APS NEWS

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In Memoriam Peter Adams
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2016 APS General Election

Voting will be open from June 20 to July 29, so watch for an email with information on voting procedures. Those who are elected will begin their terms on January 1, 2017. Information on voting, and the candidates' statements and biographical information, are available at http://go.aps.org/aps-vote-2016

Vice President

David Gross, ***University of California, Santa Barbara***

"I have been a member of the APS for over 50 years and have benefited from its journals, its meetings and its role as the premier physics society in the advocacy of Physics. As Vice-President I would seek to continue and strengthen the role of the society in serving the community of physicists, informing the public and encouraging public support for science."

David A. Weitz, ***Harvard University***

"My goal in this position will be to work tirelessly for, and with, the members of our Society … . Research budgets are destined to remain approximately flat for the foreseeable future. Nevertheless, we must work to convince our political leaders of the value of our work."

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Edward Bouchet Continues to Inspire

By Gabriel Popkin

At a time when hardly anyone made a career in science, Edward Alexander Bouchet made history by doing so. In 1876, he became the first African-American and the sixth person of any race to earn a physics Ph.D. in the Western Hemisphere, and went on to have a four-decade science teaching career. Today, Bouchet is probably more prominent than ever. His name graces a growing number of honors, including the annual Edward A. Bouchet Award that APS established in 1994, and the Bouchet Leadership Award Medals given by Yale University, where Bouchet received his Ph.D.

The selection of Florida Agricultural and Mechanical University emeritus physics professor Joseph A. Johnson III for one of Yale's 2016 Bouchet Medals has special resonance with the honor's namesake. Johnson also earned his Ph.D. from Yale, in 1965, and went on to do pioneering fluid dynamics research in both academia and industry, as well as work to increase the representation of minorities in the sciences. He is an APS fellow and the 1995 recipient of the APS Bouchet Award, which he helped establish. Johnson received his medal at the Annual Yale Bouchet Conference on Diversity and Graduate Education held at Yale in early April, where he proposed a "new Bouchet epoch" combining recent advances in scientific discovery with progress in diversifying science.

The Bouchet revival has been gathering momentum for almost 30 years. It started with the 1988 founding of the Edward A. Bouchet International Center for Theoretical Physics (now the

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Careers Report

Serving the Next Generation of Physicists at APS Meetings

By Crystal Bailey, APS Careers Program Manager

According to the AIP Statistical Research Center, less than a quarter of physics Ph.D. graduates will end up in permanent faculty jobs (1). And even though many well intentioned mentors would like to prepare their students for eventual careers outside of academia, many do not have networks or experience to do so, especially for careers in the private sector.

In bringing together so many physicists across all subfields and sectors, APS meetings present a great opportunity to bridge that gap. Students often have questions about private-sector careers, such as how the culture differs from that in academia, what kinds of problems physicists are working on, and what extra preparation they might need to do well. APS provides an opportunity for students to get answers to these questions through informal Q&A panels with industry physicists at our annual and division meetings.

For example, the 2016 APS March Meeting included a special panel focused on careers in industry, "Meet Your Future: An Interactive Session on Industrial Careers for Physicists," at which several physicists from industry answered questions. At this session Barbara Jones, current chair

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Crystal Bailey

APS job fairs help students explore a variety of career options.

Kavli Session Celebrates Neutrino Physics

By David Voss

2016 APS April Meeting — This year's Fred Kavli Keynote Session at the APS April Meeting in Salt Lake City featured two Nobel laureates and a retrospective on the life of a physicist who many feel would have shared the prize had he been alive. The occasion was the 60th anniversary of the first detection of neutrinos by Clyde Cowan and Frederick Reines. Speakers Arthur McDonald and Takaaki Kajita, who shared the 2015 Nobel Prize in Physics for the observation of oscillation of neutrino types (called flavors), were joined by astrophysicist Neta Bahcall, who discussed the life and work of her husband John Bahcall.

After an introduction by 2016 APS President Homer Neal, Arthur McDonald, professor emeritus at Queen's College in Kingston, Ontario, took the audience on a journey to the Sudbury Neutrino Observatory, where he led one of the teams that showed neutrinos changing from one flavor to another. He started by mentioning the observation by Cowan and Reines of antineutrinos from the nuclear reactor at the Savannah River power plant in South Carolina in 1956, but the neutrino oscillation story really starts with measurements of solar neutrinos from the sun led by Ray Davis in the late 1960s. The solar neutrino flux measured was three times lower than what John Bahcall had predicted.

The solar neutrino problem

McDonald explained that one of the ideas proposed to resolve this neutrino deficit was to assume that

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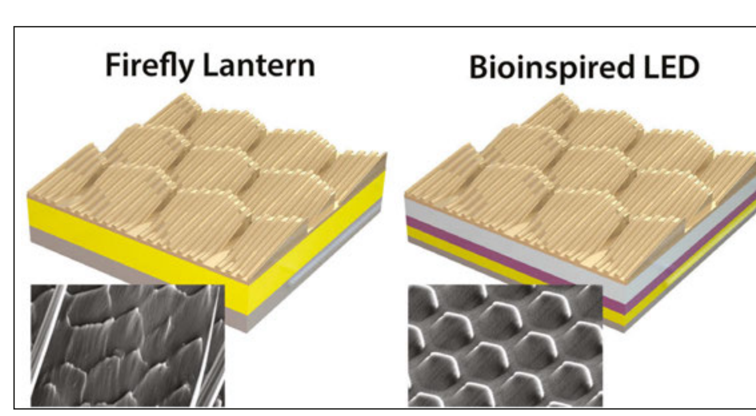
Research News: Editors' Choice

A Monthly Recap of Papers Selected by the Physics Editors

Shine Bright Like a Firefly

Taking inspiration from fireflies, scientists have fabricated an organic light-emitting diode (OLED) with a complex surface pattern that improves the output efficiency by 61% compared to a smooth surface. Fireflies signal to potential mates by emitting light from a photogenic region on their abdomens, the most efficient bioluminescent organ known. This organ has a specially patterned outer shell, or cuticle, with micrometer-scale tile-like features, as well as nanosized linear ridges. These surface structures help light escape from the cuticle to the air. While previous work focused on a single type of cuticle structure, Jeong *et al.* (*Nano Letters* 16, 2994) have investigated the hierarchical combination of micro- and nanostructures. They imaged the cuticles of male fireflies (*Pyrocoelia rufa*) and showed that the hierarchical structure reduced internal reflection. The team reproduced the firefly cuticle pattern in a UV resin that they placed on top of an OLED.



Masse et al. Nano Letters 16, 2994 (2016)

Fireflies have a patterned light-emitting region (left) that can be copied in light-emitting diodes to improve efficiency.

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Revised 06/28/16

Members in the Media

"If this is really true, then it would possibly be the most exciting thing that I have seen in particle physics in my career — more exciting than the discovery of the Higgs itself."
***Csaba Csaki**, Cornell University,* New York Times, *May 2, 2016, on the mysterious 750 GeV signal seen at CERN.*

"It's taken as an insult if a physicist is considered too philosophical. Most physicists think that philosophers just sit in their armchairs and think. Physicists are very down-to-earth, empirical people. They don't want to think hard about what it all means or where it all comes from."
***Sean Carroll**, Caltech,* Boston Globe, *May 6, 2016, in discussing his new book "The Big Picture."*

"Next Gen … is the first [set of] science standards that I'm aware of where scientists actually had an input in designing the standards."
***S. James Gates**, University of Maryland,* U.S. News and World Report, *May 2, 2016.*

"Physics isn't what I do; it is what I am."
***Walter Kohn**, Harvard University,* Los Angeles Times, *May 10, 2016. Kohn, who died on April 19, 2016, shared the 1998 Nobel Prize in Chemistry for developing density functional theory.*

He "was not just looking for a convenient way to do these calculations," Langer said. He sought "the truth of the situation."
***James Langer**, U.C. Santa Barbara,* Los Angeles Times, *May 10, 2016, in comments about Walter Kohn.*

"You know, the facts speak for themselves. It's like you've got a hospital and you're not bothering to check if your doctors are using antibiotics or bloodletting."
***Carl Wieman**, Stanford University,* National Public Radio, *April 13, 2016, on the lack of self-evaluation of teaching practices in American higher education.*

"I don't watch the show with a pad of paper and calculator," he said. "If they get the science right, it's like an Easter egg hidden in the story."
***James Kakalios**, University of Minnesota,* Tech Insider, *April 26, 2016, on the science in the TV show "The Flash."*

"I remember pleading with my family 'Let's try not to fold … . If we fold, we don't have anything'."
***Xiaoxing Xi**, Temple University,* 60 Minutes, *May 13, 2016, on the pressures of the now-dropped espionage case against him.*

"I think Harry was happiest when he was doing one of his workshops and getting on the ground with the kids building models of buckyballs."
***Mark Riley**, Florida State University,* New York Times, *May 4, 2016, on the death of Harold Kroto, co-discoverer of buckminsterfullerene.*

"I am lucky enough to have a successful private company where I don't have to answer to anyone else for what I do, so I can do crazy projects like that."
***Stephen Wolfram**, Wolfram Research,* cnbc.com, *April 7, 2016, on his Wolfram|Alpha search engine.*

"Scientists of the past were not just like scientists of today who didn't know as much as we know. They had completely different ideas of what there was to know, or how you go about learning it."
***Steven Weinberg**, University of Texas at Austin,* Science News, *March 18, 2016.*

This Month in Physics History

June 1785: Coulomb Measures the Electric Force

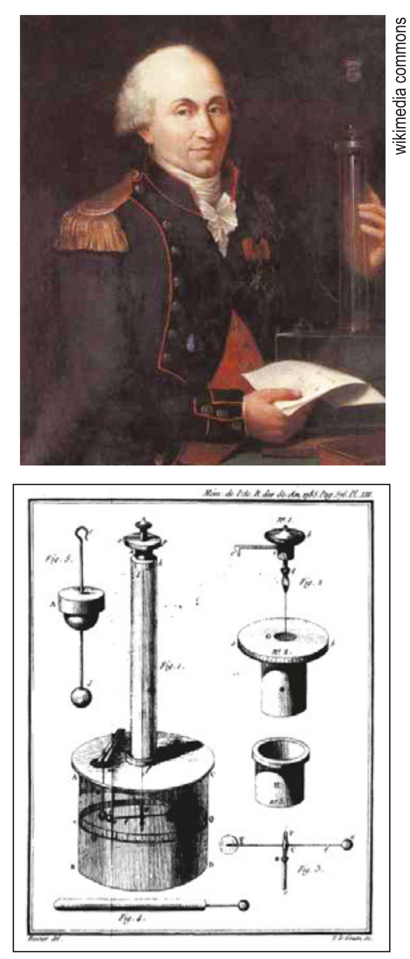
By Richard Williams

Around 600 BC, the Greek philosopher Thales wrote that when he rubbed pieces of amber with fur, the amber attracted bits of straw and other small objects. When scientists began to study the phenomenon, they already had a word for it, thanks to Thales: "electricity," derived from "elektron," the Greek word for amber. In studying this force, others observed that charged objects sometimes attract one another and sometimes repel. Twenty-three centuries later, Benjamin Franklin attributed this effect to the existence of two electrical fluids, one positive and the other negative.

Much of the modern physical description of electrical forces comes from careful experiments done by the French scientist Charles Augustin Coulomb (1736-1806).

His parents came from wealthy families living near Montpellier [1], and they moved to Paris when Coulomb's father began work there. Coulomb earned a degree at the engineering school at Mezieres and became a lieutenant in the military engineering force.

As a trained army engineer, he received several assignments in France. In 1764, Coulomb went to Martinique to supervise the construction of a fort. Coulomb oversaw the construction from 1764 to 1772, and then he returned to France. His health, impaired by the tropical ailments of Martinique, would trouble him for the rest of his life. With his return, his attention also shifted — after many projects in engineering, he began to work on pure physics.



Charles Augustin Coulomb (top) used a calibrated torsion balance (bottom) to measure the force between electric charges.

Coulomb became interested in measuring the electrical force between small charged objects and perfected a torsion balance which could reliably measure such small forces [2]. He suspended a needle on a fine fiber of silver, copper, or silk. The needle held a small electrically charged pith ball at one end and a counterweight at the other end, balanced so that the needle could rotate in a horizontal plane. The calibrated torsion balance measured the force needed to twist the needle through a given angle.

By bringing a similarly charged pith ball near the one on the needle, Coulomb determined the repulsive force between the charged balls as a function of their separation. With these experiments, he launched the quantitative study of electric force. He wrote "The repulsive force of two small globes with the same nature of electricity is inversely proportional to the square of the distance between the centers of the two globes" [2].

When the two pith balls had charges of opposite sign, the experiment described above did not work well. If the balls came too close to one another, they would jump together and stick, ending the experiment. With difficulty, he did measure the relation between force and separation in this case, but he decided to use a completely independent method to confirm the result [3]. He suspended a needle with a small plate on one end, and the plate was then charged. The opposite charge was placed on the surface of a hollow sphere of copper or metal-coated cardboard, about a foot in diameter.

Coulomb assumed that the large sphere would behave as if all its charge were concentrated in a point at its center. The needle was made to oscillate in a narrow arc in the horizontal plane. The period of oscillation depended on the force between the charged sphere and the charged plate on the needle, just as the period of the ordinary simple pendulum depends on the force exerted by gravity. Coulomb then measured the period of oscillation at various distances from the large sphere and, using an equation similar to that for the pendulum, related the period to the force between the charges.

The result: Coulomb's law [3]. "We have arrived here by a method absolutely different from the first ... to conclude that the attraction of the electric fluid called 'positive' for the electric fluid, ordinarily called 'negative,' is as the inverse square of the distance." He went on to show that, for a charged metal object or other conducting object, all the charge resides on the surface, no matter the shape of the object [4].

Coulomb's law underlies much of atomic physics. The attractive force F between an electron of charge e a distance r from a nucleus of atomic number Z and charge Ze is $F = Ze^2/r^2$. Ernest Rutherford, studying the scattering of alpha particles, used this equation to show that the diameter of the atomic nucleus is orders of magnitude less than that of the atom — i.e., that the nucleus is effectively a point mass. Later, Niels Bohr used this result as the starting point of

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of the APS Forum on Industrial and Applied Physics and a condensed matter theorist with IBM, described what working in industry is like, and what research is at the forefront of product development in her field.

Every year, upwards of 200 students attend the "Meet Your Future" panels, and speakers will often remain long after the session has ended to network with students individually.

The 2016 APS April Meeting featured a similar panel, but with physicists with backgrounds at national labs and in policy; this panel also was well attended and received positive feedback. And a new industry panel debuted at the 2016 APS Division of Atomic and Molecular Physics Meeting in Providence, R.I., in May.

Gatherings such as these are often the only opportunities that students have to interact with physicists who are not among their own — or their advisor's — immediate pool of academic colleagues. Therefore, APS plans to continue holding these types of events at the annual meetings, as well as working with division leadership to offer them at a growing number of division meetings in the coming years.

APS also serves its early career members by providing straightforward, nuts-and-bolts guidance on how to successfully plan and move forward along a career trajectory. Every year at the APS March Meeting, author and science coach Peter Fiske (author of *Putting Your Science to Work!*, a widely read career development book for early career scientists and engineers) gives a comprehensive workshop on making the transition into the workforce, from the point of view of a graduate-level scientist.

This year, Fiske's presentation focused on important topics like career planning and self-assessment, effective networking, writing a good resume, and negotiating your best offer — but it also included a strong message that early-career physicists are highly motivated, smart individuals who can have a powerful role in shaping the world for the better. Every year, this event receives extremely positive feedback, and many participants state that this empowering message is one of its most useful aspects.

The annual and division meetings are also opportunities for job seekers to connect with employers who are actively recruiting for positions. Every year, a job fair is held at the APS Division of Plasma Physics (DPP) Meeting and the APS March Meeting, in which participating employers can post and interview for jobs directly on site. Though historically the majority of participants have been from academic institutions and national labs, in recent years there has been an uptick in the percentage of private sector employers (at the DPP Job Fair in 2015, nearly 40% of the jobs posted were from companies). In addition to its job fair, DPP has also recently begun offering a popular "Resume Help Desk" for attendees to get feedback to help improve their CVs. The Help Desk staff has included volunteers with hiring experience in academic, national lab, and private sector environments.

Career and professional development events at APS meetings are an invaluable resource for students who may otherwise have difficulty learning about paths outside of what is (incorrectly) considered to be the "traditional" academic route. As one attendee of the March Industry Career Panel stated, "The talks presented were vital in assuring me that I didn't make a major mistake in my life decision to follow my love of physics … that I will be able to provide for my family and myself without much worry of being able to get a job, being poor all the time, and having to work with people who aren't science minded." APS is glad to be able to provide this broader perspective to early-career members and boost the career confidence of the next generation of physicists.

To learn about career events taking place at APS division and section meetings, look for the "Career" track in the APS Meeting app, or under the "Career Events" page of the main meeting webpage. Or you can send email to bailey@aps.org.

You can also learn about the Future of Physics days, which are special events held for undergraduate students at the APS March and April meetings, by visiting http://www.aps.org/meetings/events/futurephysics/

1. AIP Statistical Research Center, *Focus on Physics Doctorates Initial Employment*, March 2016.

COULOMB continued from page 2

his theory of the line spectrum of the hydrogen atom.

The French Revolution brought changes to Coulomb's professional life. His role in the Académie des Sciences ended when it was closed. His contributions to the weights and measures committee and the supervision of the water supply ceased during the revolution, but in later years he was able to resume some of this work. In June of 1806 he contracted a fever that caused his death in August [1], but Coulomb's name lives on in physics. Today, the coulomb is the unit of electric charge, and the scattering observed by Rutherford is Coulomb scattering.

Further Reading:

1. C. Stewart Gilmor, *Coulomb and the Evolution of Physics and Engineering in Eighteenth Century France* (Princeton University Press, Princeton, New Jersey, 1971).
2. C. A. Coulomb, *Premiere Memoire sur l'electricite et le Magnetisme, Histoire de l'Academie Royale des Sciences*, 569-577 (1785). An English translation of this article is available by searching on "Bucciarrelli translation of Coulomb's first memoir" with either Google Search or Bing.
3. C. A. Coulomb, Seconde *Memoire sur l'electricite et le Magnetisme*, Histoire de l'Academie Royale des Sciences, 578-611 (1785).
4. C. A. Coulomb, *Quatrieme Memoire sur l'electricite et le Magnetisme, Histoire de l'Academie Royale des Sciences*, 67-77 (1785).

Profiles in Versatility

IBM Technology at Work in Africa

By Alaina G. Levine

K. Bhattacharya

Kamal Bhattacharya moved to Nairobi, Kenya to start IBM's research center there.

It was a bright and sunny morning in Bangalore, India, when Kamal Bhattacharya, a senior manager for information technology and cloud computing at IBM Research, got a game-changing phone call from his boss. The company was going to launch a research lab in Africa, IBM's 12th research lab and its first on the continent. The conversation consisted of a simple query — did Bhattacharya, a Ph.D. physicist, want to take the reins and lead the charge? His answer was also simple — a resounding yes.

So in 2012, Bhattacharya and his family packed up their things and moved across the Indian Ocean to Nairobi to launch IBM Research – Africa. He arrived in Kenya with the goal of establishing the lab specifically to address grand challenges in Africa, through commercially viable innovation that impacts people's lives. But he had to start from scratch. There wasn't a building. There were no machines or instruments or any sort of infrastructure. There were no other employees. "I had the opportunity to define what it is we wanted to do," says Bhattacharya. "It was an ambitious effort for IBM to set up a lab of this type in Africa. I had no peers and there was no precedence."

But as a veteran IBM employee since 1999, with experience working on four continents and in multiple roles throughout the organization, he was uniquely suited for the challenge. In particular, his diverse worldview aided him in understanding the significance of the assignment. Given that Africa was the only continent where IBM did not have a presence, there was much opportunity to be pursued here. "If we as a company want to be relevant to the world, we should go where we face the most pressing of challenges," he says.

Bhattacharya began his effort by negotiating with the Catholic University of Eastern Africa to move into a 40-year-old defunct library to use as the lab's main building. His partnership with a team of architects and engineers helped pave the way for the concept behind what the facility would look like. "What's in a lab? It depends what we do," he notes. He envisioned a data center with state-of-the-art computing systems and an open environment that fosters collaboration.

His first exposure to reframing the use of technology in developing markets was through a project to ensure that patients receive their malaria medicine on time. Through his rapidly growing network across the continent, he learned of people using text messages to track pharmaceuticals. "We are a commercial company, so when I heard about this simple solution of sending a quick message to a database to find out where the malaria medicine is, I asked 'What's the impact?' and I was thinking commercial impact," he shares. But when his colleague replied that they saved 400,000 lives, "It hit me. I never considered how we can we build technology that is commercially viable that can affect people's lives in this way. That's when we switched things around. I called my chief scientist and I said we are going to create a lab to develop commercially viable and innovative technologies to address key societal issues on the African continent with impact potential in the millions."

The lab, which now employs 60 scientists and engineers, has made some considerable strides in only three years. In agriculture, the researchers have developed technology to monitor how resources, such as water, are being utilized, and to advise farmers how to improve productivity. In healthcare, they are looking at how to leverage technology to alleviate challenges at the first point of care. For example, when someone goes to a primary physician, a software program called a "cognitive advisor" will enable the doctor to better identify and treat medical problems and move patients to the next step, whether it is to send them to a hospital or provide them with a prescription.

Another key accomplishment of the lab has been the improvement of Kenya's regulatory business environment, as measured by the World Bank. Bhattacharya and his team analyzed multiple aspects of regional and national government to pinpoint what processes could be improved to increase the country's rank in the bank's assessment. They scrutinized everything from how to start a business to trading across borders, and made recommendations on how to improve efficiency through both process reengineering and through technology. "In the first year, we helped Kenya increase its rank by 28 points," he says. "This was genius work the team does — it is a lot of technology and a lot of policy and legal work. We brought together people who can understand this at a very deep level. Now we have become a trusted advisor to the Kenyan government and our approach is core to the government's desire to make things easier, especially for small and medium businesses."

Another interesting concept and technology developed by the lab relates to financial inclusion. Across Africa, only 20% of people have access to formal financial services. Kenya, a leader in mobile money products, is a fertile ground for experimentation on more inclusive mobile banking products geared towards the low-income population. So IBM Research – Africa engineers, in collaboration with financial institutions, built cognitive algorithms based on machine learning that provide the banks with the information they need to make a sound decision, with data gleaned from various outputs such as call records and even social media activity. The innovation "can help banks and financial services companies provide loans with much lower risk and at a much bigger scale," he notes.

The lab has had its share of false starts, however. "Over time we have learned how to fail because some of the ideas we had were innovative but were not commercially viable, or vice versa," he notes. Other ideas "didn't address social challenges we cared about."

Regardless, Bhattacharya, who received his doctorate in theoretical statistical physics from the University of Göttingen in Germany in 1998, says he is well prepared for the large-scale challenge of leading the R&D center precisely because of his education. "My way of thinking, which I learned as a physicist, was attractive to IBM. Physics strives for a simplicity and elegance and it requires you to have a common sense," he notes. "At the end of the day, when it comes to engineering systems relevant to society, things never turn out to be as pretty as they were [in physics]. Sometimes you have to make compromises on purity because you want to get things done. Once you make that transition, a lot of complementary skills in physics and engineering have tremendous value in making the world better."

Bhattacharya continues to press forward with innovations in cognitive technologies relevant to Africa. Last year, he launched the second IBM Research – Africa site in Johannesburg, South Africa, which is currently looking at problems in

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Letters

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

Equal Rights and Proposition 2

I was gratified to see "The Back Page" column by Michael Falk and Elena Long (*APS News*, March 2016) in which Falk recalled his 1994 letter to *APS News* defending the APS Council action on Colorado Proposition 2. I wrote the preceding letter in that issue defending the action, as the representative of the APS Panel on Public Affairs (POPA).

I was responsible for bringing the issue to the attention of POPA, motivated by my longtime association with the Aspen Center for Physics. I believed not only that Proposition 2 was morally wrong, but as an Aspen homeowner whom gay inlaws now felt uncomfortable visiting, I felt that it trampled on my property rights. After considerable discussion, POPA took action, and the resolution ultimately passed. There was not unanimous support for APS getting involved; my recollection is that both in POPA and in Council, the resolution passed by roughly 2 to 1.

This episode had an interesting personal aftermath. After my term as a POPA member was finished, I was asked to run for Chair of POPA and was told by the Nominating Committee that I was very likely to be selected. Anticipating a heavy workload, I resigned a year early from a National Academy commission on which I had completed two years of a three-year term. In November 1995, I was informed that I had not been elected as chair; it appears that in suggesting APS take action on Proposition 2, I had made enemies as well as friends. I was not informed who was elected POPA Chair, a defect in the APS election procedure.

Having now an open block of time, and seeing that any further role in APS governance was closed, I decided to resume piano lessons and regular practice that I had stopped at age 16. I have never regretted this decision, which has brought me great pleasure over the years.

Stephen L. Adler
Princeton, New Jersey

Inside the Beltway

The Times They Are A Changin'

By Michael S. Lubell, APS Director of Public Affairs

Come gather 'round people/Wherever you roam/And admit that the waters/Around you have grown/And accept it that soon/You'll be drenched to the bone/If your time to you/Is worth savin'/Then you better start swimmin'/Or you'll sink like a stone/For the times they are a-changin.'

Songwriter and iconic folk performer Bob Dylan penned those lyrics more than 50 years ago. And they became an anthem for young people who felt increasingly alienated from their government, disillusioned with their leaders, and powerless to effect change by any conventional means, especially in the Vietnam War that eventually claimed the lives of 55,000 Americans and more than 10 times as many Vietnamese. Many young Americans simply dropped out, but others took to the streets, as Dylan lyrically exhorted them to do.

We might be on the verge of another revolt, but this time not driven simply by a disaffected youth cohort but also by a disaffected shrinking white middle class. I'll return to the shrinkage in a moment, but first a historical synopsis of how we've gotten to where we are today politically. It holds some significant lessons for candidates in the upcoming elections.

The year 1968 is a good starting point. Buoyed by thousands of antiwar college students, Minnesota Sen. Eugene McCarthy nearly upset President Lyndon Johnson in the first-in-the-nation New Hampshire primary on March 12. Within days, sensing Johnson's weakness, Robert Kennedy, then a New York senator, announced his candidacy as well. Two weeks later, after Johnson unexpectedly announced he would not stand for re-election, Hubert Humphrey, his vice president, jumped in.

By the time Democrats con-

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neutrinos come in more than one flavor, and over the long journey from sun to Earth, they change into a flavor that could not be detected in Davis' experiment. His colleague Herb Chen suggested in 1984 that a heavy water detector might be used to confirm this proposal. McDonald remembered Chen calling up Los Alamos National Laboratory and asking "Do you think we could borrow 4000 tons of heavy water?" — about $1.2 billion at the time. But careful design brought the requirement down, and the group was able to convince Atomic Energy of Canada to lend the heavy water to start the Sudbury Neutrino Observatory.

The first phase of data collection began in November 1999, and the final phase was completed in December 2006, with final combined analysis published in 2013. The payoff was the evidence that electron neutrinos from the sun were changing into other flavors, which brought the measured flux into good agreement with John Bahcall's calculations. McDonald concluded with a description of SNO's plans for future neutrino experiments and expansion into dark matter searches.

Atmospheric neutrinos

Takaaki Kajita, leader of the team at the Superkamiokande experiment, then talked about the role played by neutrinos created in cosmic ray interactions in the atmosphere in proving the existence of neutrino flavor oscillations. Little over 50 years ago, two underground experiments — one in South Africa the other in India — reported the first detection of atmospheric neutrinos by observing the muons they produced.With increasing depth, the muon flux produced directly by cosmic rays decreases and plateaus to a level where the muons are produced by the penetrating atmospheric neutrinos.

The story then switches to proton-decay experiments of the 1980s motivated by interest in grand unified theories. Kajita explained that one of the most important background signals in looking for proton decay turned out to be atmospheric neutrinos, so it was important to understand their origin. In doing so, researchers found a deficit of muon neutrinos compared to what was expected, a situation very similar to the solar neutrino problem. Neutrino oscillations were also proposed as the solution, but Kajita noted, the deficit alone wasn't proof. "We really had to think harder to find the cause of the deficit," he said.

In the mid 1990s, the Kamiokande experiment found a clue. There was a deficit in muon neutrino flux for long paths through Earth, but no deficit if the path length was short. The interpretation is that the neutrinos going the longer route had time to change into other flavors but the ones taking a shorter path did not. Unfortunately the difference was not statistically robust.

To get the needed data, Kajita says, Kamiokande was upgraded to Superkamiokande, which begin operation in April 1996. "The detector worked very well," he added. "It took only two years to obtain the very important first result." The confirmation of oscillations came in 2004, when Superkamiokande was actually able to see a dip in flux at a particular pathlength. Kajita explained that future work at Superkamiokande and other neutrino labs would include an effort to understand the so-called mass hierarchy problem — because we only know the differences in squares of the masses we don't know the order of the masses of the neutrino flavors.

Remembering John Bahcall

A key player in all of this was the late John Bahcall, a physicist who was at home both in theory and experiment. His wife and scientific collaborator Neta gave the third talk in the keynote session on his involvement in the neutrino story, which she framed as a tale of "individual courage, amazing persistence, and triumph over 40 years." It began, she said, as a simple question — how does the sun shine?

The basic scheme of nuclear reactions was in hand, but John Bahcall sought to answer the question in the early 1960s with a solar model and detailed calculations. At about the same time, Ray Davis was proposing to detect solar neutrinos with a large tank of carbon tetrachloride. In 1968 the first results came in and it was a good-news/bad-news situation. "The good news was that neutrinos were detected," said Neta Bahcall. "The bad news was [the flux] was three times lower than John predicted." The discrepancy remained a mystery for 40 years.

The solution was neutrino oscillations, covered by the first two speakers. Neta recounted how in the intervening years she and John met, married, and had a family. During this time, however, John had to withstand the criticism from particle physicists that "astronomers can't calculate the sun to a factor of three," Neta said. The only alternatives were that Davis' experiment was wrong or that current understanding of neutrino physics was wrong. The experiment and theory were checked and rechecked, but few believed the latter possibility, Neta recalled.

John Bahcall died in 2005 having mentored over 300 students and postdocs, with several other key astrophysical discoveries to his name. He didn't live to see the final stages of the Superkamiokande and SNO results, but as Neta concluded in quoting astrophysicist Michael Turner, "John mastered the nuclear oven of the Sun and triumphed."

The entire symposium can be viewed on the APS Youtube channel at go.aps.org/1Ug0a1J

2016 Kavli Keynote Session Speakers

Queen's University

Arthur McDonald

University of Tokyo

Takaaki Kajita

IAS

Neta Bahcall, with John

Peter Adams 1937-2016

Peter Adams

Peter Adams, longtime editor with the APS *Physical Review* journals, died on April 16, 2016. Adams joined the editorial office in 1969, while it was located at Brookhaven National Laboratory, where he carried out research in condensed matter physics. He played a key role in the split of the single *Physical Review* into *Physical Review A* through *D*, and in 1970 he became the first full-time editor to lead *Physical Review B*, a position he held until 2012.

During his 47 years at the APS, Adams also held appointments as deputy managing editor and deputy editor in chief of the journals. In those roles he was responsible for the design and development of a computer-based UNIX project to move all editorial operations, data management, journal-page composition, and printing into the digital era.

"When I joined APS as an editor for PRB in 1996, Peter took me under his wing," says Daniel Kulp, Interim Editor in Chief and Editorial Director of the APS journals. "Just about everything I know about editorial work came from him. Peter was always open to sharing his knowledge and insight with the entire editorial staff. For

ADAMS continued on page 6

Education & Diversity Update

2017 Graduate Education and Bridge Program Conference

APS will hold the 2017 Graduate Education Conference and Bridge Program Conference jointly at the Hyatt Regency Atlanta on February 10 - 12. The conference will feature plenary talks on physics graduate education, as well as panels and interactive discussions on diversity. Student programming includes networking, a graduate student poster session, and professional development opportunities. Email bridgeprogram@aps.org for more information.

2017 Physics Teacher Education Coalition Conference

The 2017 Physics Teacher Education Coalition (PhysTEC) Conference is the nation's largest meeting dedicated to educating physics teachers. It will take place February 17 - 18 at the Hyatt Regency Atlanta. The conference features workshops, poster sessions, panel discussions on best practices, and presentations by national leaders in physics teacher education, as well as excellent networking opportunities. The conference will directly precede the 2017 AAPT Winter Meeting.

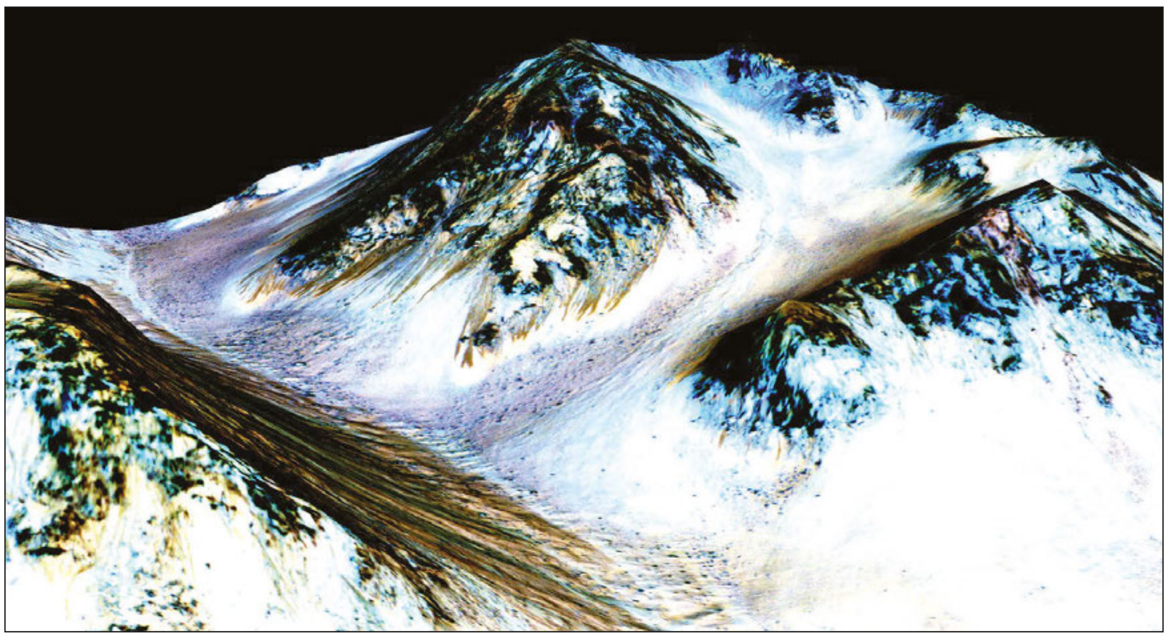
Is your institution interested in joining PhysTEC? Institutions that are involved in or wish to become involved in preparing preservice physics teachers are invited to join the Physics Teacher Education Coalition (PhysTEC). Go to phystec.org/webdocs/Join.cfm for more information.

Fall 2016 APS National Mentoring Community Conference

The National Mentoring Community Conference will be held October 21 - 23, 2016 at the University of Houston. This conference will feature plenary talks by Louisiana State University Professor Gabriela Gonzalez, spokesperson for the Laser Interferometer Gravitational-Wave Observatory project that detected gravitational waves in 2015; Florida Institute of Technology Professor Hakeem Oluseyi, who appears regularly on eight television series, including as co-host of the Science Channel's *Outrageous Acts of Science*; and scientist-turned-STEM-education-policy researcher and National Science Foundation data scientist Dr. Frances Carter-Johnson, expert on using socio-cultural factors to broaden participation in STEM. There will also be mentoring and career workshops, a Research Experiences for Undergraduates / Grad School Fair, an undergraduate research poster session, a NASA tour, and much more! Visit go.aps.org/nmc-conference to register and learn more.

Join the APS Undergraduate Mentoring Community

The APS National Mentoring Community (NMC) is an effort to increase the number of African American, Hispanic American, and Native American undergraduates obtaining physics bachelor's degrees. NMC connects students with faculty mentors and supports those relationships with resources and networking opportunities. Register to become an NMC Mentor at www.aps.org/nmc



NASA

Seasonal changes in the appearance of streaks on the steep slopes of Mars may indicate that boiling water plays a role in shaping the surface.

RESEARCH continued from page 1

Compared to a smooth-surface OLED, this bio-inspired device emitted more light and also had a wider angle of illumination.

Turmoil on the Red Planet

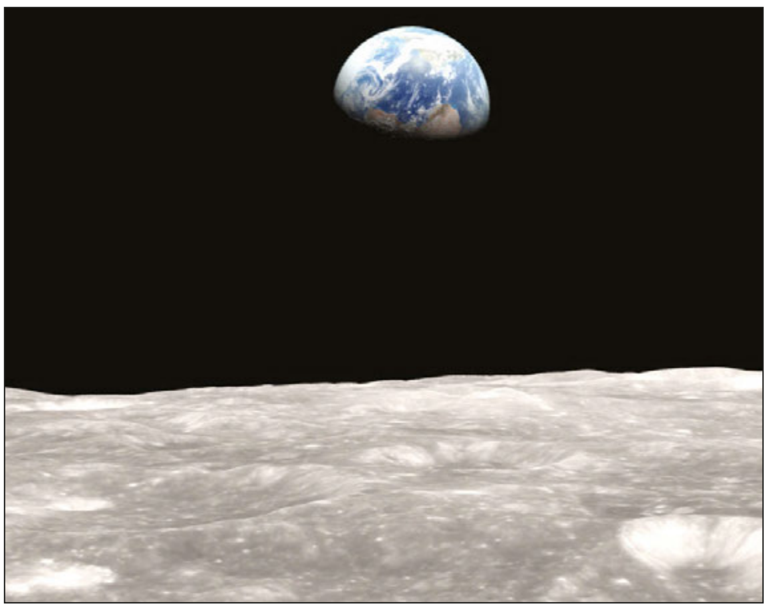
Experiments suggest that boiling water may be causing changes on the surface of Mars, as reported by Massé *et al*. (*Nature Geosci.* doi:10.1038/ngeo2706). Recently, spacecraft observations of the planet's steep slopes have revealed discolorations that lengthen and shorten according to the seasons. Such streaks could indicate flowing water or brines — salty solutions formed from water percolation. But in the thin Martian atmosphere, liquid water is expected to either freeze or evaporate very quickly. To simulate what may be happening on Mars, Massé *et al*. carried out lab experiments at pressures typical of the red planet (less than 1% of Earth's sea-level pressure). They let a small amount of ice melt on top of a sand-covered slope, then watched the meltwater percolate downwards through the sand and boil at the interface between wet sand and air. The boiling water ejected sand grains, forming piles that collapsed, leaving dark-colored streaks reminiscent of those seen on Mars. The results suggest that even modest quantities of boiling water could be a key factor shaping the planet's surface.

This White Dwarf Isn't Like the Others

The first white dwarf with an almost purely oxygen atmosphere has been discovered in new data from the Sloan Digital Sky Survey. The oxygenated dwarf is one of about 32,000 in the survey, but its spectrum reveals an atmosphere with a unique chemistry, challenging scientists' understanding of stellar evolution. As they age, stars with less than 8 to 10 solar masses typically become white dwarfs. These dense, Earth-sized objects form once hydrogen and helium have been largely consumed and can no longer fuel the fusion that counteracts gravity. The remaining hydrogen and helium float to the surface, where they dominate the visible emission spectrum. Kepler *et al*. (*Science* 352, 67), however, found a dwarf whose spectrum was dominated by oxygen lines, suggesting the outer layer of hydrogen and helium disappeared as the white dwarf formed. Instead of hydrogen and helium, they saw a mixture of oxygen, neon, and magnesium that is most commonly found in more massive white dwarfs, and trace amounts of silicon that are associated with the formation of neutron stars.

Lunar Iron Points to Nearby Supernova

Researchers studying lunar soil samples have uncovered high levels of an iron isotope (^{60}Fe) consistent with fallout from a nearby supernova about 2 million years ago. Nearby supernova might be connected with extinctions on Earth. Besides emitting deadly radiation, these events also spew out elements such as ^{60}Fe, which can settle on planetary bodies within the blast zone. Since this isotope has a radioactive half-life of 2.6 million years, finding high levels of it in a geological sample imply a fairly recent (and close) supernova. The supernova hypothesis — first proposed in 1999 — is supported by recent observations of ^{60}Fe in the Earth's oceanic crust. But the unworked surface of the Moon is a better record. Fimiani et al. (*Phys. Rev. Lett*. 116, 151104) obtained lunar soil samples from the Apollo missions. They found the ratio of ^{60}Fe to total iron was around 1 part in 10^{15}, which is about 10 times higher than the measured background. Cosmic-ray interactions — another possible source of ^{60}Fe — could not account for this high concentration. (Adapted from the *Physics* article "Supernova Footprint on the Moon.")



NASA

Iron isotopes in lunar soil samples are consistent with a nearby supernova occurring 2 million years ago.

Theorists Tackle a 750 GeV Bump

A quartet of papers in *Physical Review Letters* attempts to explain the origin of a 750 GeV signal found last year at the LHC. The observation has generated many theory papers and, if confirmed, would imply the existence of surprising new particles. Three of the papers center around some new 750 GeV bosons: a pion-like boson associated with a new type of strong force (Y. Nakai et al., *Phys. Rev. Lett*. 116, 151802), a Higgs-like boson that couples to new kinds of fermions (G. Li et al., *Phys. Rev. Lett*. 116, 151803), or a boson that is the supersymmetric partner of a hypothetical fermion called the goldstino (C. Petersson and R. Torre, *Phys. Rev. Lett*. 116, 151804). The fourth (W. S. Cho et al., *Phys. Rev. Lett*. 116, 151805) proposes that the signal is not due to a 750 GeV particle at all, but to some even heavier particles that decay via a cascade to lighter particles along with photon pairs of about 750 GeV. By the fall of 2016, the LHC should have collected enough data to determine whether the hint is a real signal or a statistical fluctuation. (Adapted from the *Physics* article "Explaining a 750 GeV Bump".)

CERN

Theorists seek to explain a 750 GeV anomaly.

THE TIMES continued from page 4

vened in Chicago that August, Kennedy had been assassinated and the youth vote was in full revolt. Inside the convention hall the scene was far from serene, but it paled by comparison with the rioting outside. But establishment leaders ignored the anti-establishment fracas on the streets and anointed Hubert Humphrey the Democratic standard-bearer.

Voters craving change, especially young anti-war voters, saw Humphrey as Johnson-lite, and without their support, he lost the election. Richard Nixon, his opponent, easily captured the Electoral College 301 to 191 (segregationist George Wallace received 46), but Nixon eked out only a narrow 0.7 percent victory in the popular vote.

Earlier that year Republicans had been split, with New York Gov. Nelson Rockefeller leading the East Coast liberal wing and popular California Gov. Ronald Reagan leading a rapidly growing conservative movement. But at their August convention in Miami the party easily united around Nixon, who accepted his nomination with these words: "When the strongest nation in the world can be tied down for four years in Vietnam with no end in sight, when the richest nation in the world can't manage its own economy … then it's time for new leadership … ."

Eight years later, after Rep. Gerald Ford had been appointed under the 25th Amendment to fill a vice-presidential vacancy in 1973; after Nixon had resigned on the eve of a 1974 House impeachment vote; after Ford had been sworn in as Nixon's replacement without ever having run for either vice president or president; and after Ford had pardoned Nixon for any crimes he had might have committed in the Watergate Scandal, Georgia Gov. Jimmy Carter, a peanut farmer who had become a nuclear engineer, captured the White House for the Democrats. Many political historians today attribute Ford's narrow 1976 loss to his pardon of Nixon two years earlier.

Carter's success was short-lived. In 1980 Ronald Reagan capitalized on the realignment of the South's racially driven politics and the Rust Belt's disaffected working class voters, and trounced Carter in both the popular vote and the Electoral College. For another 12 years Republicans held sway in national elections.

Finally, in 1992, businessman Ross Perot's independent candidacy provided an opportunity for Arkansas Gov. Bill Clinton to defeat incumbent Republican President George H.W. Bush. He did so with only 43 percent of the popular vote.

In truth, it took Democrats until 1996 to regain their national footing. Even though Perot again played the role of Republican spoiler, Clinton did not really need much help, as he ran his popular vote total to just shy of 50 percent and captured the Electoral College 379-159.

As the balance of the 2016 election year unfolds, the political landscape has a whiff of 1968. Young voters, once again, have lost faith in the establishment, as they rally around the candidacy of Sen. Bernie Sanders. This time it's not because they are opposing a war, but because they see Washington policies as unfair to the average American, and the status quo offering them little hope for a better future.

As two Pew Research Center studies, one in 2015 and one this May, have documented, the portion of U.S. families classified as middle class has shrunk from 62 percent in 1970 to 43 percent in 2014. The shrinkage has been widespread, with 203 of 229 metropolitan areas surveyed between 2000 and 2014 showing that pattern. In 53 areas the decline was at least 6 percent.

For the average American, wages have stagnated for more than 30 years. And since 1999, the median household income, adjusted for inflation, has declined by 7 percent, according to the U.S. Census Bureau.

For these voters Donald Trump, the presumptive Republican nominee, has particular appeal. I spoke to one of them yesterday — I'll call him Fred — who told me "Any change is better than more of the same." He said he knows that Trump is not well versed in foreign policy, military matters or economics, but he believes that someone who has been successful in business "will know how to shake up the system and make things work."

As I've traveled around the country, I've met many Freds. Their stories differ in specifics, but they are eerily the same in their general perceptions.

Any candidate for public office this year who ignores the growing disaffection, disillusionment, and despair of young and middle class voters does so at his or her own peril. At the presidential level, the danger is greatest for Hillary Clinton, whom most voters see as the embodiment of the establishment they have grown to distrust.

But the peril is also there for anyone running for Congress. As Dylan wrote in 1964:

Come senators, congressmen/Please heed the call/Don't stand in the doorway/Don't block up the hall/For he that gets hurt/Will be he who has stalled/There's a battle outside/And it is ragin'/It'll soon shake your windows/And rattle your walls/For the times they are a changin'.

ADAMS continued from page 5

many generations of editors, he was a mentor and a colleague."

"We are grateful for all that Peter contributed to the development and evolution of the *Physical Review* journals over his long career in the Editorial Office at Ridge," adds APS Chief Executive Officer Kate Kirby.

Adams graduated from the University of Wales, Aberystwyth, and in 1964 obtained his Ph.D. in Physics from Imperial College London. He was elected a Fellow of APS in 1972, and was a Fellow of the UK's Institute of Physics.

BOUCHET continued from page 1

Edward Bouchet Abdus Salam Institute) in Trieste, Italy, and has only grown from there, says Ronald Mickens, a physicist at Clark Atlanta University who edited a 2002 volume on Bouchet and received the APS Bouchet award in 2008. "[Bouchet's] name got out into the public, and so everyone now wants to claim a piece of him."

That his name would one day adorn awards, honor societies, academic conferences and institutions around the world would probably have surprised Bouchet, given that he did not receive major recognition in his lifetime. Edward Bouchet was born in New Haven, Connecticut, on September 15, 1852. He grew up at a time when American science was in its infancy, practiced by a few members of the educated elite, often outside the university system.

Bouchet was, needless to say, not from that socioeconomic class. His father worked as a janitor at Yale and served as a deacon of New Haven's oldest black church, and his parents were active in the city's abolitionist scene. He graduated high school in 1868 and became the first black student to attend the private Hopkins School (essentially a feeder school for Yale), where he graduated at the top of his class. In 1870 he became the second black student to enter Yale.

The climate at Yale was not exactly welcoming — students sang racist songs at graduation, and Bouchet was unable to join any of the university's secret societies, making him one of only four members of his class not to do so. Nevertheless, he graduated sixth in a class of 124, and was the first African American elected to the Phi Beta Kappa honor society.

Alfred Cope, a philanthropist and board member of the Institute for Colored Youth (ICY), a private, Quaker-run school in Philadelphia, heard about Bouchet and recruited him to teach there, but encouraged him to stay on at Yale for his doctorate first. Bouchet agreed to do so only after Cope offered to finance him with a $1,500-per-year stipend. Bouchet's Ph.D. thesis was on measuring refractive indices. His advisor was Arthur Wright, who had earned Yale's first physics Ph.D. (and the first in the U.S.) in 1861. No known copy of Bouchet's doctoral thesis remains, Mickens says, but his experiments probably tied into then-growing interest in geometrical optics and mineralogy.

Bouchet left almost no written records, so it is unknown whether he wished to pursue an academic career, for which he was clearly qualified. But Mickens suspects he likely didn't even consider the possibility, since American higher education institutions were not open to hiring black faculty members. Instead, Bouchet began teaching at the ICY in fall of 1875. In addition to physics, he taught chemistry, astronomy, geography, physiology and entomology, earning a modest salary of $1,200 per year (around $25,000 in today's dollars).

Unfortunately, his benefactor, Cope, died the year Bouchet began at ICY, and the school's remaining managers were less enthusiastic about Cope's project to educate black students in math and science. Bouchet fought for years to get the school to buy laboratory equipment. (Bouchet's few records include some of these requests.) He nevertheless remained at ICY until 1902, when he was fired, along with the rest of the staff, as the school moved out of Philadelphia and transitioned from an academics-focused institution to one oriented toward vocational education — a move strongly backed by prominent African-American leader Booker T. Washington.

Bouchet moved often during the rest of his life, teaching at schools in Saint Louis, Ohio, Virginia, and Texas. He never married and had no children, but he was a member of the Franklin Institute in Philadelphia and the American Academy of Political and Social Science, and was active in the NAACP. His status among America's educated elite didn't shield him from the horrors experienced by black people during his time; at one point he was severely beaten after bumping into a prominent white lawyer in Lawrenceville, Virginia. Bouchet died at 66 of heart failure in New Haven in 1918, the same year Elmer Imes became the second African-American to earn a Ph.D. in physics.

The dreams Bouchet might have held of helping inspire African-American achievement in science ultimately ran into powerful headwinds from those who thought black students should focus on vocational rather than academic subjects, and didn't come to fruition in his lifetime. But during four decades of teaching, Bouchet educated hundreds of students, many of whom went on to professional careers. "Certainly it is impossible to assess the far reaching influence of Dr. Bouchet upon the hundreds of persons whose lives he touched," wrote Lillian Allen, who attended Lincoln School in Gallipolis, Ohio, when Bouchet was principal there, and who went on to become head of music education at Howard University in Washington, DC.

Despite much progress since 1876, the number of African-Americans earning physics Ph.D.s remains far below their representation in the U.S. population. And some of the disparity's causes echo factors from Bouchet's time. Several historically black colleges and universities have shuttered their physics departments recently, and others are under threat of closure, notes Theodore Hodapp, Director of Education and Diversity at APS. Mickens adds that the heavy recruitment of women and minority science undergraduates into dual-degree engineering programs starting in the 1980s drained the pool of potential physics Ph.D. candidates.

Recently founded programs now aim to reverse these trends and retain talented minority students in physics, led by the Fisk-Vanderbilt Masters-to-Ph.D. Bridge Program, the leading producer of minority Ph.D.s in physics and astronomy. The APS Bridge Program, started in 2009, is positioned to increase the fraction of physics Ph.D.s awarded to underrepresented minority students to equal the fraction of physics bachelor's degrees granted to these groups, with African-American students likely to make the largest gains. And the Society's new National Mentoring Community is providing mentoring to more than 100 underrepresented minority physics students.

Meanwhile, for minority physicists who have made major contributions to the field, the visibility provided by the APS Bouchet Award is "crucial to being a role model to peers and students," says Nadya Mason, a physicist at the University of Illinois at Urbana-Champaign and current chair of the APS Committee on Minorities. "It's one of the biggest things we do to increase the visibility of underrepresented physicists." But she adds, noting the continued underrepresentation of African-Americans and other groups in physics, "The work that needed to be done in Bouchet's day still has to be done today."

Further Reading

Ronald E. Mickens, ed., *Edward Bouchet, The First African-American Doctorate* (World Scientific Publishing Company, 2002).

"Edward Bouchet Becomes the First African American Ph.D. in Physics," This Month in Physics History, *APS News* (June 2007).

2016 Edward Bouchet Award

This year's recipient is Pablo Laguna at the Georgia Institute of Technology. His award citation reads "For contributions to numerical relativity and astrophysics; in particular, on the simulation of colliding black holes." He received the award at the 2016 APS April Meeting in Salt Lake City, Utah.

Pablo Laguna

Pablo Laguna received his degree in physics from the Universidad Autonoma Metropolitan at Iztapalapa in 1981 and his Ph.D. in physics from the University of Texas at Austin in 1987. In 1992, he joined the Department of Astronomy and Astrophysics at Pennsylvania State University. He was promoted to associate professor in 1998 and to professor in 2000. He was named associate director of both the Center for Gravitational Wave Physics and the Institute for Gravitational Physics and Geometry in 2001. In 2008, he became professor in the Schools of Physics and of Computational Science and Engineering at the Georgia Institute of Technology. Laguna is founding member and was first director of the Center for Relativistic Astrophysics at Georgia Tech until 2013 when he became chair of the School of Physics. His research is in computational astrophysics, investigating astrophysical phenomena involving binary systems with black holes and/or neutron stars. Laguna was named a Fellow of the American Physical Society in 2008 and elected to the Mexican Academy of Science in 2007.

ANNOUNCEMENTS

Reviews of Modern Physics

Colloquium: Non-Markovian dynamics in open quantum systems

Heinz-Peter Breuer, Elsi-Mari Laine, Jyrki Piilo, and Bassano Vaccini

An ongoing theme in quantum physics is the interaction of small quantum systems with an environment. If that environment has many degrees of freedom and is weakly coupled, it can often be reasonable to treat its decohering effect on the small system using a "memoryless," or Markovian description. This Colloquium shows that for many phenomena a more refined, non-Markovian, treatment is necessary. The suite of developing theoretical tools is reviewed, with which recent progress on this problem has been based.

dx.doi.org/10.1103/RevModPhys.88.021002

journals.aps.org/rmp

IBM continued from page 3

pollution forecasting and prevention. He is collaborating with organizations that IBM has traditionally not partnered with, such as the Bill and Melinda Gates Foundation and USAID. He has also initiated Project Lucy in 2013, which leverages IBM's Watson and related cognitive technologies to utilize Big Data to improve the way of life in developing countries. "This is a new way of thinking about artificial intelligence and cognitive computing as helpful to Africa," he says. "The true drivers of change on the African continent will be technologies, and the ability for us in Africa to take a science-driven view to impact change and make a difference is what I am most proud of. It keeps me going every day."

ELECTION continued from page 1

Chair-Elect, Nominating Committee

David B. MacFarlane, *Stanford Linear Accelerator Center Stanford University*

"If elected, I would be both honored and diligent in taking on the task of persuading outstanding candidates to stand and believe I have a background and relevant experience for this role."

David D. Meyerhofer, *Los Alamos National Laboratory*

"The APS has a number of issues that it needs to continue to work on ... If chosen, I will work with the Nominating Committee to develop a slate of candidates who can further these efforts and represent the Society at all levels."

International Councilor

Carlos Henrique De Brito Cruz, *University de Campinas, Brazil*

"The Physics community has grown in the U.S. and abroad and there are many opportunities for enhancing the instruments and means for international collaboration in research and education.. As an International Councilor I can contribute to this, drawing from my experience in developing international collaborations at the São Paulo Research Foundation in Brazil..."

Marta Losada, *Universidad Antonio Narino, Colombia*

"Furthering research in physics as well as physics education in Colombia has been a top priority during my professional career... My more recent interest is in developing new and alternative teaching approaches and strategies for undergraduate physics courses."

General Councilor

Andrea Liu, *University of Pennsylvania*

"As a General Councillor, I will work to strengthen the APS by helping it to better serve its diverse members and to engage with all potential members. I will also focus on helping the APS to continually rethink and improve its efforts to communicate the contributions and value of physics to policymakers, funding agencies and society at large."

Neal Weiner, *New York University*

"The APS provides an important structure to help foster and encourage young scientists, to help us take advantage of the diverse talent that could be brought into the field, and to improve scientific literacy in society. As a Councilor, I intend to help support and develop these programs and help make the APS as effective as it can be in the current era."

The Back Page

Nuclear Energy, Global Warming, and the Politicization of Science

By Spencer Weart

Two quirks of physics pose an existential threat to civilization. In 1939, Frederic Joliot and two colleagues found that when a uranium nucleus is struck by a neutron and fissions, it emits two or three neutrons. That allows an explosive chain reaction. They did not predict this; it just happens to work out that way. And in 1859, John Tyndall found that two triatomic molecules, H_2O and CO_2, absorb infrared radiation but not visible light. That causes our planet's greenhouse effect. He did not predict this; it just happens to work out that way. Today, if the United States and Russia were to use all their nuclear bombs, there is a good chance that vital ecosystems would be ruined, and agriculture and civilization would collapse. The same outcome is likely if we continue on the current trajectory of burning fossil fuels.

"It was inevitable that scientists familiar with these quirks of nature would become deeply engaged in politics, and that science itself would become politicized."

Whether either of these existential threats will come to pass depends mainly on policy choices, that is, politics. So it was inevitable that scientists familiar with these quirks of nature would become deeply engaged in politics, and that science itself would become politicized. In this essay I will sketch the specific path that was followed in each case and draw some general conclusions.

First, the nuclear case. It wasn't politicized — it was born political. Joliot's team fully understood the potential implications of their measurement when they planned it. Within months of their publication of the number of neutrons per fission, the world's premier scientist, Albert Einstein, brought uranium to the attention of the world's premier politician, Franklin Roosevelt. By 1943, before any atomic bombs existed, scientists in the Manhattan Project were planning to take political action after the war's end by going to the public with an information campaign. They meant to impress upon everyone the dreadful potential of atomic warfare ... and the hopeful potential of peaceful nuclear energy. That was the traditional outsiders' route to politics: Explain matters to the public, and trust that appropriate official policies would follow. Meanwhile a few leaders took the insiders' route: They privately approached policy makers within the U.S. government with advice (in particular, whether the first atomic bombs should be used on cities).

Immediately after the war ended, the "atomic scientists" gave interviews to journalists, wrote articles, gave public speeches, and held classes on atomic science for eager groups of Congressmen and Senators; meanwhile some privately counseled officials and diplomats. One aim was to secure international control over atomic weapons. That effort failed. Another aim was to secure civilian control and promotion of a peaceful nuclear industry. That effort triumphed in the 1946 Atomic Energy Act.

And so it continued. Some scientists worked strictly through government channels, like the JASON group offering secret advice to the Department of Defense. Others were wholly outsiders, like the Union of Concerned Scientists, founded in 1969 to agitate against plans to build anti-ballistic missiles (ABMs). The apogee of the insiders was the Presidential Science Advisory Committee, which made significant contributions to policy. President Richard Nixon disbanded the committee when some members publicly opposed ABMs and other administration priorities. It's not easy to be both an insider and a public advocate. (In the Soviet Union, when Andrei Sakharov published his opposition to ABMs he was likewise expelled from his insider role.)

Science itself, the claim to knowledge, became politicized in the biggest battle of the early decades. Opponents of nuclear weapons tests, led by physical chemist Linus Pauling, pointed with alarm to the radioactive fallout. The radioactivity might be far below the background radiation level, but this small addition, spread across the entire global population, must cause millions of cancers and birth defects. Other scientists, led by physicist Edward Teller, insisted that at such levels the harm from radioactivity is negligible. To this day the question has not been settled definitively. In any case both sides agreed that the real issue was to prevent billions of deaths from nuclear war: by slowing weapons development (Pauling) or by improving deterrence (Teller). The public debate was mirrored in private by government insiders, including Teller and Sakharov. The result was a 1963 ban on tests in the atmosphere, but not underground. The negotiations for the ban marked an improvement in Cold War relations, so the effort was a partial success for all.

Spencer Weart

There were troubling side effects. First, the debate divided and polarized. People on the political left came to despise Teller's side as tools of militarists, while those on the right despised Pauling's side as dupes of the Communists. Either way, the debate weakened the traditional public image of all scientists as objective, remote from politics, and benign.

Second, radioactivity itself came to be seen as uniquely and horribly evil. Two medical physicists who had supported the test ban, John Gofman and Arthur Tamplin, applied to civilian nuclear industry the argument that even low levels of radiation had a potential for widespread harm. Many others, for example the Union of Concerned Scientists, likewise turned to criticizing the safety of civilian reactors. Ultimately governments placed strict limits on emissions of radioactive substances — far stricter than they permitted for comparably carcinogenic and mutagenic substances from other industries (for example, coal-fired power plants). It is an open question whether this was a success for the politics of science.

"We need to broadcast a human-level explanation of how the scientific community manages to arrive at trustworthy conclusions."

Next, the climate case. This was only gradually politicized. To be sure, by 1960 a few noted scientists had warned both the public and policy makers that there was a long-term risk of dangerous climate change from humanity's CO_2 emissions. But they were not certain the risk was real, so the only policy they advocated — persistently, for decades — was better coordination and funding for climate research. They did get some money, but coordination remained sketchy.

A turning point was a 1983 report issued by insiders at the Environmental Protection Agency, predicting dangerous impacts from fossil fuel emissions. President Ronald Reagan's administration, hostile to anything that might stimulate regulation of industry, saw the report as a political attack. They attacked it in return, opening a caustic public debate. The issue was taken up on the left by environmentalists (including the Union of Concerned Scientists). Again scientists were called on to give tutorials to journalists and groups of senators. Stephen Schneider, in particular, reached out to the media and wrote for the public. He faced acid criticism from some colleagues: the sound bites necessary for television lacked the lengthy caveats and subtleties that they felt a true scientist must deploy. Wasn't it better to stick to writing scientific papers, and trust that the facts would ultimately persuade governments to adopt correct policies?

By the late 1980s many leading climate scientists were saying that governments should vigorously restrict emissions. In response the fossil-fuel industry launched a coordinated public relations campaign to raise doubts about the validity of climate science. A lobbying effort meanwhile approached Congress and officials behind the scenes. Millions of dollars, eventually hundreds of millions, subsidized everything from book publications to primary election campaigns. Many people with anti-regulation convictions independently supported the campaign.

Not only scientific results were called into question. Far more than before, individual scientists came under vicious and scurrilous personal attack; some had to call for police protection or take up legal defense of their privacy and reputations. The attacks spread beyond the personal. The Intergovernmental Panel on Climate Change, which reported the unanimous consensus of scientists representing the world's governments, was denounced by one widely-read blogger as "guilty of nothing short of making the science fit their political agenda" [1]. A well-publicized scientist pointed to ambiguous quotations cherry-picked from a trove of stolen emails as indicating a "conspiracy to commit fraud" [2]. A leading U.S. senator repeatedly called global warming a "hoax" [3]. It was an assault, beyond any historical precedent, on the public's trust in the objectivity and integrity of an entire scientific community.

The nuclear and climate cases have much in common. Both began without noticeable partisan polarization, but split sharply into left vs. right as soon as government policies came into question. In particular, the issue of regulation of an important industry naturally divided people with different ideological commitments. In both cases scientists were deeply involved both inside the corridors of government and in appeals to the public, but got into trouble if they tried to do both.

Results were mixed. Scientists were united in their efforts to make people fear nuclear war, and they contributed significantly to preventing it ... so far. Scientists were successful at first in fostering a civilian nuclear industry, but disagreement among experts contributed to limiting this success. A sustained effort to tell the world it must act to avert global warming was quite successful in a few European nations, but in most nations the progress has been too little, too late.

The chief difference between the cases is that the existential threat of nuclear war has diminished, while that of climate change has grown. There are several reasons why climate has proved intractable. For one, chauvinism and militarism are potent but diffuse foes, whereas the fossil fuel industry and right-wing ideology are vast and well organized concentrations of power. Today scientists must defend not only particular individuals, not only particular scientific results, but science itself: our methods and our community. Experience shows that in such a struggle, facts are not always convincing (even when they are understood, which is rare). We need to broadcast a human-level explanation of how the scientific community manages to arrive at trustworthy conclusions. It is the obligation of every scientist to participate in this crucial enterprise.

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