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APS physics

More on the APS April Meeting
See pp. 3 and 4

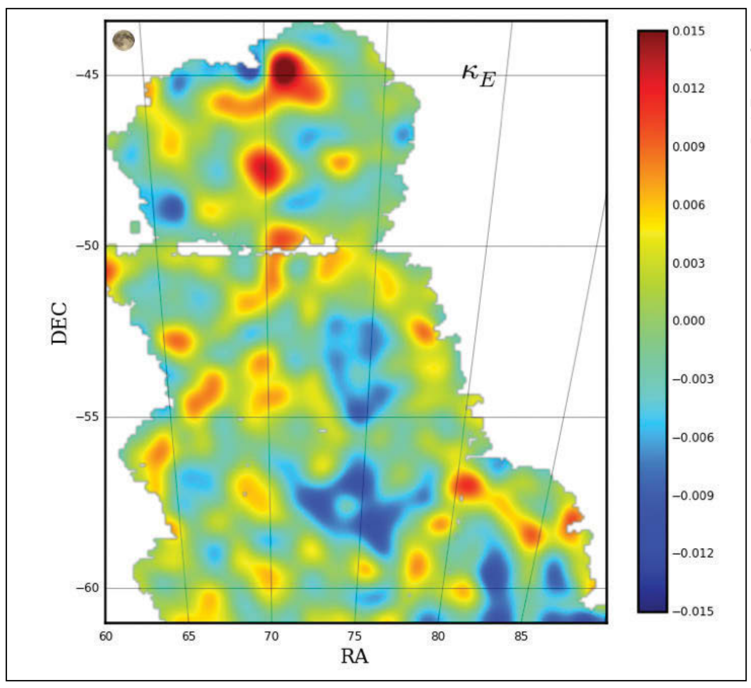
Mapmakers Chart Distribution of Dark Matter

By Michael Lucibella

APS April Meeting 2015, Baltimore — Scientists working on the Dark Energy Survey (DES) released a map of a section of the southern sky charting the location of matter based on its lensing effects on light from distant galaxies. The map, presented at the April Meeting, is the first preliminary analysis of results from the survey, and the first detailed picture of the distribution of matter in the universe out to about seven billion light years.

This new information about the distribution of dark matter complements the findings of existing surveys of luminous matter. "It … [includes] not only the galaxy and stars we know and love, but also the dark matter," said Chihway Chang of the Swiss Federal Institute of Technology.

MAPMAKERS continued on page 7



Map of total (luminous and dark matter) mass distribution produced by the Dark Energy Survey team based on gravitational lensing of light from distant galaxies. Red indicates higher mass densities and blue the lower mass density regions. Size of moon is shown in upper left for comparison with the area of sky mapped.

Nuclear Needles in Cargo Haystacks

By Shannon Palus

APS April Meeting 2015, Baltimore — Every day, some 60,000 ship-borne cargo containers pull into United States ports. Each metal box is about 2.4 m by 2.4 m by 12 m, which is plenty of space to hide a nuclear bomb, says Areg Danagoulian, a nuclear scientist at MIT. In fact, there are bombs that could blow up several city blocks, and could fit in a backpack. Danagoulian asks: "How do we detect something so small?"

At the April Meeting, Danagoulian presented data from a proof-of-concept demonstration that peers into cargo with beams of gamma rays. Within the decade, he hopes, the method will be used at ports to accurately scan cargo at a rate of about two minutes per container. His is just one of the technologies that physicists are developing to prevent the proliferation of nuclear materials, whether through terrorism or war.

It's been decades since school children were advised to "duck and cover" to shield themselves from Cold War atomic bombs. According to the National Academy of Engineering (NAE), preventing nuclear terror is still an important goal, and the NAE put it on the list of 14 Grand Challenges of Engineering to be solved in this century.

"Peaceful energy programs could mutate into weapons programs," says Danagoulian. "You could use a reactor for synthesizing plutonium, and [make] a weapon out of that." Also, weapons can be stolen from existing stockpiles; there are 17,000 warheads in the arsenals of Russia and the U.S.

Today, port inspectors use passive methods to detect nuclear contraband, like looking for radiation coming from a container. That is easy to block with lead if

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PhysTEC Selects Four New Sites to Share $1.2 Million

By Bushraa Khatib

The Physics Teacher Education Coalition (PhysTEC) project has added four newly-funded comprehensive PhysTEC sites and also nine sites that received smaller recruiting grants. Since the project began in 2001, it has funded a total of 46 sites (including the newly-funded sites) to build model physics teacher education programs. Collectively, these institutions have doubled the number of high school physics teachers graduating from their programs.

The four new comprehensive sites selected to develop their physics teacher education programs into national models are Rowan University, Texas State University, West Virginia University, and a joint University of Northern Colorado/Colorado School of Mines project. Funding for the new sites, up to $300,000 per site over three years, will begin in fall 2015.

PhysTEC, the flagship APS education program, aims to improve the education of future physics teachers by creating successful models for physics teacher education programs and disseminating best practices. The PhysTEC program is led by APS, in partnership with the American Association of Physics Teachers, with support from the National Science Foundation and APS donors.

Monica Plisch, Director of PhysTEC and APS Associate Director of Education and Diversity, said, "We were pleased to have received such strong proposals that promise to develop new models for physics teacher education." The nationwide need for physics teachers is acute; only one third of physics teachers have a degree in the field.

In one of first partnerships of its kind, the University of Northern Colorado (UNC), one of the top producers of science educators in Colorado, has teamed up with the Colorado School of Mines (CSM), one of the largest physics undergraduate programs in the country.

Wendy Adams, director of Science Education Programs at UNC, said the PhysTEC grant has already helped leverage institutional support, including a six-year commitment for a full-time Teacher-in-Residence (TIR), one of the key components of successful PhysTEC sites.

Vincent Kuo, director of the Center for Engineering Education at CSM, and a champion for PhysTEC, said that as a science and engineering school, CSM has historically not been involved with producing educators. With this collaboration, the school is uniquely positioned to fill the licensure pool with exceptionally qualified undergraduates.

Texas State University is the first PhysTEC site in Texas and an institution serving Hispanic students. The program aims to produce five physics teachers per

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Particle Physicists Gather to Plan Next Accelerator

By Michael Lucibella

As news broke that the restart of the Large Hadron Collider (LHC) would be delayed, more than 300 physicists, including many of CERN's top scientists and administrators, gathered in Washington, D.C. in late March 2015 to plan for the machine's successor — the Future Circular Collider (FCC), to be built at CERN. This meeting was the second annual design conference for the FCC, and the first held in the United States.

The FCC would surpass the LHC in both size and energy. Though early in the design process, the FCC is envisioned as a 100 TeV circular collider between 80 and 100 km in circumference, compared to the LHC's 27 km ring and 13 TEV energy (after the current upgrade is complete). Such a gargantuan project faces a variety of technical, economic, and political challenges, some likely easily surmountable, others less so.

"I think for the next collider, we should go to the Moon," said Bruce Strauss, a physicist in the U.S. Department of Energy (DOE), using an Apollo-era metaphor. "There are some challenges ahead, but I think we should go."

The current plan is to run the LHC through about 2022. Then a major upgrade, completed by 2025, would turn it into a high-luminosity machine, the HL-LHC, which would support a ten-year science program. FCC would start construction shortly after this program ended.

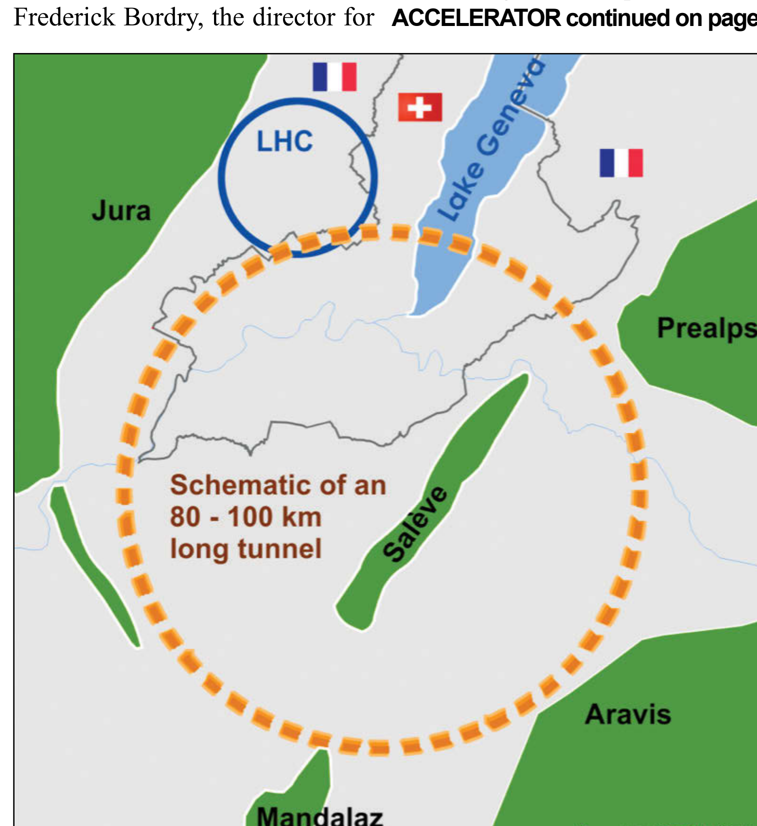
Participants in the meeting, which was organized by IEEE in conjunction with the DOE and CERN, hope to complete the FCC's technical report by about 2018, in time for the next update to the European Strategy for Particle Physics (ESPP) in 2019 or 2020.

"The LHC is the main machine, and now we have people looking at what else can be [built]," said Frederick Bordry, the director for accelerators and technology at CERN.

The final design for the FCC is up against a parallel effort to design the Compact Linear Collider (CLIC). The envisioned 42-kilometer long, 3 TeV electron-positron linear collider would also be located at CERN. Once both designs are completed, CERN administrators will recommend one of the two options when it is time to update the ESPP.

Though the FCC planners at the

ACCELERATOR continued on page 6



LHC and one possible successor (dotted line)

Revised 06/17/2015

Members in the Media

"They wanted to eviscerate the book. … My first thought was, 'This is so ridiculous I won't even respond.'"

***Kenneth W. Ford**, reacting to the Department of Energy's desire to redact portions of his memoirs about working on the hydrogen bomb,* The New York Times, *March 23, 2015.*

"It's beyond our imagination right now."

***Xiang Zhang**, University of California, Berkeley, on the future of new applications for metamaterials,* The New York Times, *March 23, 2015.*

"You know, we've probably got a reasonably good idea of what water is like and what ice is like. But when it gets near a surface, it becomes a different beast, and we don't really understand it at all. … It's quite interesting that even today we're able to come up with new scenarios for water that we haven't previously thought of."

***Alan Soper**, Rutherford Appleton Laboratory, on a new structure of ice found when sandwiched between two layers of graphene,* NPR.org, *March 25, 2015.*

"We were having beers and thinking [about] what could we do that's smaller scale, that we can handle ourselves. And while we were chatting … we were, of course, fiddling with our smart phones, and that's when we realized, 'Hold on a second, these smart phones can actually be used as particle detectors!'"

***Daniel Whiteson**, University of California, Irvine, on designing an app to detect cosmic rays,* NPR.org, *March 27, 2015.*

"There's a lot of science in art."

***Walter Massey**, School of the Art Institute of Chicago, on his efforts to infuse more science into his school's arts programs,* The Chicago Tribune, *March 30, 2015.*

"You'd need the best equipment, and you'd need everything to go right, like landing in the exact right spot, but there's no reason a car couldn't parachute down and keep right on driving."

***Matthew Kleban**, New York University, on the driving physics in the film "Furious 7,"* The Chicago Tribune, *April 4, 2015.*

"This is not built upon trust. … This is built upon hard-nosed requirements in terms of limitations on what they do, at various timescales, and on the access and transparency."

***Ernest Moniz**, U.S. Department of Energy, speaking to Congress about inspection requirements for Iran in the recently-agreed-upon nuclear framework,* The New York Times, *April 6, 2015.*

"If people are learning and changing their behavior, then there must be something that's changing in their brain. … The brain can't be constant. It has to be changing in some way."

***Danielle Bassett**, University of Pennsylvania, on how the brain learns new skills,* The Chicago Tribune, *April 6, 2015.*

"My life story was published recently by Phillip Schewe with the title *Maverick Genius: The Pioneering Odyssey of Freeman Dyson.* I disapproved of his project and gave him no help. To my surprise, when the book appeared, I found out that he had done a good job. I apologized, and we remain friends."

***Freeman Dyson**, Institute for Advanced Study, when asked who he would want to write his life story,* The New York Times, *April 16, 2015.*

"We hope to see many, many more Higgs we can study in detail."

***Ulrich Heintz**, Brown University, on the restart of the LHC,* The New York Times, *April 20, 2015.*

"The ship was partially decontaminated, but some of the fission fragments are expected to be still bound to the ship."

***Kai Vetter**, University of California, Berkeley, on the discovery of the sunken U.S.S. Independence, which was used in early atomic bomb tests,* FoxNews.com, *April 21, 2015.*

"Hubble gave us beauty in a way that no other telescope had ever done."

***John Mather**, NASA Goddard, on the 25th anniversary of the Hubble's launch,* The Washington Post, *April 22, 2015.*

This Month in Physics History

May 5, 1933: *The New York Times* Covers Discovery of Cosmic Radio Waves

Much of the outdoor footage for the 1997 film *Contact* was shot on-site at the Very Large Array observatory in New Mexico. Far more people have heard of the film than of the man for whom that observatory is named: Karl Guthe Jansky, known among astronomers as the father of radio astronomy.

Born in 1905, Jansky was one of six children. His father, Cyril, an electrical engineering professor at the University of Wisconsin, instilled a strong love of physics in his three sons. Karl's older brother, Cyril Jansky Jr., insisted that his younger sibling "was no bookworm," citing his skill at tennis and hockey, and later status as a Monmouth County table tennis champion in New Jersey, as evidence.


Bell Telephone Laboratories

Karl Jansky built an antenna that could be rotated on the wheels of a Model T so that he could track down sources of radio static, inventing radio astronomy in the process.

Karl Jansky earned his degree in physics from the University of Wisconsin, and spent an extra year as a graduate student, although he never completed his thesis. Instead, he joined the research staff of Bell Telephone Laboratories in 1928. He had been diagnosed with chronic kidney disease in college, so Bell Labs was initially reluctant to hire him, but relented when big brother Cyril — an electrical engineer, like his father, and a former Bell Labs staff member who helped build some of the earliest radio transmitters in the U.S. — interceded on his behalf.

Jansky's first assignment was to study intermittent static sources that might be interfering with radio waves used for transatlantic telephone transmissions. It was a challenging assignment; Jansky had to design and build special instruments for that purpose, most notably a large directional antenna system mounted on a motor-driven turntable that rotated through 360° about a central vertical axis, riding on a circular track on the wheels of a Model-T Ford. It was dubbed "Jansky's merry-go-round."

Once he analyzed all that data — collected over many tedious months — Jansky identified three basic types of static: local thunderstorms, distant thunderstorms, and a third he described as being "composed of very steady hiss static the origin of which is not yet known." His careful wording came at the advice of his supervisor, who cautioned him against making over-bold claims, lest his finding not hold up to further investigation. But Jansky suspected that the signal originated in the center of the Milky Way galaxy, making it the first known detection of extraterrestrial radio signals.

His reasoning was simple. He studied that third type of static for over a year, and noted that it rose and fell once a day. At first, Jansky thought this meant it was radiation from the sun. But a few months later the brightest point of the signal moved away from the sun's position. Furthermore, the rise and fall did not repeat exactly every 24 hours, but every 23 hours and 56 minutes — a property of fixed stars and other celestial objects beyond our solar system. The most likely source of the radiation, he concluded, was the center of the Milky Way, where the signal was strongest, in the constellation of Sagittarius.

As Cyril later recalled, "The scientist's problem is to recognize basic facts even though they are obscured by a wealth of extraneous material, and then to apply creative imagination in their interpretation. This Karl Jansky did."

The result was not one, but three published papers, including "Electrical disturbances apparently of extraterrestrial origin," which he presented at a meeting of the International Scientific Radio Union in April 1933. This, in turn, led to a high-profile news story in *The New York Times* on May 5, 1933, trumpeting his discovery, and the University of Wisconsin finally awarded him his master's degree based on the three papers.

Jansky was keen to continue investigating these mysterious cosmic signals and wanted to build a 30-meter dish antenna for that purpose. But Bell Labs was more interested in applied research at the time — the height of the Great Depression. Since Jansky's work showed the hissing static should not be problematic for transatlantic communications, they judged the project complete. Jansky was assigned to other projects. He remained at Bell Labs for the rest of his career, toiling in relative obscurity despite pioneering a new field of science, although he was elected as a fellow of the Institute of Radio Engineers in 1948.

That new field, radio astronomy, didn't emerge overnight. The dire economy and Jansky's lack of professional standing as an astronomer dissuaded various observatories from investing in further research. One key early figure was Grote Reber, who heard of Jansky's discovery and built a radio telescope in his own backyard in 1937, using it to conduct the first systematic survey of cosmic radio waves.

The development of radar during World War II provided a boost to radio astronomy, such that after the war ended, another astronomer named John Kraus was able to start a radio observatory at Ohio State University. Kraus eventually wrote a textbook that became a bible for radio astronomers. By 1964, it was an established field — the year Arno Penzias and Robert Wilson used a giant horn antenna to discover the cosmic microwave background radiation.

Jansky died in 1950 at the age of 44, the result of a massive stroke stemming from his kidney disease. When that first 1933 paper was reprinted in *Proceedings of the IEEE* in 1984, the editors noted that Jansky's work would mostly likely have won a Nobel prize, had the scientist not died so young.

COSMIC RADIO WAVES continued on page 7

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Environmental Physics at the April Meeting

By Michael Lucibella

APS April Meeting 2015, Baltimore — Presenters at the April Meeting highlighted the role that physicists can play in combating climate change. Researchers shared ways to reduce carbon emissions in the developing world, innovate new techniques to harness the sun's energy, and even extract carbon dioxide from the air.

The APS Forum on Physics and Society honored Berkeley physicist Ashok Gadgil for his work improving global health and the environment. One of the projects he spearheaded was the Darfur Stove — a cheap and efficient wood stove first distributed to refugees at camps in Sudan.

He designed the stoves to maximize their energy efficiency, conserving the wood fuel, a scarce resource that is dangerous for people to collect in arid northern Africa. At Lawrence Berkeley National Laboratory, Gadgil and his team designed and tested a $20 sheet-metal stove that could be inexpensively shipped all over the world.

He estimates cooking with the stoves saves two tons of carbon per stove per year compared to the traditional method of heating a pot raised on three stones over a small fire. So far, the nonprofit that manufactures and distributes the stoves, Potential Energy, has dispensed more than 46,000 of them throughout the region and plans to send another 5,000 by the end of the year.

Ari Glezer of the Georgia Institute of Technology is developing a clean, renewable energy source that induces and harnesses the power of desert whirlwinds, colloquially known as dust devils. "Right now dust devils form spontaneously," Glezer said. "The idea here is to create a prescribed number of them."

The dusty vortices start swirling after a layer of warm air forms just above the surface of the sun-baked ground. The layer of air starts to rise, but small disturbances easily produce spinning vortices of warm and cool air.

The assembly expends no energy to create the artificial dust devil. Glezer and his team built a bladed structure that looks like the inside of a water turbine, which directs the rising warm air into a spinning vortex, artificially inducing a dust devil. With a fan attached to a generator at the top, the team has been able to harvest usable electricity from the rising air.

"The vortex can be sustained as long as the thermal stratification can be sustained," Glezer said. "Startup was really not much of a problem."

His team built the first Solar Vortex machine in Atlanta then shipped it to Mesa, Arizona, last summer for the first round of successful field tests in the dry air. They're planning on testing a five-meter-diameter version this August.

The hope is that this kind of electricity generation could be competitive in cost with conventional wind energy. It's also not affected by changing wind speeds and less impacted by clouds than traditional solar energy.

Glezer and his team are also looking to test whether humid air would work in the Solar Vortex. Both the Department of Energy's ARPA-E and the Department of Defense have supported his research, and he hopes to commercialize his work starting in 2016.

ARPA-E is also pursuing other avenues to improve conversion of sunlight to electricity. Howard Branz, the Department of Energy's ARPA-E program director for solar energy, offered some insight into spectrum splitting, possibly the next big game-changer for solar power.

He highlighted the work of a group at Caltech that uses special

ENVIRONMENT continued on page 6

LBL

Ashok Gadgil at Lawrence Berkeley Laboratory designed a stove that improves energy efficiency without changing traditional cooking practices.

Profiles In Versatility

First responders: Getting the bad guys and fighting fires … as physicists

By Alaina G. Levine

As an officer with the University of Arizona Police Department (UAPD), Andrew Lincowski spends most of his days ensuring campus safety by patrolling the streets, responding to calls, and visiting students in their dorms. But in between shifts, he pursues another passion — he is an undergraduate in physics and astronomy and plans to go to graduate school and become a theoretical astrophysicist.

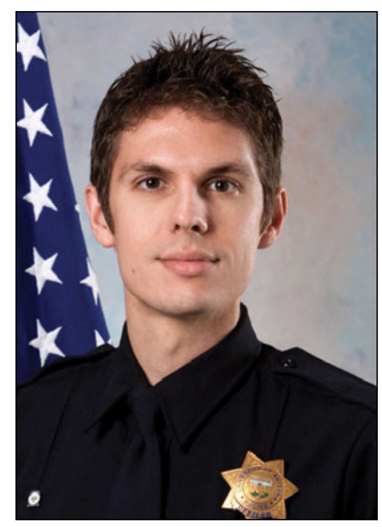
Lincowski traces his love of science back only a few years. "In high school, I really wanted to do physics, but at the time, in my infinite wisdom as a teenager, I couldn't imagine a concrete career," he says. And so, "my science path was initially diverted." He graduated in 2006 with a bachelor's in accounting and immediately began working in the housing market. But when the economic crisis hit, he shifted towards law enforcement, eventually becoming a cop with the Tucson Police Department (TPD). "My goal was to become a detective as quickly as possible," he says, with an eye towards a federal agency such as the IRS, where he could use his accounting skills to investigate financial crimes.

Never a gambling man, as he prepared for the detectives exam, Lincowski also applied to UA as a physics student. The move paid off: "I didn't make detective eligibility, so I went back to school," he says, and he was happier because of it. He stayed with TPD for 4 years before transferring to UAPD.

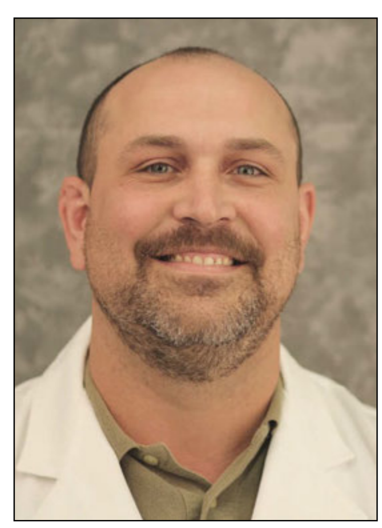
Now a senior, Lincowski is set to graduate in May 2015. He's done quite a bit as a physics student, including completing an internship at NASA's Goddard Space Flight Center, where he contributed to the Haystacks Project, which supports the search for habitable exoplanets by simulating telescopic planetary system images across a wide range of wavelengths. Ultimately, his efforts will improve the development of future telescopes in the search for exoplanets. He also was one of only 16 nationwide recipients of the prestigious John Mather Nobel Scholarship, offered by the National Space Grant Foundation.

Derrick Brown, a firefighter with the city of Savannah, GA, has taken a different path. Although he went to college, "It wasn't for me," he says. He left without graduating and eventually found his way to the Army, where he was deployed several times to the Middle East. When he returned stateside for good, he pondered his next vocational move, and got hooked on the idea of becoming a firefighter. But he knew that if he were ever to move up the ladder and pursue a position in command, he would need a bachelor's degree. "I really wanted to get a degree that's worthwhile that I could use," he says. With the right major, "If I break my leg tomorrow, I would have security."

He originally thought he'd go for engineering, but at the regional college, Armstrong State University, the only related offering was in applied physics. That was fine



Andrew Lincowski



Derrick Brown

with Brown, who immediately became attracted to the discipline. And the more he studied it, the more he relished the many examples of applied physics he saw in action, from understanding the stratification of gases in a burning structure, to knowing how far away from a wall you can place a ladder and not have it slide. "I immediately saw why we did certain things on the job," he says, and as a result it made him a much more perceptive firefighter.

This insight is especially critical as a first responder because, as Brown explains, "No two fires are alike." His education has given him a deep understanding of the physics of fires and the technology used to fight them, which "helps me provide a better argument for taking certain actions" when called to serve.

The experiences of Lincowski and Brown as first responders have also greatly helped them as physics students. Lincowski reports that he has improved his time management and his ability to deal with stressful situations and conflict. "I don't tend to be affected as much by stress," he says. "It's hard to be stressed about deadlines, presentations, or tests when you've been on the street with people who want to kill you."

Lincowski also has honed the skill to focus on facts and ignore preconceptions. "As a police officer, I can go to a call and have to weigh my experience with certain people to know how they'll react," he says. "I have to use that to inform my investigations, but not at the expense of ignoring the current facts of the incident." This extra sense of awareness has helped him as a scientist, although he also adds that he has learned not to "judge things too quickly, because they can change very quickly."

On the other hand, his physics education has also helped him on the force. For example, he has a greater appreciation of technology used by law enforcement, such as TASERs, and he has leveraged his physics familiarity to bolster his ability to solve cases. Early on in his studies, he was taking a mechanics class where the instructor was discussing collisions between moving vehicles. Soon, Lincowski was called to testify in a lawsuit pertaining to a car accident. While up in the witness stand, "I used my physics knowledge to show that the guy had been going over 50 miles per hour in a 25 mph zone," he says. "The lawyer said I had no knowledge of this, but I was able to refute this. … The attorney got flustered, because they were ready to throw that information out. But I had proof and showed them the math. Most police officers can't articulate that." In preparation for the next hearing, he worked out the equations to demonstrate that the defendant had skidded.

Brown, whose fire department also handles emergency response for vehicular collisions or illness, has developed the knack to calm people down quickly and synthesize multiple streams of information in order to make the right decision. And pursuing such a challenging subject has helped him recognize his own innate tenacity, which he never realized he possessed. "I've gotten my feelings hurt. Calculus 2 punched me in the nose and chemical thermodynamics was difficult because I hadn't taken chemistry for a few years," he shares. But "what I've learned from studying physics is not to quit."

As first responders, their flexible schedules have definitely made it easier to pursue physics. Lincowski typically works four 10-hour shifts each week, which leaves him plenty of time to attend courses and present at conferences. However, when he's on duty, his focus is completely on law enforcement. "I can't do homework in the car," he jokes. And although he loves identifying how physics is part of many aspects of his job, "I try not to be 'that guy,' who has a story for everything from class." Brown, who works 24-hour shifts and then has 48 hours off, can

RESPONDERS continued on page 6

Letters

Members may submit letters to letters@aps.org. APS reserves the right to select letters and edit for length and clarity.

Science or Islamic Science?

I have been following the coverage of The International Year of Light 2015 in *APS News* with interest. In particular, Joseph Niemela's article in the February 2015 issue contains a lot of timely information.

The following passage bothers me however: "… IYP 2015 is celebrating 1000 years of Islamic optics, starting with the book of optics written by Ibn al-Haytham during the so-called golden age of Islamic science."

What surprises me are the notions of Islamic optics or Islamic science. Does it mean that there are also Christian optics, or e.g. Orthodox science, and so on.? Are Einstein's discoveries Judaic science? Has Abdus Salam, a person devoted to Islam, to be considered as a part of modern Islamic science?

To my mind science is not and never was about any religion. It is counterproductive and against the international and non-religious spirit of science to attribute its achievements to any faith. Of course, some scientists are religious and their scientific discoveries can be inspired by their faith. But it does not make a scientific discovery attributable to religion.

Miron Ya. Amusia
Jerusalem, Israel

Better Physics Colloquia

Thanks to James Kakalios for his instructive Back Page essay "The Physics of Physics Colloquia" (*APS News*, February 2015) in which he summarized Robert Geroch's 1973 paper "Suggestions for Giving Talks." However, Geroch was not the first to try to upgrade physicists' public speaking skills. More than two decades earlier, Karl Darrow published "How to address the APS" (Darrow, 1951).

In that article, he asked "Does everyone head for the corridors when you rise to read your paper? If so, the Secretary of the Physical Society wishes to have a word with you." Unfortunately, the quality of APS talks did not improve and therefore it was reprinted in *Physics Today* in 1961 and 1981.

After Darrow and Geroch raised the issue, there came "Advice to beginning physics speakers" (Garland, 1991) and "What's wrong with those talks?" (Mermin, 1992).

Richard Hake
Woodland Hills, California

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N. D. Mermin, "What's wrong with those talks?" *Physics Today* **45**, 9 (November 1992).

Nuclear Pasta and Neutron Waffles

APS April Meeting 2015, Baltimore — Neutron stars contain some of the densest matter in the universe, second only to black holes. Astrophysicists say that these compact, Manhattan-sized remnants of stars have a thin, 100-meter crust whose structure resembles different kinds of noodles: strings of protons and neutrons, smashed together like flour and eggs in a pasta press.

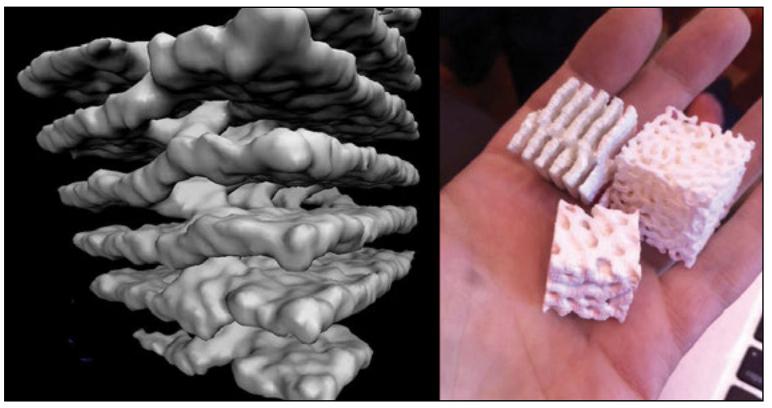
At the April Meeting, graduate student Matt Caplan gave an update on the research conducted in a group led by Charles Horowitz at Indiana University. This team of theoretical physicists uses supercomputer simulations to explore the dense nuclear "pasta" — "the region where things get weird," as Caplan calls it. Though he can't make real neutron star matter here on Earth, Caplan printed out 3-D models of it (see right side of figure).

Caplan and his colleagues recently showed that nuclear pasta has regions where the noodles are disordered. These are sites of electron scattering in the neutron star crust that lower the electrical and thermal conductivity of the star, causing it to remain hotter longer.

Caplan showed off another food-like substance hidden in the neutron star: waffles (see left side of figure), so named for their similarity to the grid-like depressions in the familiar breakfast food. "The waffles are significant because they mark one of the first identifications of a pasta structure outside of what was predicted in the original theory papers on pasta," says Caplan.

The new discovery comes thanks to improved computer power: The

PASTA continued on page 7



Horowitz Group/Indiana University

Neutron waffles and 3D nuclear pasta

The Art and Science of Black Holes

By Shannon Palus

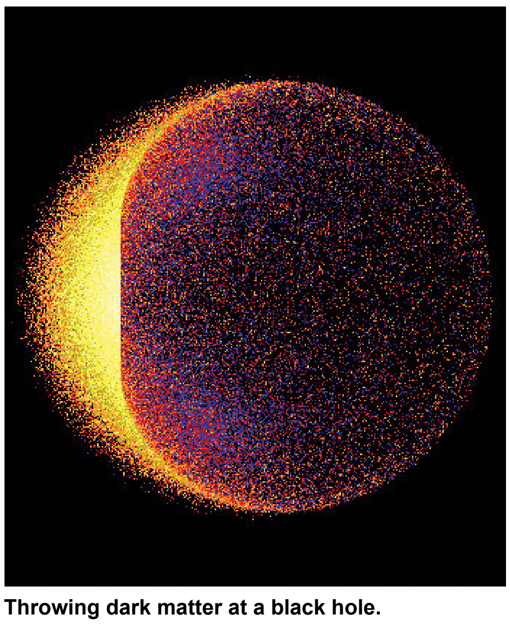
APS April Meeting 2015, Baltimore — This year's April Meeting was swirling with black hole physics. Physicists can catch only an indirect glimpse of these spacetime singularities, so the main tools are computer calculations or observations of how black holes affect nearby matter. Among other findings on offer in Baltimore: supercomputer simulations of dark matter collisions with black holes, new additions to the black hole family tree, and predictions of what mergers between black holes and neutron stars look like. There was even a sound and light art installation produced by filmmakers and physicists at Montana State University showing a projection of matter trapped in a black hole's fatal embrace.

Great escapes

In 1969, before Stephen Hawking developed his idea that black holes could radiate energy, Roger Penrose showed that sometimes when a particle decays into two particles near a black hole, one may fall in and the other may escape. And that escaping particle could have more energy than the original particle.

"In one fell swoop, he showed that you can get something out of a black hole and you can get a free lunch," says Jeremy Schnittman, a physicist at NASA Goddard. But at the limit for the extra energy at about 30% that of the original particle, it isn't very efficient. Or, rather, wasn't. Using a simulation of a black hole — the code is called Panduratoa, named after a species of black orchid — Jeremy Schnittman showed that in some cases, the extra energy can be on the order of 600%.

In the simulations, he threw billions and billions of weakly interacting massive particles (WIMPS are one of the dark matter candidates) at the hypothetical black hole. The black hole acts like an accelerator for the particles, says Schnittman. That's handy, because dark matter particles would not work in a traditional accelerator, as they do not interact with an electric field. Zooming around and into the black hole, sometimes a couple of the particles collide. The smash-up creates gamma rays; some fall in and some escape. Since the particles whip around the black hole in one direction, they light up just one side of the black hole with their energy-efficient glow.



J. Schnittman/NASA

Throwing dark matter at a black hole.

Why so much more efficient? The energies of Schnittman's colliding particles aren't too great in the first place. "All the previous work had looked for those perfect, critical particles that just barely fall into the black hole, so they collide with the maximum possible energy," he explains.

The energies in these so-called Penrose collisions "are not quite as impressive," says Schnittman. But they are greater in terms of efficiency. By way of explanation, Schnittman offers the classic tortoise and the hare moral that "sometimes second best wins!"

The middle child

There are black holes that are a million, or even a billion times more massive than our sun. There are the comparatively small black holes, at a few solar masses. University of Maryland physicist Dheeraj Pasham showed off data from a rare middle-sized black hole that officially clocks in at 400 solar masses

Pasham and his colleagues at NASA Goddard explored hot spots of gas swirling around M2-X1 using six years of archival data from the now-defunct RXTE satellite. By measuring the ratio at which hot spots at different distances from the black hole flash, the team can extrapolate its size. The key, says Pasham, was scaling up a common technique used to measure the nearby — and much brighter — stellar-mass black holes.

The small black holes form when a massive star collapses under its own gravity. But how a supermassive black hole, like the one at the center of our galaxy, forms is

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PHYSTEC continued from page 1

year by the end of the funding period, and plans to engage a TIR to focus on course improvement and community-building activities. The physics department at Texas State University has committed to physics education as a core activity, and recently hired two faculty members who specialize in this area.

John and Gay Stewart, who developed an exemplary PhysTEC site at the University of Arkansas, plan to use the lessons they have learned there to remove institutional barriers to teaching at West Virginia University (WVU). "Our model at the University of Arkansas was always departmental transformation leading to the growth of the undergraduate major, with increased graduation of well-qualified teachers a natural outcome of that growth," said John Stewart, site leader of the WVU PhysTEC project. The project will partner with WVUteach, a brand new UTeach replication effort that has already shortened the licensure path of physics students from six years to four.

Rowan University in New Jersey has a thriving undergraduate physics program with over 150 majors, many of whom are interested in becoming high school teachers, but find it difficult to complete both physics and education majors in four years. Karen Magee-Sauer, PhysTEC site leader at Rowan, said, "Becoming a PhysTEC comprehensive site will help us push for institutional change to eliminate obstacles to certification." Magee-Sauer is also excited that students will have plenty of opportunities to teach throughout their years at Rowan as learning assistants and tutors at both the university and high school level. The program aims to make the Rowan physics department a "teacher-rich" environment, with strong mentors available to help students develop their passion for teaching.

PhysTEC also selected nine sites to receive recruiting grants (up to $30,000 over three years) in order to explore new approaches for increasing the number of new high school physics teachers and engage bachelor's-granting physics departments, which collectively educate over half of all physics teachers in the U.S. While comprehensive sites deal with all aspects of physics teacher preparation, these smaller sites focus on recruiting more future high school physics teachers.

The sites selected for funding beginning in September 2014 include Boise State University; Bowdoin College; East Tennessee State University; Indiana University South Bend; Northwestern Oklahoma State University (a multi-institution site involving four universities in Oklahoma); Salisbury University; Sonoma State University; University of Massachusetts Dartmouth; and University of Wyoming.

These sites will use PhysTEC grants to boost marketing efforts, improve advising, create streamlined pathways to the physics degree/certification, provide financial support, develop early teaching experiences, and fund a part-time TIR.

The author was formerly APS Bridge Program Coordinator. She is now at the Drexel University Autism Institute.

Diversity Corner

New APS Ad Hoc Committee on LGBT Issues Gaining Ground

The new APS ad hoc Committee on LGBT Issues (C-LGBT) is charged with making recommendations to the APS on how to make physics more inclusive for LGBT individuals, and the committee will make a report in early 2016. For a *Physics Today* piece on C-LGBT, go to: scitation.aip.org/content/aip/magazine/physicstoday/article/68/3/10.1063/PT.3.2716

Also, profiles of LGBT physicists are available online at the following URL: scitation.aip.org/content/aip/magazine/physicstoday/news/10.1063/PT.5.9034

M. Hildred Blewett Fellowship: Applications due June 1

APS is now accepting applications for the M. Hildred Blewett Fellowship. This award is intended to enable women to resume physics research careers after an interruption. The deadline to apply is June 1, 2015. For more information and/or to apply, please visit: www.aps.org/programs/women/scholarships/blewett/

Follow Physics Diversity on Twitter

Curious to hear the latest happenings in physics and diversity? Follow @APSDiversity on Twitter.

Sign up to receive the COM/CSWP *Gazette*

The *Gazette* is the newsletter of the APS Committee on the Status of Women in Physics (CSWP) and the Committee on Minorities (COM). It features updates on CSWP and COM activities and programs, book reviews, statistical reports, and articles on programs designed to increase the participation of women and minorities in science. The *Gazette* is distributed free of charge. To add your name to the *Gazette* mailing list, email women@aps.org and include your postal mailing address.

Accepting Nominations for the CSWP Woman Physicist of the Month

The APS Committee on the Status of Women in Physics (CSWP) Woman Physicist of the Month award recognizes female physicists who have an impact on an APS member's life or career, both past and present, and/or who are worthy of recognition. Each CSWP Woman Physicist of the Month is featured on the APS Women in Physics website (www.WomenInPhysics.org), announced in the Gazette, and recognized at a reception at an APS national meeting.

Nomination is easy: Email a three-paragraph statement explaining why the physicist you are nominating is worthy to women@aps.org

APS March Meeting 2015 Kavli Foundation Special Symposium: Frontiers of Light





This year's March Meeting Kavli Symposium featured five speakers on the theme of light, to coincide with the International Year of Light and Light-based Technologies. Clockwise from top left: Stefan Hell, Howard Hess, William Moerner, Margaret Murnane, and Shuji Nakamura. Hell, Moerner, and Nakamura are all 2014 Nobel Laureates. See aps.org/march/ for more.

INSIDE THE Beltway

The White House Budget Bungle

by Michael S. Lubell, APS Director of Public Affairs

The budget game is far from over, but the president booted the ball on opening day, all but assuring his adversaries a victory. Barack Obama may have the intellectual mettle for the highest office in the country, but too often his political instincts don't measure up. The contest over the fiscal year 2016 budget makes that crystal clear.

Three months have passed since the White House released its spending blueprint, blasting apart the spending caps imposed by the 2011 Budget Control Act (BCA). In February, the non-partisan Congressional Budget Office was already forecasting a decline in the federal deficit to $468 billion in fiscal year 2015, dramatically below the high of $1.4 trillion in 2009. And the president argued that it was time to hike spending for both national security and domestic needs that had been accumulating during the last four years.

His budget request contained $74 billion more in expenditures than the BCA allowed, split about evenly between defense and non-defense discretionary accounts. That split, he said, struck the right balance. Contained in the increase, incidentally, was a boost of more than 5 percent for science accounts, almost all of them on the non-defense side of the ledger.

The president has shown a proclivity for exercising executive authority over a variety of contentious issues, but removing the BCA caps was one he knew he could not accomplish unilaterally. Congress needed to pass new legislation. And with Republicans in control of Capitol Hill, he must have known the odds were against it, at least on the non-defense side.

Defense spending is another matter. Except for the small band of isolationists among them, most members of the GOP were clamoring for more military money. Fiscal hawks wanted offsets from non-defense accounts, but others were content simply to find a BCA work-around.

As House and Senate Republicans began to tackle the Budget

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2015 APS General Election

The 2015 APS Nominating Committee is pleased to present an outstanding slate of candidates for this year's annual election. Voting will be open from May 15 through June 30. Those who are elected will begin their terms on January 1, 2016. Information on voting, and the candidates' statements and biographical information, are available at go.aps.org/aps-votes-2015

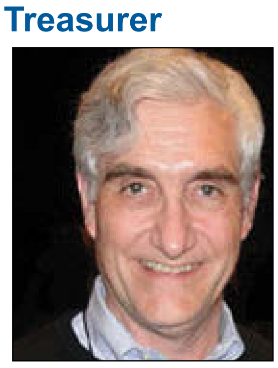
Candidates for Vice President

Roger Falcone
University of California, Berkeley

Lyman Page
Princeton University

Candidates for Treasurer

Thomas Halsey
Exxonmobil



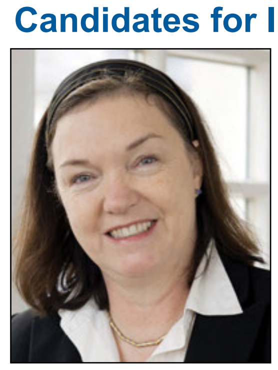
James Hollenhorst
Agilent

Candidates for Chair-Elect Nominating Committee

Deborah Jin
University of Colorado

Robert McKeown
Jefferson Laboratory

Candidates for International Councilor

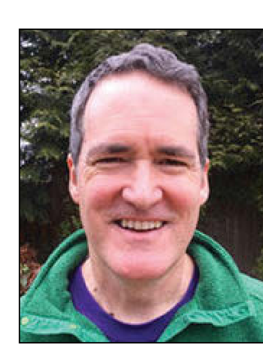


Johanna Stachel
University of Heidelberg, Germany

Joachim Ullrich
Max Planck Institute

Candidates for General Councilor

Bonnie Fleming
Yale University



Brad Marston
Brown University

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the smuggler has any competence, says Danagoulian. Inspectors also use broadband x-ray beams, ranging in photon energy from 1-6 MeV, to gauge the density of the material inside the container. But when used to discern the atomic number, the method is inefficient, and requires a high dose to work.

In Danagoulian's cargo interrogation method — 10 times as efficient as the broadband method — two monochromatic gamma-ray beams, one at 4.4 MeV and one at 15.1 MeV, pass through a container to a detector on the other side. The flux of the 4.4 MeV beam through the container reveals the density of the material; combined with the 15.1 MeV flux, the method also yields information on the atomic number Z.

Danagoulian has completed a proof-of-concept test of the technique with several materials, from aluminum to iron to copper to lead, but not plutonium, which is hard to get, even for a scientist studying how to stop it from spreading. The data clearly show that as Z increases, the number of photons that go through the container decreases.

But his system alone isn't enough to conclusively determine what's inside the container. "If you start mixing materials, you are going to measure the effective Z," says Danagoulian. Adding low-Z materials to a container with plutonium could throw off the system.

One method that might complement gamma-ray inspection is neutron radiography. "Neutron radiography is good at analyzing materials with low Z," says Danagoulian. That includes plastics and organic material. "I see it as a way of augmenting the range of Z reconstruction," he explains.

When it comes to capturing a warhead, or the material for one, "There is no silver bullet," says Danagoulian. Ultimately, he envisions a combination of methods employed at ports, the data from each utilized in a decision-making algorithm. And the methods work for catching more banal contraband, too. Coffee importers smuggling beans to avoid import taxes may not be as threatening of a scenario, but it's one customs agents are more likely to see on a regular basis.

ENVIRONMENT continued from page 3

mirrors to split white light into its constituent wavelength in order to hit photovoltaics optimized for specific wavelengths ranges. He said that this technique might boost a solar cell's efficiency from around 5 percent to 50 percent.

Other teams are taking the idea a step farther. For example, after the sun's visible light is absorbed, the remaining infrared radiation is directed at a thermal collector.

"There's lots of advanced optics going on at ARPA-E," Branz said. "We need the advances for buildings, solar power, dry cleaning, all kinds of things."

For other researchers, generating electricity without producing carbon dioxide isn't enough. Concerned about the ever-increasing amount of greenhouse gases in the atmosphere, Klaus Lackner is developing new membrane materials to remove carbon dioxide from the air. He is working on a device that can theoretically absorb carbon dioxide 1,000 times faster than a tree.

"We want to show that the air capture side can actually scale to a viable size … commensurate with what we need to do," Lackner said. "We can take CO_2 out of the air and bury it."

Last year Lackner founded the Center for Negative Carbon Emissions at Arizona State University, where he and his team have been working on different prototypes to efficiently and economically remove carbon dioxide.

His team has been experimenting with different device designs and anion exchange resins that bond with carbon dioxide. The resins are currently used for water purification, but are ideal for carbon capture because the carbon dioxide can be washed out in ordinary water for sequestration and the resin reused.

The prototype he's been developing uses a truss-like structure resembling chicken wire in order to maximize its surface area. He hopes to get a working prototype on the roof of their building in the near future.

"These things are entirely passive, they can be made out of smaller units and they are entirely mass-producible," Lackner said. "The raw material is very, very cheap."

However, the challenge of scrubbing the atmosphere of excess carbon is formidable. Lackner estimates that it would take 100 million of his full-scale, shipping-container-sized scrubbers to fully offset the amount of carbon dioxide that has built up over the last 200 years.

RESPONDERS continued from page 3

do homework at the stationhouse in between fires, but the climate presents a challenge. "It's like a frat house," he admits with a chuckle. "I have to hide in the bathtub to do my homework."

Lincowski is proud of the contributions he has made as a police officer. He has stymied crime rings that included identity theft and fraud and has locked up suspects on armed robbery and domestic violence charges more than once. Similarly, Brown has aided people and even animals in need. However, these victories are uncommon. "One of the reasons I am leaving law enforcement is that the moments you make a difference are few and far between," says Lincowski. "Most times, people are booked into jail and then are out before I file my report." And yet, "it's nice to make a positive impact," he adds.

Now as they approach graduation, they are both contemplating leaving their posts as first responders. Brown is interested in getting a job with an engineering firm and is currently interviewing and pursuing different career options. He was recently accepted into Medisend International's General Richard B. Myers Veterans Biomedical Equipment Technology Program. Lincowski will head to graduate school in the fall. But one thing is clear with these men: even though they are leaving "the job" behind, it will stay with them always, as will physics. "I'm definitely a different person, studying physics now than if I had done it the first time around," he says. As a police officer, "I see the bigger picture. I want to tie my work into good for the greater society."

Alaina G. Levine is 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.

ACCELERATOR continued from page 1

meeting saw no obvious scientific deal-breakers, there would be a number of engineering challenges to overcome. The biggest will be designing magnets sufficiently powerful for the giant particle accelerator's storage ring.

The dipole and quadrupole magnets that would direct and focus the 100 TeV particle beams will need to be significantly more powerful than any built so far. Researchers estimate that the magnets will have to produce 20-tesla magnetic fields to contain and control the beam. Currently, LHC magnets produce about 8 tesla, while Fermilab has built 11-tesla prototypes. Designs for the HL-LHC call for 16-tesla magnets.

Another significant technological challenge is containing the synchrotron radiation emitted by the particle beam as it circles the outer storage ring. The LHC currently produces a relatively negligible seven kilowatts of radiation, while the FCC would generate about five megawatts of radiation, enough to potentially wreak havoc on its sensitive cryogenics, electronics, and other equipment.

Because they make up the majority of the machine, the magnets and their raw materials would also be the project's biggest cost-driver. Based on the size of the accelerator, it's estimated that at least 6,000 metric tons of superconducting niobium-tin would be needed to build the requisite magnets.

"The present cost of niobium-3 tin is a … [deal-breaker], " said Ezio Todesco, a researcher at CERN. He added that to be practicable, the cost would have to drop to about $800 a kilogram, down from the current $1600 a kilogram price tag. Though he said that manufacturers he spoke to are willing to take on the challenge, "We are still very far from this."

Surprisingly, computing power to track the vast numbers of particles produced in collisions was also highlighted as a potential concern. Microprocessors have continuously become smaller and cheaper over the years, but that trend may not continue.

"Extrapolating computer technology 20 years into the future is non-obvious," said Ian Bird, the computing grid project leader at CERN. "We're close to the physical limits for feature size."

On the flip side, as long as computer power progresses, detector technology is generally expected to keep up with the needs of the particle physics community.

"Much detector technology is driven by silicon technology and computing power, so we can count on significant improvements," said Werner Riegler, chair of the technical board of the LHC's ALICE detector.

Making the science case for building the machine is also a top priority, but complicated by the discovery of the Higgs boson in 2012. There are no more obvious holes left in the standard model to fill in, though mysteries persist about the nature of dark matter and supersymmetry.

"The first goal is the complete exploration of the Higgs boson and its dynamics," said Michelangelo Mangano, a theoretical physicist at CERN. "Dark matter remains a crucial element in the search."

But without a clear next step, persuading funders that this next-generation machine is necessary could be difficult.

"I'm not convinced we can actually make it make sense to the people who actually pay the bills … unless we have some really compelling arguments," said James Siegrist, the associate director of the Office of High Energy Physics at the DOE.

The role of the U.S. in the project is uncertain, in part because the timing of the study is awkward for the high energy physics community. Two years ago, before the FCC project geared up, the leadership of this community came together for a field-wide meeting to help develop a broad, ten-year roadmap for future high energy physics projects. The 2013 meeting, known as Snowmass on the Mississippi, played a major role in informing the final report of the DOE's subsequent Particle Physics Project Prioritization Panel, which laid out the agency's official ten-year strategic plan.

"I don't think at Snowmass [the FCC] was thoroughly assessed," Siegrist said. "From an agency perspective, we don't really know what the U.S. community thinks about this."

He added that the consensus that emerged out of the 2013 meeting was to put the heft of U.S. research behind developing technologies for the proposed International Linear Collider and the HL-LHC.

"The HL-LHC is the highest priority in the near term," Siegrist said. "We can't have everybody run off to work on the FCC while we're still not finished with the high-luminosity LHC."

The LHC Accelerator Research Program (LARP) is the main U.S. collaboration with CERN to advance accelerator technologies. Right now, the program is geared entirely towards developing magnets for the HL-LHC.

"In terms of direct studies, [FCC] is not something I can directly invest in," said Giorgio Apollinari, the LARP director at Fermilab. "I would love to be able to help but the mandate is what it is."

American scientists have a lot of experience to draw on. The United States was almost always pushing the cutting edge of accelerator technology until the cancelation of the Superconducting Supercollider in 1993. Even after accelerator dominance was ceded to Europe, U.S. researchers put together a major theoretical study in 2003 for a 240-kilometer "Very Large Hadron Collider" at Fermilab.

"The U.S. has a lot to contribute," said Michael Syphers of Michigan State University. "The U.S. has 25 years in running a 2 TeV collider, and 10 years designing and partially constructing a 40 TeV collider."

Throughout the conference, the ghost of the SSC seemed to loom over much of the proceedings. Presenters made frequent references to a variety of lessons learned from the aborted project.

"Had we gone down that route, we could have had the Higgs a decade ago," said Rep. Bill Foster (D-Ill.), who opened the conference. He was an accelerator physicist at Fermilab before running for Congress, and worked on some components of the SSC. "[Europe] got the project and we didn't, so doing the politics right is important."

One of the biggest lessons he said he drew from the failure was the need to bring in a broad coalition of regions into the project, either across U.S. states or countries around the world. "You need a balance of effort going from region to region, and you need a balance of money going from region to region," Foster said.

Though the LHC experiments and detectors are international projects, involving collaborations with dozens of nations around the world, the accelerator itself was a European-funded and built machine.

"Everyone is convinced that the next machine is a world-wide machine," Bordry said.

ANNOUNCEMENTS

Convey the excitement of Laser Science to undergraduates by bringing distinguished scientists to colleges and universities!

Distinguished Traveling Lecturer (DTL) Program in LASER SCIENCE

The Division of Laser Sciences (DLS) of the American Physical Society announces its lecture program in Laser Science, and invites applications from schools to host a lecturer in 2015/2016.

Lecturers will

- Visit selected academic institutions for two days, during which time they will give a public lecture open to the entire academic community
- Meet informally with students and faculty
- They may also give guest lectures in classes related to Laser Science

The DLS will cover the travel expenses and honorarium of the lecturer. The host institution will be responsible for only the local expenses of the lecturer and for advertising the public lecture. Awards to host institutions will be made by the selection committee after consulting with the lecturers. **Priority will be given to those predominantly undergraduate institutions that do not have extensive resources for similar programs.**

2015/2016 LECTURERS:

Laurie Butler
University of Chicago

Hui Cao
Yale University

Jim Kafka
Spectra Physics

Wayne Knox
University of Rochester

Christopher Monroe
University of Maryland

Luis A. Orozco
University of Maryland

Carlos Stroud
University of Rochester

Ron Walsworth
Harvard University

Linda Young
Argonne National Lab

Applications should be sent to:

DTL committee
Chair: Rainer Grobe (grobe@ilstu.edu) and to the DLS Secretary-Treasurer Joseph W. Haus (jwhaus@udayton.edu).

Deadline for application for visits in Fall 2015 is May 30.

Detailed information about the program and the application procedure is available on the DLS-DTL home page:
physics.sdsu.edu/~anderson/DTL/

Reviews of Modern Physics

Colloquium: Majorana fermions in nuclear, particle, and solid-state physics

Steven R. Elliott and Marcel Franz

In nature one can associate to each particle an antiparticle with equal mass and opposite charge: to the electron there is the positron, to the proton there is an antiproton, etc. When they meet particles and antiparticles annihilate each other producing light in the process. Majorana fermions are particles with an identity crisis: they are their own antiparticles and hence they self-annihilate. Although they have been theoretically predicted to exist, they are recondite and only recently traces were found of their existence. In this Colloquium the nature of Majorana particles and their presence in several different branches of physics is discussed from nuclear to condensed matter.

DOI: dx.doi.org/10.1103/RevModPhys.87.137

journals.aps.org/rmp

Corrections: The interview with Alan Alda in the March 2015 issue failed to mention that he was nominated for fellowship by the APS Forum on Outreach and Engaging the Public. Also, in the April 2015 issue, the caption in the page 1 article "APS March Meeting: Know When to Fold 'Em" incorrectly attributed the toggle switches to the Wyss Institute. The work was done at Cornell and the University of Massachusetts Amherst.

BUDGET continued from page 5

Resolution that would determine overall spending, it became clear that the work-around would carry the day. The instrument they settled on was an account called Overseas Contingency Operations (OCO), which is not subject to BCA caps.

Using that mechanism, both chambers added about the same amount of new money for defense the president had called for in his February budget request. And with military needs taken care of, congressional Republicans refused to consider legislation that would rewrite the BCA. Non-defense discretionary programs would simply remain subject to the law's spending limit.

So as the appropriations process rolls forward, Congress is poised to give the president half a loaf without having to lift a negotiating finger. It's hard to see how he can reject the very defense spending he called for. And it's also hard to see how he can achieve the non-defense spending he sought. The opening day budget error has left him with precious few bargaining chips.

Consider where he might be today if had he focused his February request solely on non-defense spending increases. He could begin bargaining with defense hawks by threatening to veto military increases, unless they agreed to a deal that would add money to non-defense discretionary programs. By so doing, he eventually might be able to arrive at the spending balance he asserted was right for the country.

I respect Barack Obama's intellect, integrity, and sincerity, but succeeding in the often-brutal world of today's Washington requires far more. Politics is the art of recognizing what is possible and then using effective bargaining skills to achieve the end you want. Starting at the end and trying to convince people you're right and they're wrong is usually a losing strategy – even when you are right and they are wrong.

Logic and evidence might carry the day in science and law, but in politics persuasive argument, alone, will not suffice. Compromise, horse-trading, and an occasional threat of retribution are additional essential ingredients for success.

The president's budget bungle is a *fait accompli*, and all the kvetching in the world can't change it. We'll just have to live with the consequences: increased military spending and, in all likelihood, a series of continuing resolutions (CR) for almost everything else. Of course before we get to the CRs we'll have to weather threats of vetoes, actual vetoes, threats of government shutdowns, and more lollygagging than we can stomach.

But, hey, this is Washington. By now we should be used to it. A decade ago, sausage-making was an apt though distasteful metaphor for legislating. Today all that remains of the sausage is a rancid odor.

HOLES continued from page 4

still a bit of a mystery. It may be that material is falling onto medium black holes. These, in turn, could result from mergers of stars in a dense star cluster, says Pasham. A mega star could quickly collapse into a black hole, so further study of the rare middle-sized object could reveal if that's the case.

Two to tango

Short gamma ray bursts — less than two seconds— are thought to come from a spinning black hole in a magnetized gaseous disk, with twin jets of matter emanating from its sides. In the outer regions of the cloud, gamma rays and electromagnetic afterglows — X-rays, visible light, radio waves — are born.

The thinking goes that these jets are created from the magnetic field that arises from a neutron star orbiting a black hole, eventually being sucked in and swallowed up. But, "no computer simulations based on the laws of general relativity and magnetohydrodynamics have been able to form a jet [after] the neutron star merger with the black hole," says Stuart Shapiro from the University of Illinois.

But Shapiro's colleague, Princeton physicist Vasileios Paschalidis, found a way. "All the simulations have assumed that the magnetic filed was confined to the interior," says Shapiro. So Paschalidis allowed the magnetic field to extend to the exterior of the doomed star.

In his computer rendition, which he ran with the help of Milton Ruiz of the University of Illinois, the star and black hole fall closer together, and the black hole distorts the field and the star; the star forms a tail, and eventually a disk of magnetized matter around the black hole, with funnels jetting matter outward. "The magnetic field lines are wound up tighter and tighter. As time goes on, a funnel forms near the poles." And then, the gamma-ray-spitting jet forms.

Fittingly, the time it takes the neutron star disk to be eaten by the black hole is about half a second. "This source lives for about as long as we see a gamma ray burst," explains Shapiro.

MAPMAKERS continued from page 1

The map covers less than one percent of the total sky, but by the end of the five-year survey, the team hopes to have maps covering about a quarter of the southern sky. "The patch of sky is more than 20 times the size of the full moon across, which is a pretty substantial chunk of the universe," Chang explained.

To create this map, the DES team observed about two million distant galaxies to find out how their shapes are distorted by the mass of both nearer galaxies and dark matter. Then the team analyzed these distorted shapes to assemble the map.

"This distortion information in fact tells us how the matter is distributed in front of us," Chang said. "In most cases, galaxies don't get bent that much, they only get slightly distorted because there is some form of foreground matter in front of … [them]."

Ultimately, the team wants to use these maps of dark matter to probe how the universe's accelerated expansion, driven by dark energy, affected the structure of galaxies and galaxy clusters as they formed. Structures are formed by gravitational coalescence of matter, so accelerated expansion of the universe slows that process of formation.

"There are very well-defined ways that we can use such maps to calculate, as a function of time, to what extent … dark energy has slowed the expansion of structure," said Bhuvnesh Jain of the University of Pennsylvania. "So to see that structure, we need to see the dark matter, for which we use lensing."

The blue and red spots on the otherwise green map represent areas of greater or less lensing. Using other optical data, the researchers overlaid known galaxies to highlight areas that appeared to have more or less concentrations of dark matter than expected.

The team is now in its second year of collecting data from the 4-meter Victor M. Blanco Telescope at the Cerro Tololo Inter-American Observatory in Chile.

"With this data and other data that we have in hand, we'll be able to make a very impressive catalogue … because we're going out much further than other studies of superclusters have gone," Jain said.

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specific structure of the pasta depends on the temperature, density, and the number of protons. Varying these parameters revealed the waffles. (Add more protons, and the waffles turn to lasagna.)

The Horowitz team is now trying to learn if the crust can support pasta mountains. On a neutron star, a mountain the size of a coffee cup would have the mass of Mount Everest. That means a spinning lumpy neutron star could be a very energetic source of gravitational waves.

COSMIC RADIO WAVES continued from page 2

Today the "jansky" is the unit of measurement for radio wave intensity (flux density). A crater on the moon is named after him, and there is now a monument in his honor at the New Jersey site of his pivotal experiment. And of course there is the Very Large Array.

References

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The Back Page

A Big Tent for Soft Matter

Jesse L. Silverberg

Starting at the top and going clockwise are images representing many diverse areas of research in soft matter: (1) Simulated colloidal gel consisting of 750,000 attractive hard spheres. [Source: R. N. Zia, B. J. Landrum, W. B. Russel, J. Rheol. 58, 1121 (2014)]; (2) Mechanical properties of polymer fibers are measured with minimally invasive tetrapod quantum dots. [Source: S. N. Raja et al., Nano Lett. 13, 3915 (2013)]; (3) High-performance computing is used to investigate properties of lipid membranes. [Source: R. W. Pastor, R. M. Venable, S. E. Feller, Acc. Chem. Res. 35, 438 (2002)] (4) Low energy electron microscopy image Pb self-assembly on a Pb/Cu surface alloy. [Source: Sandia National Laboratory]; (5) Air-stable water droplet networks on a superhydrophobic surface. [Source: J. B. Boreyko et al. PNAS 111, 7588 (2014)]; (6) Vortex avalanche in disordered packings. [Source: http://cnls.lanl.gov/~olson/images.html]; (7) Simulations of nanoscale mechanisms for stress corrosion and cracking in a wet environment. [Source: ANL/James Kermode, King's College London] (8) Flock of Auklets flying off Kasatochi before 2008 eruption. [Source: Vernon Byrd, U.S. Fish and Wildlife Service]; (9) Micrograph of nano-iron emulsion with applications in environmental remediation. [Source: NASA]; (10) Mouse fetal heart fibroblast cells used in studies of stem cell-based tissue repair. [Source: Jesus Isaac Luna, Kara McCloskey lab, University of California, Merced]

It was my first APS March Meeting and I was invited to join a group of soft matter physicists from the University of Chicago for dinner. At the restaurant, I ended up in the last open seat and while waiting to order, chatted with some friends from the previous summer's soft matter workshop hosted by the University of Massachusetts Amherst physics department. Working my way through the conversations, I eventually turned to my right and saw an unfamiliar face. He was older, grayer, sporting coke-bottle glasses, and seemed to have an open air about him. Smiling, I introduced myself with,

Hi. I'm Jesse Silverberg. I'm a second-year graduate student in Itai Cohen's lab at Cornell.Who are you?

His smile turned to a look of amused stoicism as my question sank in. He responded in a voice loud enough to be heard from across the table and stern enough to attract attention from those nearby,

You don't *KNOW* who I am??

Either I wasn't thinking straight, or just felt goaded on by the question. Regardless, I gave an overly honest response:

No. *SHOULD* I?

The older gentleman grinned at my complete failure of diplomacy and through a full-bellied laugh, managed to get out,

Oh boy! *YOU'RE* in trouble!!

We were both laughing at this point, and the conversation continued from there. This is how I met Heinrich Jaeger, long-time professor at the University of Chicago's James Franck Institute, leader in the field of granular physics, and, as it turned out, the person who bought dinner for everyone that night.

This story illustrates two points: First, the field of soft matter physics is full of fun, animated, and quirky personalities, a definite plus for anyone who enjoys such company. Second — and from anecdotal evidence, I think this applies broadly to our field — I didn't know I wanted to be a soft matter physicist until I was already a soft matter physicist. After all, if I had known anything about the field before joining, I wouldn't have asked such an ignorant question! Now that APS is home to GSOFT (aps.org/units/gsoft), the topical group on soft matter physics, I think this second point deserves a bit more attention. Why? Well, I noticed over the course of my Ph.D. and into my postdoc that despite being an intellectually rich field of research, many physicists don't actually know what soft matter is, what it isn't, and how it relates to some of the more established branches of physics. Though I found my way into the field by a combination of coincidence and luck, a broader awareness has to be raised so future generations of bright and talented physics students can find their way too.

With this idealistic vision in mind, I'll confess that in preparing this article, I was warned that any attempt to concretely define soft matter would likely be met with failure. The boundaries are nebulous, topics diverse, and the practitioners widely distributed across academic departments. All of this is true, but nevertheless, there is a clear community with a common language. Because of this reality, I've come to view soft matter as less of a walled city built around specific questions, and more of a big tent party that encompasses diverse views and paths of inquiry. Along these lines, I've heard stories of young soft matter physicists introducing themselves to colleagues in high energy physics, cosmology, and even hard condensed matter, where a typical conversation often goes something like this:

Oh, you're in soft matter? Isn't that just biophysics?

Or,

Oh, you're in soft matter? Isn't that just polymer physics?

Soft matter is neither biophysics nor polymer physics, though these research topics can and do come under "the tent." A list describing this scientific coalition based on several leading conferences identifies some major hubs of activity:

- **Active and driven matter** explores systems of particles that interact with each other while consuming energy. This is a valuable test bed for studying collective dynamics in nonequilibrium systems ranging from vibrated grains of sand to motile bacteria and animal flocks.
- **Biological soft matter** probes the mechanical properties of hierarchically organized biological materials from cytoskeletal networks to entire organs. Coarse graining across length-scales is extremely useful as it offers insights for structured and functional materials.
- **Colloids** are a mainstay of the soft matter community. The ability to image and track these micron-sized particles in experiments enables direct tests of fundamental thermodynamics, phase transitions, self-assembly, and suspension rheology. Moreover, they have numerous real-world applications including flexible electronics and drug delivery.
- **Dynamics of structured and complex fluids** is a subject similarly at the roots of the soft matter. These solid-liquid, solid-gas, liquid-gas, and liquid-liquid suspensions, to name just a few, exhibit unusual flow behavior that can be attributed to microscopic internal structure.
- **Fracture and failure** have become topics of broader interest for their role in phenomenology beyond linearized continuum theories. For example, fracture depends critically on the concentration of energy in materials, and hence non-equilibrium microscopic dynamics. Failure, on the other hand, has more to do with mechanical instabilities — buckling, wrinkling, and snapping — that are widely utilized in biological pattern formation.
- **Membranes, vesicles, and droplets** are relevant to problems in biophysics where regulated flow of molecules between the external environment and internal cellular machinery are critical for survival. More broadly, understanding both how confined fluids fluctuate, deform, and pinch, as well as the consequences of these structural changes, still holds unsolved questions.
- **Packing, geometry, and topolog**y covers not a specific material system, but a broad set of organizational principles. Jamming in granular systems, arrangement of colloids on spheres, topological defects in liquid crystals, and finite deformations of linkage structures are just some of the problems that benefit from these deeper mathematical ideas.
- **Polymers**, like colloids, are at the heart of soft matter. Recognized with the 1991 Nobel Prize in Physics awarded to Pierre-Gilles de Gennes, this topic builds on an understanding of statistical mechanics and chemistry to explain mechanical properties. Remarkably, even Feynman diagrams have been introduced to polymer theory to help understand the multitude of interactions governing these systems.
- **Self-assembly** describes the processes by which individual units come together to form organized structures. Whether mediated by individual particle interactions or globally applied external fields, the principles of self-assembly can be found widely across soft matter.
- **Surfaces and interfaces** can be found whenever two phases come into contact. As with hard condensed matter, the physics of systems under confinement reveals dimensionally-dependent scaling laws and nontrivial modifications to existing theories. Self-assembly, colloidal chemistry, diffusion, and biophysical problems all stand to learn from these studies.

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A useful way to think of soft matter is as an amalgamation of methods and concepts that, within the standard university organizational structure, are spread across physics, chemistry, engineering, biology, materials, and mathematics departments (see figure). The problems that soft matter then examines are the interdisciplinary offspring that emerge from these otherwise distinct fields. Remarkably, the frontiers of soft matter are flowering at both ends in physics departments across the world: Fundamental physics has found a fresh avenue to look for "new $\hbar = 0$ physics," in strongly-interacting and non-equilibrium systems, while applied physics is forging new connections to industry and other branches of science. In fact, some of the most exciting work is coming from the most extreme fringes, where research questions struggle to fit into even the diverse range of topics described above. It seems, therefore, that for the foreseeable future the "big tent" of soft matter will continue to get bigger.

I stated above that I didn't know I wanted to be a soft matter physicist until I already was one. Largely, this is because I didn't know what soft matter was or what it involved before starting my graduate research. As a young postdoc with limited perspective, it's still premature of me to make statements about what I'll be doing 5, 10, or 15 years from now. However, I do know this: I'm excited. The future looks bright. And now that GSOFT established a home for soft matter within APS, it'll be exciting to see how the community continues to grow.

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