transparent. The facility is going to be defined by the potentially available financial resources, technical competency of the construction team, and the perceived needs of the scientific community that will use the instruments.

"Your effectiveness is not measured by longevity, rank, national origin, or gender, but rather by your merits."

Here, the scientific discourse is quite interesting. The specifications like the electron-beam energy, photon flux, and so forth surely generate heated discussion among representatives of the different fields and different generations of scientists. If this discourse is given sufficient time and proper resources are provided, a healthy mix of parameters emerge, ensuring the future success of the project in terms of its scientific impact and potential reach of the targeted user community. This implies significant research and development funds should be made available to explore the outer boundaries of several key experimental methods and accelerator components, with strong international participation.

Parallel to the specification process, there are the funding struggles. In many countries, multiple agencies and several layers of political figures become an integral part of the funding cycle, which may last for several years. While everybody involved claims to be pulling in the same direction, there are strong counter currents, which are not obvious at the first glance. Competition between different branches of governmental agencies, and between different states and provinces surface at the most critical times which can provide suspense that only rivals major Hollywood thrillers.

Photo courtesy of Esen Ercan Alp

Technical Director Dieter Einfeld (left) and Esen Ercan Alp (right) inside SESAME in Amman, Jordan, 2010.

Different approaches

Two recent examples I have encountered are the Canadian Light Source (CLS) and the synchrotron radiation source in the Middle East, SESAME. The CLS had its origins at a beamline called "The Canadian Synchrotron Radiation Facility (CSRF)" at Synchrotron Radiation Center at the University of Wisconsin-Madison, as well as at a local facility called Saskatchewan Accelerator Laboratory (SAL), in Saskatoon. Through a grass-roots international collaboration, CSRF grew from a single beamline in 1983 on a machine called Tantalus, to a three-beamline complex on a new machine called Aladdin (both closed now). For 22 years (1983-2005), CSRF trained a generation of Canadian scientists that later on laid the groundwork for CLS. This was on the heels of previous work at Stanford in the late 1970s building an Extended X-ray Absorption Fine Structure (EXAFS) station. Combined with the engineering talents of SAL a state of the art facility was to be built in 1999 in Saskatoon.

CLS was partially funded by the Canadian Foundation for Innovation, together with many different provinces of Canada, Western Diversification funds, and corporate contributions. However, not only were the pledged funds inadequate, but the delivery schedule was dependent on the decision-making bodies in each of the provinces. This complex web of funding sources made CLS a household name in many different parts of Canada, but certainly the managers at the time grew a lot of white hair. Today, CLS stands as an excellent example of the perseverance of its founders, as well as Canada's genuine embrace of international participation in management, operations, and supervision.

As for SESAME, the situation was far more "interesting" because the collaborating countries had and continued to have distinctly different foreign policy priorities. To mention the countries of Iran, Israel, Palestine, Turkey, Egypt and Jordan in one breath explains why the characterization "interesting" is an understatement. The ebbs and flows between 1999 and 2013 have left many participants who wanted to have a positive outcome exhausted, and yet SESAME is well and alive today. It is expected to have X-rays produced in 2016 or shortly thereafter. The cooperative spirit of scientists and engineers was communicated to decision makers, diplomats and politicians in each of the respective countries through the efforts of many individuals coming out of the woodwork, whose existence was not obvious at the beginning, and it is a remarkable scene to observe.

Fostering new interactions

However, this is just the beginning. As the facilities are funded and the construction starts, so does a new discourse: formation of research and construction teams, preparation of funding proposals, choice of technology and methods of building the instruments, choice of detectors and software, choice of exact dimensions and location experimental stations, choice between competing optical schemes, choice of vendors from all around the world, and acquisition of necessary help from the central facility in a timely manner. As a participant several times during my career, I now realize that not only is it the most fun part, but also it is the most painful part of scientific research. Friendships are made and lost, and new and unexpected methodologies are introduced to varying degree of success. Then comes the period of "User Science" for about two or three decades. The instruments evolve and change, sometimes completely; the seeds of the new-generation machines are sowed.

There are also benefits to the culture of science. On the experimental floor, the most valuable contributors are the ones who actually know what to do and how to do it. Oftentimes, this may even include graduate students and postdoctoral associates, which makes it truly a democratic process. This fact changes the discourse of scientific research where your effectiveness is not measured by longevity, rank, national origin or gender, but rather by your merits. It creates an interesting and very useful environment for everybody who is genuinely interested in the outcome, and makes scientific research a truly enjoyable experience.

International scientific activities promote understanding and friendship among people from different countries, religions, races, and even peace, as well as science. Scientists trained in these facilities become leaders of their own country after their return. In fact, some the best practices learned in these facilities migrate back to other countries. For example, the Super Photon Ring-8 (SPring-8) facility has adopted an international scientific advisory board, a first in Japan. Facilities like Advanced Photo Source (APS) in the USA, Electron Synchrotron Radiation Facility (ESRF) in France, SPring-8, and Positron-Electron Tandem Ring Accelerator (PETRA III) in Germany hold regular annual meetings to exchange ideas, and develop joint projects.

What I learned from working in a large scientific facility is that one needs a constant flow of well-trained scientists, engineers, and technical support, an engaged scientific user community that has a vested interest in the design and operation of the instruments, and efficient managers who are well versed in the field of practice. Equally important is the public support at the level of local mayors, congressmen, business leaders, and at the national and international levels, support of funding managers and law makers. This cannot be done by only national means. We need strong international participation to sustain these magnificent facilities of discovery and learning.

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