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Top Physics News Stories of the Decade
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"April" Meeting Highlights Latest Research and Celebrates the Laser's 50th Anniversary

The next "April" Meeting is just around the corner, convening this year in Washington, DC from February 13th to the 17th, coinciding with the annual winter meeting of the American Association of Physics Teachers. The April Meeting will bring together over 2,000 physicists, highlighting the latest particle, plasma, nuclear, and astrophysics research, with over 75 invited sessions, more than 100 contributed sessions and four poster sessions.

LaserFest. In 2010, to mark the fiftieth anniversary of the invention of the laser, APS has partnered with the OSA, IEEE Photonics and SPIE to sponsor the yearlong celebration LaserFest, which kicks off at the meeting. Events include a booth to promote the many events throughout the year, a special kick-off ceremony and a laser-themed public lecture. Nobel laureate and Director of the Max Planck Institute für Quantenoptik, Theodor Hänsch, will present his public lecture titled "From Edible Lasers to the Search for Earth-like Planets–Five Decades of Laser Spectroscopy." The talk will highlight how over the last

50 years, lasers have gone from a "solution in search of a problem" to an indispensable tool for scientists. Hänsch won the 2005 Nobel Prize in physics for his work developing the optical frequency comb technique, which measures the frequency of light waves to extraordinary precision.

Other sessions as well will demonstrate the importance of lasers in physics. Session X4 highlights how lasers revolutionized many precision instruments. J.A. Giordmaine of NEC Laboratories America will recount the invention of the original ruby laser in 1960. Federico Capasso of Harvard University will describe how Quantum Cascade Lasers, invented in 1994, have found uses in applications such as spectroscopy, trace gas analysis, and atmospheric chemistry. The third talk will further look at how Hänsch's optical comb technique dramatically improved the accuracy of nearly all known optical frequency standards.

Plenary Sessions. The three plenary sessions (E1, N1, V1) this

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Membership Count Hits New Peak

The official count of APS membership has been tabulated and has reached a new record of 47,947 members as of January 2010, surpassing last year's record by 758 members.

For the second year in a row, the number of student members has dramatically increased, driving up the number of members overall. In 2009, APS added 954 new students to its rolls.

APS Director of Membership Trish Lettieri credited much of the increase to the continued efforts by the Forum on Graduate Student Affairs to inform students of the benefits of membership in the APS. Junior Memberships, discounted membership rates available to recent graduates, were also up almost 5 percent in 2009.

"The fact that the Society membership has continued to grow in these tough economic times is very impressive," said Lettieri, "Other scientific societies have seen both their membership and meeting attendance decline over the last year, yet APS seems to be holding strong in both

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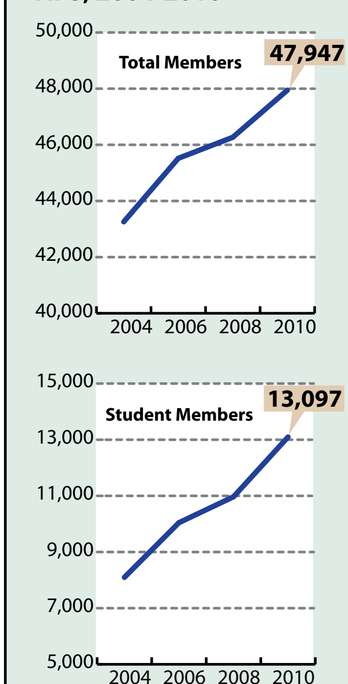
Increase in members of APS, 2004-2010



NOTE: Graphs are on different scales and totals from January 2010

Soviets Used Lasers to Track US Spacecraft

By Michael Lucibella

In October, *APS News* reported how the United States Air Force is restricting the use of laser guide star adaptive optics. Observatories that use these high powered lasers to filter out atmospheric interference have to have their observation plans approved days in advance by the Air Force's Laser Clearing House so no beams inadvertently hit a passing satellite.

Since then additional information about efforts to ease the restrictions has come to light, as well as little-known instances nearly thirty years ago when the Soviet Union tracked US spacecraft with ground based lasers.

All of the scientists and officials interviewed in October's article said that they knew of no instances where a laser hit a passing spacecraft. However a search of NASA's historical archives turned up several instance in the late 1970s and 1980s where satellites and even the Space Shuttle were tracked by Soviet ground based lasers.

During the Cold War, the Soviet Union worked to develop an anti-satellite weapon using powerful lasers at the Sary Shagan research complex in Eastern Kazakhstan. The laser they developed, known as Terra-3, was never powerful enough to shoot an orbiting space craft out of the sky, but could have damaged sensitive onboard optical equipment. Accounts as early as 1975 reported that the Soviet Union was using the red and infrared lasers at the complex to track the positions of passing satellites, occasionally interfering with infrared sensors. The Department of Defense denied those claims at the time; however after the breakup of the Soviet Union, accounts emerged in both the US and Russian media from those involved that seemed to confirm the events.

Concerns that the Space Shuttle would be used for reconnaissance led the the Soviet Minister of Defense, Dmitry Ustinov, to first ask in the fall of 1983 that the lasers at Sary Shagan be used to track the Space Shuttle. One year later, on October 10th 1984, the Terra-3 laser was trained on the Space Shuttle Challenger as it passed over the complex. The laser was set to its low power tracking setting. The United States government filed a formal diplomatic complaint with

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APS Meetings Feature Beller, Marshak Lecturers

This year, APS will sponsor the travel of three distinguished physicists from around the world to speak at the March and "April" meetings through its named lectureship grants. Each lectureship recipient was chosen by the APS Committee on International Scientific Affairs after being nominated by different APS units.

The recipient of the Marshak Lectureship, Mukhles Sowwan of Al-Quds University in the Palestinian Authority, will speak at this year's April Meeting about the formation of the Synchrotron-light for Experimental Science and Applications in the Middle East. Recipients of the Beller Lectureship, Joseph Klafter of Tel-Aviv University in Israel and Nathalie Picqué of the Laboratoire de Photophysique Moléculaire in France will speak at the March Meeting about Lévy flights and broadband spectroscopy with laser frequency combs respectively.

Sowwan's research specializes in nanotechnology, especially in the area of biophysics. His talk, in session Q3 on Monday, February 15, will describe how the SESAME laboratory is a unique multidisciplinary center for particle physics in the Middle East. Modeled after CERN, its member countries includes countries that are often political adversaries, such

LECTURES continued on page 4

Global Survey Will Compare Men and Women Physicists

The American Institute of Physics has partnered with the International Union of Pure and Applied Physics to conduct a global survey of physicists' careers. The aim of the study is to compare the experiences of professional men and women physicists around the world.

This is the first time that the experiences of both men and women are being polled, as well as the first time the questionnaire has been translated into multiple languages. This is the third time that the AIP and IUPAP have partnered to conduct such a survey.

"We want people to tell us about their career in physics," said Rachel Ivie, a member of the statistical research staff at AIP, "We're looking to see gender differences in careers."

The main aim of the survey is to collect information about how the experiences of men and women physicists compare. Ivie said that the authors of the survey hope that with this study they can put together an accurate picture of the status of physicists across the globe.

The previous two surveys only collected data from women physicists. This time, the AIP and IUPAP broadened the scope of the survey to include men as well. This way, the two organizations will be able to directly compare the reported experiences of women with men.

Since the survey is translated into multiple languages, the teams will be able to compare data, not just from English-speaking countries, but from around the world. The survey is available in English, Arabic, Russian, Chinese, Japanese, French, Spanish and German.

Already the survey has been sent out to members of the Australian Institute of Physics, and the Japanese and German Physical Societies, and soon will be sent to the Canadian and French Physical Societies as well.

The survey has already been sent out to a sample of about 3600 members of the American Physical Society. However anyone is welcome to take part in it. Questions range from queries about educations levels and marriage status, to inquiries about experiences at their first and current jobs. Ivie said that of particular interest to the survey's authors was to see what effect having children has on the careers of physicists.

The survey is also going out to physics students in addition to professionals. Questions for them also inquire about what first interested them in a career in physics, and why they stuck with it.

The survey will run through spring and can be found at http://www.aipsurveys.org/global/.

Members in the Media

"I am opposing the holy brotherhood of climate model experts and the crowd of deluded citizens who believe the numbers predicted by the computer models.... I have studied the climate models and I know what they can do. The models solve the equations of fluid dynamics, and they do a very good job of describing the fluid motions of the atmosphere and the oceans. They do a very poor job of describing the clouds, the dust, the chemistry and the biology of fields and farms and forests."

***Freeman Dyson**, Princeton.* The New York Times*, December 14, 2009.*

"Although Iran might claim that this work is for civil purposes, there is no civil application…This is a very strong indicator of weapons work."

***David Albright**, Institute for Science and International Security, after scrutinizing secret documents about Iran's nuclear program.* United Press International*, December 14, 2009.*

"[E]ach time you have this touch down, you see the disease spread out like a wave."

***Alessandro Vespignani**, Indiana University, on the surprising way diseases use cars to spread through cities,* USA Today*, December 15, 2009.*

"He gave me a high five after my talk…He was so enthusiastic and so excited to see this prediction become true."

***Randall Hulet**, Rice University, after verifying Vitaly Efimov's decades old theory on quark interactions,* MSNBC.com*, December 16, 2009.*

"Our discovery demonstrates how microscopic swimming agents, such as bacteria or man-made nano-robots, in combination with hard materials can constitute a 'smart material' which can dynamically alter its microstructures, repair damage or power microdevices."

***Igor Aronson**, Argonne National Lab,* United Press International*, December 16, 2009.*

''Anybody can change a wiki online. It may get changed back, but at least they have the ability to change it. "

***Chuck Niederriter**, Gustavus Adolphus College,* The New York Times*, December 16, 2009.*

"Maybe computers still seemed somewhat magical back in 1985…[It's] the only way to explain how two dateless teen-aged boys, desperately trying to program a computer simulation of a woman, end up with Lisa, a living, breathing and totally beautiful creation with supernatural powers."

***Sidney Perkowitz**, Emory University, on the film "Weird Science,"* CNN.com*, December 17, 2009.*

"There is a dark star song by Crosby, Stills, Nash and Young, too, that we had in mind,"

***Katherine Freese**, University of Michigan, on the naming of theorized dark matter stars that existed in the early universe,* MSNBC.com*, December 21, 2009.*

"We want it to be true–we so want to have a clue about dark matter."

***Maria Spiropulu**, Caltech, about recent anomalous readings at the CDMS detector in Minnesota,* The New York Times*, December 28, 2009.*

"My job is neat…The improvements in time and frequency measurements have made possible a revolution in telecommunications services and other important technological advancements for our country."

***Judah Levine**, NIST,* The Washington Post*, January 4, 2010.*

"The most impressive thing is it's an integration of fundamental science and world-leading engineering–it's the thing that the British are not supposed to be able to do."

***Sir Richard Friend**, Cavendish Labs, on the launch of an upcoming flexible E-reader,* BBCNews.com*, December 31, 2009.*

"We got into it, because we are trying to design new materials for the Air Force that have interesting optical properties."

***Sharon Glotzer**, University of Michigan, on ways to improve the packing density of tetrahedrons,* The New York Times*, January 5, 2010.*

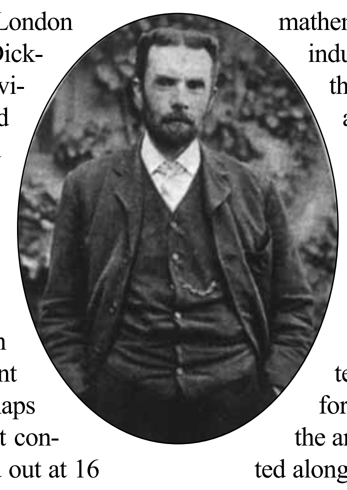
"Europeans only used half as much energy per dollar of GDP, and it was clear that their lifestyle was as good as ours."

***Arthur H. Rosenfeld**, California Energy Commission,* The Los Angeles Times*, January 11, 2010.*

This Month in Physics History

February 3, 1925: Death of Oliver Heaviside

Physicists routinely employ a handy mathematical device known as the Heaviside step function, particularly in control theory and signal processing, where it represents a signal that switches on at a specified time and stays on indefinitely. It is named after the English polymath Oliver Heaviside. While the Heaviside step function is well-known in scientific circles, it is probably one of his least innovative contributions to 19th century mathematics and science, as he toiled in relative obscurity and enjoyed little recognition in his lifetime.



A product of Camden Town–the London slum that also produced Charles Dickens–the red-haired, diminutive Heaviside was one of four sons of a wood engraver and water color artist named Thomas Heaviside. Young Oliver fell ill with scarlet fever as a child, which left him partially deaf. His social skills seem to have suffered as a result: he did not get along with the other children at school in Camden Town, although he was a top student in every subject save geometry. Perhaps traditional education simply couldn't contain his eccentric genius: he dropped out at 16 to continue his schooling at home.

It helped that his uncle was Sir Charles Wheatstone, who co-invented the telegraph in the 1830s and was a recognized expert in telegraphy and the relatively new field of electromagnetism. Within two years, young Oliver found himself working as a telegraph operator, first in Denmark and then in Newcastle upon Tyne. He quickly advanced to chief operator for the Great Northern Telegraph Company. It was the only full-time employment he ever experienced.

Heaviside discovered James Clerk Maxwell's seminal *Treatise on Electricity and Magnetism* in 1873, and was so enthralled by the work that he quit his job the following year to devote himself to studying it full-time, moving back into his parents' home in London. Despite his lack of knowledge beyond algebra and trigonometry, he soon grasped the essential points. Then "I set Maxwell aside and followed my own course, and I progressed much more quickly," Heaviside later recalled. In the end, he reduced Maxwell's equations from 20 equations in 20 variables, down to four vector equations in two variables. Those four equations, as every physicist now learns, describe the nature of static and moving electric charges and magnetic dipoles, as well as electromagnetic induction.

In addition to the step function and vital contributions to the development of vector calculus, between 1880 and 1887, Heaviside also developed operational calculus, enabling him to solve differential equations by turning them into algebraic equations. He did this by replacing the traditional differential operator with a variable (p). Once it was solved, the algebraic solution could be transformed back with the help of conversion tables to yield the solution to the original differential equation.

This particular breakthrough was controversial at the time, in part because Heaviside did not show his derivations. A paper on the subject that he submitted to the *Proceedings of the Royal Society* was rejected on those grounds. Heaviside didn't like constructing rigorous mathematical proofs, once famously declaring, "Mathematics is an experimental science, and definitions do not come first, but later on." On another occasion, he opined, "I do not refuse my dinner simply because I do not understand the process of digestion."

Heaviside's early employment as a telegraph operator also informed his research. For instance, he helped develop transmission line theory (the so-called "telegrapher's equations"), demonstrating mathematically that if one could distribute inductance in a telegraph line uniformly, this would cut down on the attenuation and distortion of the signal. In fact, if the resistance wasn't too great, there would be no distortion in the circuit at all and currents of all frequencies could propagate at the same speeds.

Based on this work, in 1887, he proposed that the use of induction coils placed at regular intervals along telephone lines could produce that uniform inductance and thus greatly decrease the amount of distortion of signals transmitted along the lines. But Heaviside never patented his idea after his paper appeared in *The Electrician*. Years later, Michael Pupin of Columbia University and AT&T's George Campbell built upon Heaviside's earlier work. Pupin was awarded the patent in 1904. He offered to share the proceeds with Heaviside, but the latter man refused unless AT&T also gave him full recognition for the innovative idea–even though he was nearly destitute by this point.

Perhaps his best known achievement, apart from the step function, is the prediction that Earth's atmosphere had an ionized reflective layer capable of bouncing radio signals back to Earth, such that the radio signals followed Earth's curvature. His hunch proved correct when it was experimentally verified in 1923 by transmitting radio pulses vertically and receiving the returning signals from the reflecting layer. This is now known as the Kennelly-Heaviside Layer in his honor. Composer Andrew Lloyd Webber immortalized this discovery in his musical *Cats*, based on the poetry of T.S. Eliot: "Up, up, up past the Russell hotel/ Up, up, up to the Heaviside layer…"

Despite his election as a Fellow of the Royal Society in 1891, and an honorary doctorate from the University of Gottingen in 1905, Heaviside never gained the recognition he deserved for his many accomplishments during his lifetime, about which he was justly bitter. He became quite eccentric in his later years, spending the last two decades of his life as a virtual recluse in Torquay near Devon, plagued by bouts of jaundice and the tormenting of neighborhood children, who threw stones at his window and scrawled graffiti on his front gate.

Neighbors reported that his home was furnished primarily with huge granite blocks. Otherwise scruffy and unkempt, he took to painting his impeccably manicured fingernails bright pink, and signing letters with the mysterious initials "W.O.R.M." after his name. He died on February 3, 1925, at home in Torquay on Devon, and is buried in Paignton cemetery in England–unsung, but not entirely forgotten.

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Education Corner

A column on educational programs and publications

Physics Teacher Education Coalition (PTEC) Conference

The sixth annual Physics Teacher Education Coalition (PTEC) Conference will be held on February 12 and 13 at the Omni Shoreham Hotel in Washington, DC. In addition to workshops led by national leaders in physics teacher education, the conference will feature plenary talks by Linda Darling-Hammond, Professor of Education at Stanford University; Kumar Garg, Policy Analyst in the Technology Division of the White House Office of Science & Technology Policy; and Stamatis Vokos, Professor of Physics at Seattle Pacific University, who will unveil the findings from the joint APS/AAPT/AIP Task Force on Teacher Education in Physics. The full program, including abstracts and presenter biographies, is available at www.PTEC.org/conferences/2010.

Education Workshop at March Meeting

The APS Forum on Education (FEd) is sponsoring a half-day workshop prior to the APS March Meeting entitled "Making it Good: A Workshop on Strategies for High-Quality, Effective Educational Materials and Efforts." Presenters Greta Zenner Petersen of the Materials Research Science and Engineering Center at the University of Wisconsin-Madison will address the iterative development process for creating educational materials, from initial concept to evaluation. The workshop will take place from 1 to 5 p.m. on Sunday, March 14. For more information, visit www.aps.org/meetings/march/events/workshops/fed10.cfm.

All FEd-sponsored sessions at the "April" and March Meetings are listed at www.aps.org/units/fed/newsletters/fall2009/woolf.cfm.

AAPT 2010 Winter Meeting

The American Association of Physics Teachers (AAPT) 2010 Winter Meeting will run from February 13 to 17 in Washington, DC with the theme "Physics For the Nation's Future." The program includes workshops on the 13th and 14th, and sessions from the 15th through the 17th. The meeting will run jointly with the APS "April" Meeting, and a number of sessions will be co-sponsored by the APS Forum on Education. For more information, visit www.aapt.org/Conferences/wm2010.

Noyce Scholarship Program

Funding for the National Science Foundation's (NSF) Robert Noyce Teacher Scholarship Program, which supports future math and science teachers, has increased dramatically as a result of the federal government's commitment to science, technology, engineering, and mathematics (STEM) education. For Fiscal Year (FY) 2010, Congress has supported the NSF's request of $55,000,000 for the program, maintaining the FY 2009 funding level, not counting Stimulus funding. As a result of this program, over 100 colleges and universities around the country have provided scholarships to future teachers who plan to teach at high-need schools in the US after graduation.

Proposals for the next round of funding for both Noyce Scholarships and NSF Teaching Fellowships/Master Teaching Fellowships are due by March 10. For more information, visit www.nsfnoyce.org.

Educate to Innovate

On January 6, President Obama expanded his "Educate to Innovate" campaign, which seeks to improve the participation and performance of America's students in STEM fields. Among other initiatives, the President announced that 79 university presidents pledged to collectively prepare 10,000 math and science teachers by 2015, as part of the Association of Public and Land-grant Universities' (APLU) Science and Math Teacher Imperative. A letter signed by the presidents cites the APS-led Physics Teacher Education Coalition (PhysTEC) project as well as a joint NSF-funded APS-APLU Math and Science Partnership that is studying conditions that promote change.

Congressional Appropriation to NSF

For Fiscal Year (FY) 2010, Congress has provided $872,760,000 for the Education and Human Resources (EHR) division of the NSF, an increase of $27.4 million, or 3.2 percent, over the FY 2009 appropriation as well as an increase of $14.9 million, or 1.7 percent, over the administration's request. According to the accompanying statement, "The increase over the budget request is to support additional work in experiential learning as directed by the House with a substantial portion of the initiative focused on K-6 STEM education."

COUNT continued from page 1

of those areas."

The number of international memberships increased modestly as well, growing by almost 200 people. About 10,000 international physicists make up 21 percent of APS's overall membership.

These membership counts are held every year to assess the health of the Society. The membership numbers are important also in enhancing the Society's grass roots lobbying efforts when advocating for improvements in science policy and increased research funding.

Looking Back: The Top Ten Physics Newsmakers of the Decade

January 1st brought not only a new year but an entire new decade. Usually in this issue, *APS News* looks back over the biggest news stories of the last 12 months. However, with the dawning of a new decade we wanted to take time this issue and highlight not just the biggest physics newsmakers of 2009, but the biggest physics newsmakers of the last ten years. These are the stories that may or may not have the most lasting physical significance, and may or may not have had the most impact within the physics community, but they represent the physics news that the public was reading and hearing about in the broader media over the last decade.

The Large Hadron Collider. With the potential to produce colliding beams of 7 TeV, it's the most powerful particle accelerator in the world. With a circumference of 17 miles, it's also the largest particle accelerator in the world. Costing upward of $6 billion to build, it is the most expensive science project in history. With millions of individual precision parts it is the most complex machine in the world. There are so many records associated with this modern marvel of science that it may also be the most superlative-laden physics story in history.

After almost fifteen years of development and construction, the accelerator was first switched on in September of 2008 with much fanfare. Just over a week later it suffered a critical malfunction when an electrical fault triggered a major leak of liquid helium, knocking more than fifty of its superconducting magnets out of alignment. Major repairs shut the collider down for over a year. However in November of 2009 it restarted, taking its time to warm up this time around. Now colliding particles at energies over 2.36 TeV, it is renewing its search for the Higgs boson.

The Decade of Carbon. Over the last ten years research into regularly structured carbon molecules has expanded tremendously, becoming one of the hottest fields in condensed matter. Carbon atoms arranged in hexagonal lattices have shown remarkable electronic and structural properties. Many in the field say that these materials are poised to revolutionize electronics over the next century. With careful manipulation carbon nanotubes and graphene can be used to create microscopic wires, diodes, semiconductors and more, shrinking electronics to unprecedented levels. At the same time these nanostructures are extraordinarily strong and with more development could be used to create materials of unprecedented strength. It's even been surmised that nanotubes could serve as a tether that runs from the surface of Earth to an orbiting satellite for a proposed space elevator.

Negative Index of Refraction Materials. Tremendous advancements have been made over the last several years in creating meta-materials that can make objects seem to disappear. British scientists first theorized a way to make composite materials that divert light around an object in 2006. Since then, scientists around the world have been developing ways to engineer it. After first constructing a prototype that could redirect microwaves, a team at Duke University created a material that can redirect wavelengths from nearly the entire electromagnetic spectrum. All the while, the press has had a blast comparing the material's ability to bend light to Harry Potter's invisibility cloak, or to a Star Trek cloaking device, or to the Predator's invisibility suit.

The Wilkinson Microwave Anisotropy Probe. The cosmic microwave background radiation is the leftover heat from the Big Bang that permeates the universe. The Wilkinson Microwave Anisotropy Probe's mission (WMAP as it is

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INSIDE THE BELTWAY

WASHINGTON ANALYSIS AND OPINION

Vox Populi

by Michael S. Lubell, APS Director of Public Affairs

Sean Hannity, Glenn Beck, Bill O'Reilly and the rest of Roger Ailes's *Fox News* minions might have given the "Tea Baggers" a larger megaphone than their actual numbers merited during last summer's congressional town hall meetings, but make no mistake about it, the protesters were steeped in something more profound than a boiling teapot of right-wing palaver.

It's easy to dismiss people who walk around with a fringe of tea bags dangling from the brims of their bonnets as members of a lunatic fringe. But polling data reveal a trend in public sentiment in which the Tea Baggers may actually be in the vanguard. They could very well represent the cusp of a brewing populist uprising, one that has already taken down a major Democratic leader, five-term Connecticut Senator Christopher J. Dodd, who announced in early January that he would not seek re-election in November.

Two years ago Dodd's withdrawal would have been unthinkable. During his three and a half decades of service in Congress, poll after poll perennially rated him one of the most popular politicians in Connecticut. But within the last year his approval ratings plummeted–so much so that analysts increasingly viewed the 2010 race as a certain Republican pick-up.

What brought Dodd to the brink of electoral rejection was voters' perception that he was too cozy with big banking and too enthralled with big government. As chairman of the Senate Banking Committee, he stood accused of getting a sweetheart personal deal from now-defunct mortgage lender Countrywide Financial and of protecting the bonuses of executives of Connecticut-based insurance giant AIG, which received more than $150 billion in government loans.

The Senate Ethics Committee exonerated him of any wrongdoing with Countrywide and records show the White House had requested the waiver for AIG executives on legal grounds, but both charges stuck in the minds of his constituents, and that's all that matters.

As acting chairman of the Senate Health, Education, Labor and Pensions (HELP) Committee, Dodd also had the task of pulling together the Senate's first version of a health reform bill. The sea of accusations of a government takeover and the creation of death panels drowned out discussion of any positive features the bill contained. In the end, the HELP bill foundered and all that remained afloat was the image of Dodd embracing Washington.

Dodd's decision not to run will probably keep the Connecticut seat in the Democratic column, but the saga highlights the very palpable public pique with big government, big banking and big business. Such hostility is a big deal because it can have profound political and policy consequences–so profound that even science could be caught up in an ensuing full-blown populist rebellion.

From the times of the founding of the Republic, Americans have never been enamored of an elite ruling class. As Eric Burns's book, *Infamous Scribblers*, so ably documents, even George Washington came under withering attacks by the nascent Antifederalist press, which articulated the populist sentiments and sensibilities of the era.

Back then Benjamin Franklin was synonymous with American science. But back then, Franklin, as his biographer Walter Isaacson writes, was regarded with some distrust as more French than American, more elitist than plebian.

Given such a landscape it is remarkable that the framers even mentioned science at all in the United States Constitution. They did once in Article 1 Section 8, but

VOX POPULI continued on page 7

Letters

Steps to Remember in Teaching Science

Regarding Joseph Ganem's Back Page article in the October *APS News* on the status of physics teaching in American schools and subsequent letters by Tony Loomis and Ian Hutchinson: My experience and observations are based on my teaching of physics at a high school, community college and at a university in Canada.

The elementary school teachers are not subject specialists and therefore they need a lot of help which they do not get and they end up teaching the subject of science on the basis of their experience as to how they were taught science.

In the high schools, most of the teachers who teach physics have never taken any university physics courses or if taken it would be only one. As not having much deep knowledge in the subject they are unable to recognize the importance of conceptual learning and hence never try to bring in related demonstrations, examples of life experiences, so students do no learn as to how to think and the technique of problem solving.

Instead of going into the status of teaching physics at the undergraduate and post graduate level, I would like to state the pedagogical steps that teachers should remember in the profession of teaching "science" as stated by the late Prof. Arnold Arons, Professor of Physics, Washington State University, in the Plenary Session Address, August 1991, at the Soviet/American/Canadian Conference on Science Education.

• Scientists should not extrapolate their own experience to the majority of their students. Only a very small fraction of our students learn as rapidly as we did.

• There exist no verbal explanations and no demonstrations so perfect and so clear as to convey understanding, mastery of concepts, or mastery of modes of abstract reasoning to passive listeners. It is necessary to keep returning to the ideas and modes of thinking at intervals in altered and richer context. On each return, a few additional students achieve success.

• Such mastery of thinking and reasoning do not become rapid with increasing age of the learner.

• Many slower learners fail to grasp abstract concepts and modes of reasoning unless they are led to explain the reasoning more than once, in their own terms.

• Understanding is knowing where the ideas that we are dealing with come from.

Eknath Marathé
St. Catharines, ON

Electron Accelerators Best at Treating Cancer

In the article on accelerators in the December *APS News*, Dennis Kovar says that the scientific community needs to do a better job of conveying those (applications of accelerator beams) benefits. The rest of the article clearly demonstrates this.

Claims that cancerous tumors were first treated with accelerated particle beams in 1961 (Harvard proton cyclotron) are a perfect example. Proton therapy was first performed at Berkeley in 1954. However, electron accelerators were used in radiation therapy much earlier, beginning in the 1940s. I thought maybe electrons weren't being considered as "particles", but the article did mention the FEL at TJNAF.

Jurgen Debus described how proton therapy is used to treat a relatively rare disease that has other effective treatment options. This is another great example of truly failing to communicate the benefit of accelerator R&D. If ocular melanoma is a prime example of the benefit, then Brian Baird is right; the money should be spent elsewhere.

In truth, it is electron accelerators that have provided the largest benefit in treating cancer. These are accelerators (particle ones, I believe) and they have become very mature. Proton accelerators have not as yet provided a comparable benefit in this area. They may, particularly as technologies develop (superconducting devices, laser wakefield accelerators, dielectric wall accelerators, etc.).

In the meantime, I think it is true that we do need to do a better job of communicating.

Charles Bloch
St. Louis, MO

Bob Park Got There First

I was disappointed that the article on the "new" physics blog put out by the APS Washington office did not mention the fact that this is far from a new idea. The Washington office of the early 1980s established the blog–not known by that name, then, of course–"What's New," edited by Bob Park. It thrived and when he retired he continued it under his own steam with other support–in fact, it still is regularly issued. I welcome the successor, it fills a real need, but it is not an original idea.

Phil Anderson
Princeton, NJ

CORRECTION

In my Letter to the Editor published in the May, 2009 issue of *APS News* I erroneously referred to Yakov B. Zel'dovich as "Yuri."

I deeply regret this oversight.

Victor S. Alpher
Austin, TX

Less Einstein and Edison, more Pasteur

In his Back Page article (December 2009), Philip Wyatt raises very important issues about the place of physics in today's American society. While I share his concerns about the disconnect between physicists and "industry," I want to comment on a few points where I have some disagreements. As someone who works in industry (almost nine years in R&D of a great US chemical company) but also spent seven years in postdoctoral fellowships, I see very clearly that the atmosphere, motivation, and rewards in academia and industry are very different. There is always a tension between striving to understand a phenomenon to the best of our ability (which is what scientists want) and to utilize one's understanding to benefit one's company, or country, or humanity (which is what inventors want). As one of our old-timers was saying, an industrial scientist should strive to be less like Albert Einstein (pure science) or Thomas Edison (inventions based on great intuition and hard work) but more like Louis Pasteur (combining research with its application). Obviously, this means constant internal compromise, significant discipline, and ability to prioritize. For many people who go into physics to emulate Einstein, industrial positions could mean unhappiness, constant regret, and family problems; "Waiting-for Godot" postdoctoral positions would be much better! Wyatt suggests that re-directing one's effort to help American manufacturing could be a worthy goal. Perhaps; yet I do not believe that anyone should be forced to sacrifice personal happiness for that goal. If they voluntarily decide to, they must be clear why they are doing that.

This is, of course, looking back. Going forward, I agree that there needs to be a dramatic improvement in training of young physicists to make them better prepared to the demands of today's and future industry. This probably should mean a stronger emphasis on the development of Applied Physics and Engineering Physics programs in most universities, as well as clear delineation of Pure Physics programs. Young people who go into Pure Physics should be given to understand that they will likely have difficulty finding jobs in their field (like History, Art, or Ancient Languages majors); but, they will have an opportunity to interact with Nobel Prize winners and spend a few years in CERN or the Kavli Institute working on some of the most interesting problems in all of modern science. On the other hand, Applied or Engineering Physics programs should be closely integrated with local industries (in Michigan, most Detroit-area universities–Wayne State, Kettering, Oakland–used to work very closely with Big Three auto companies), have engineers from those companies as adjunct or visiting professors, and include mandatory classes on patents, intellectual property, and economics in their curriculum. An applied physicist is going to have a very difficult and thankless task of having to stop his/her research at the moment of maximum intellectual satisfaction in order to transfer the results from research to development; seeing his/her most interesting patents gathering dust because of adverse economics; and ultimately getting rewarded for something that became a success but really was an "it works but I have no idea how!" product. People who can cope with that–and only those people–will be able to enjoy an industrial career. And, of course, professors who do not understand this dynamic cannot fully prepare their students–or, for that matter, do good industry-sponsored research.

Finally, a comment about terminology. I think that in industry today, anyone who has a degree in something which does not have "Engineering" in it is a little suspect. Many "Materials Engineering" PhDs I know are really physicists; some "Chemical Engineering" PhDs have their thesis work done essentially in Polymer Physics. Having degrees in "Applied Physics" or "Engineering Physics" should probably go a long way in alleviating managers' anxiety described by Wyatt. Again, though, I assume that the curriculum in those Engineering Physics programs would prepare students for careers in which Pasteur, and not Einstein, will be their role model.

Valeriy V. Ginzburg
Midland, MI

Need 2-Way Street Between Industry and Academia

The key problem which Philip Wyatt fails to address [*APS News* Back Page, December 2009] is the culture within academia that becoming part of industry constitutes "academic failure." It is perceived as a one-way track: if you join industry then there is very little chance for you to ever rejoin academia, you won't produce papers, you've "sold out." If you see 70% of PhDs clinging desperately to non-permanent post-doc positions then it's specifically because of a fear that once they let go there's no turning back. If there really is a desire to revitalise the connection between physicists and industry then that perception must change, and for that to happen there have to be very clear avenues back to academia if someone decides that they don't enjoy industry after all.

I otherwise strongly agree with everything in the article and that the US will continue to rust if the current trend continues.

Chris Ouellet
Upton, NY

Show Me the Money

Commercial enterprises operate to maximize profit. That is a basic tenet of capitalism. "Outsourcing, financial re-structuring" etc. are not accidents, they are deliberate actions whose goal is to increase profits.

In his Back Page in the December *APS News,* Philip Wyatt implies that the erosion of "the country's manufacturing base" could be reversed if physicists were less "distant, aloof, nerd-like" etc. and the physics community were more involved with industry.

Perhaps he, or someone else, could tell us how the various recommendations he makes would increase the profits of US industry. The trends he laments will not change for any other reason.

Eustace Mendis
Toronto, ON

Physicist Serves on Ford Board

In his December 2009 Back Page article, Philip J. Wyatt states that "No major manufacturing firms in the US have a physicist on their board of directors; nor do such firms have physicists in the top echelons of management." This is not true. Homer Neal, of the University of Michigan, has been a member of the Board of Directors of Ford Motor Company since 1997.

The fact that Ford has come through the recent economic crisis better than other US auto manufacturers may in fact support the point Wyatt was trying to make, but a critical reader will be wary of sweeping generalizations like this.

Eric Myers
Poughkeepsie, NY

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as Bahrain, Cyprus, Egypt, Iran, Israel, the Palestinian Authority, Jordan, Pakistan and Turkey. He was nominated by the Forum on International Physics.

Klafter is one of the earliest pioneers and biggest contributors to the statistical physics of Lévy flights, a category of random walk. In session A4 on Monday, March 15, he will present his research developing ways to better model human mobility in complex environments. His work has many applications in epidemic modeling, city planning, and statistical physics. He was nominated by the Topical Group on Statistical and Nonlinear Physics.

Picqué will speak as part of the March Meeting's focus session on New Trends in Spectroscopy in session Q27 on Wednesday, March 17. She has done much work developing ways to use laser frequency combs in Fourier Transform spectroscopy, and will speak about their uses for broadband spectroscopy in real-time. She was nominated by the Division of Chemical Physics.

The Beller lectureship was first established by Esther Hoffman Beller in 1994 to bring notable physicists from abroad to speak at APS meetings. The Marshak Lectureship was first established in 1996 by Ruth Marshak in memory of her late husband and former APS president Robert Marshak to bring physicists to the APS meetings from developing nations and the Eastern Bloc.

The Greening of the Physicist

By Alaina G. Levine

As a physicist employed by the R and D division of United Solar Ovonics (USO), Jessica Owens' job is to help develop new production materials for solar cells. Working with thin films, "we take recipes to make the solar cells and we try to develop better recipes [to improve efficiency]," she says. As a producer of integrated photovoltaic (PV) materials, USO's goals include constructing solar cells that have higher power output, increased longevity of material, and innovative coatings to capture more light. Clients include global organizations such as Wal-Mart, GM, and Frito Lay.


Jessica Owens
United Solar Ovonic LLC

"I do solid state physics and optics," she gleefully declares, recognizing that although she did not plan to pursue a so-called green job, it was a "happy coincidence" that she is able to apply her scientific know-how to solving problems for society in this way. As part of her position, Owens, whose master's in physics centered on Raman Spectroscopy, works in a laboratory and "develops characterization tools to better understand and better engineer the films we develop," she says. Her work covers a variety of topics and requires versatility. "One day I might help develop substrate materials or another day I might help process the end materials," she explains.

The best aspects of her job, she says with a smile, are "getting to solve a puzzle and playing with toys for a living." But in all seriousness, "at the end of the day, I can say in my own way, I'm doing something for the betterment of other people."

Whether it's for the puzzle or the people, more and more physics-educated professionals are heading towards careers that involve sustainability and the environment. And industries such as alternative energy (solar, wind, geothermal, etc.), green construction, and electronics are eagerly embracing people with physics degrees. More and more green-focused jobs in government and policy are also available for physicists to pursue.

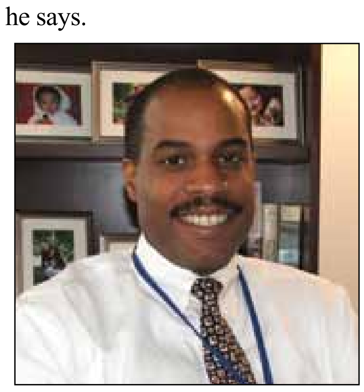
According to information from the Pew Charitable Trusts, as reported by *Physics Today* (June 26, 2009), green energy job creation is occurring at twice the rate of job creation in traditional industries. Jobs in "environmentally friendly services" and clean energy arenas, such as wind and solar, grew at a rate of 9.1% from 1998-2007, compared to other industries, which grew at a rate of 3.7%.

Martin Killeen, US Recruitment Manager for Acre Recruiters, a global firm specializing in sustainability, climate change and the environment, says that in general, any type of technical degree is prized by green industries. On the positive side, "we have had clients who ask [specifically] for physics degrees," he says, although he admits that often the companies want experience to accompany those degrees, generally about five years worth in an industry such as solar and wind energy. He argues that a physics degree is "potentially of value" to employers, especially as the sector migrates to focus more on energy efficiency. "A physics degree is the right avenue to pursue for a green job," declares Killeen.


Paul Maycock,
Founder, PV Energy Systems

This is no wonder to the many physicists who have found success in green industries. Paul Maycock has a master's in physics, and after more than 18 years working for Texas Instruments and the DOE, launched his own consulting firm PV Energy Systems in 1982. His main work today involves conducting due diligence for clients who are interested in photovoltaic solar cell applications. He says that although he doesn't do physics research per se, "it's all physics," and he has moved "from doing physics to evaluating others who are doing physics," Maycock explains. A recent exciting project for his client the International Finance Corporation (IFC) of the World Bank involved an evaluation of a new PV plant in China, in which he did a detailed cost analysis and 20-year forecast. Ultimately, he recommended that the IFC fund it.

His industry is "totally physics-based," Maycock points out, and this need for physics and physicists who understand PV cells will continue to grow as new materials and new structures of cells are developed. "Physicists do very well in PVs because all of it is physics or physical chemistry processes–deposition, ion implantation, junction formation, stabilization layers, conducting oxides, and infusion," he says.


Dr. Albert Green,
CEO of Kent Displays

There are also opportunities for physicists in green construction. Dr. Daniel Boss, Vice President for Engineering at Serious Materials, values people with physics degrees because of the fundamental aspects of science, and in particular optics, that his company's research arm is addressing. His seven-year-old firm produces green construction products intended to save energy, including specially-designed windows, doors, and drywall.

Physicists can easily tackle problems associated with optics, properties of materials, sensors and controls, and heat transfer, all of which are intrinsic to the green building sector, says Boss. Furthermore, since most technical staff in green construction, at least in his company, tend to have an engineering pedigree, physicists provide a diverse and needed viewpoint. "It's nice to have people with different perspectives," he explains. His aim of a "holistic approach to problem solving" is especially prudent given that the industry is becoming more and more technically-based. "Products have to be continuously improved," says Boss, "and that's where cross-functional teams [with] physicists will contribute."

Still, few green building jobs carry the title of "physicist." In December 2009, Serious Materials advertised for the position of Senior Engineer, a job that someone with a master's in physics could easily fill, according to Boss. The job involved research in optics and polymers in the company's windows division, where the person would be developing a new product for windows that would help to control energy flow.

Just as Killeen insists that technical talent often trumps degree title in the competitive world of green jobs, so too does Dr. Albert Green, a physicist himself who is the CEO of Kent Displays. For physicists interested in environmentally-friendly careers, "what matters is not what your degree is in, it's your technical skills," argues Green. His company develops and manufactures reflective, bi-stable LCDs. Their LCD displays do not require power to retain an image, which provides significant energy savings compared to traditional backlit LCDs, according to corporate communications. Their displays also allow for conservation of natural resources through ePaper applications.

"I think the term 'physics' is too restrictive…it's technical knowledge [that matters most] and I want [employees] to know all those things," including chemical physics, electrical systems, materials sciences, and other disciplines, says Green.

And yet, Green believes that "physics is great training, particularly the PhD in physics, because you are able to look at very complex problems and break them apart… That's really the skill that's most important for a physicist." Physicists can also easily migrate to new subject areas, which makes them an asset to his organization and sector.


Elaine Ulrich

This migration of physicists leaving their usual lairs to dwell in verdant pastures is especially seen in Washington. The green sector absolutely relies on physicists who work on the policy side, who often come from diverse backgrounds, says Dr. Elaine Ulrich, a contractor with New West Technologies,

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Letters (continued)

APS Should Conduct an Independent Climate Study

There is much to applaud in APS President Curtis Callan's responses to interview questions in the January 2010 issue of *APS News*. He is indeed correct in noting that all scientists have 'a dog in the fight' to maintain the integrity of the science process in the climate issue. He is also correct to emphasize the importance of due process conducted by elected representatives. Therefore, it is critical that the ongoing process surrounding the APS Climate Statement be above board, engendering confidence by all members, regardless of their point of view.

As one of the group of members who developed the May 2009 Open Letter to the Council, I can say that we were heartened by the Ad Hoc Committee's recognition of problems with the 2007 APS Statement and by the Council's remanding it to POPA for addressing issues of 'clarity and tone.' However, we were disappointed that the Ad Hoc Committee rejected our proposed Alternative Statement, referring only to IPCC reports and their derivatives. These were the very reports that had been challenged, so that merely nodding to them again added no value.

Thus, the Committee did not provide new information to the Council, having simply transmitted IPCC findings while ascribing 'authority' to them. Accordingly, we have proposed that the Society conduct an independent scientific study and assessment so as to gain its own insight into the issue. As of this writing, the Petition for such a study/assessment has gathered nearly 250 signatures, including 90 Fellows and 15 members of national academies. In addition, letters from hundreds of other members demonstrated that a substantial fraction believe that the current APS Statement should be withdrawn, pending an independent scientific assessment. The Petition was submitted to APS leadership in late November. To date, no acknowledgement has been received.

The need for an independent study/assessment has been underscored by the recent "ClimateGate" disclosures. Whatever else these disclosures may demonstrate or lead to, they emphasize the need for the Society to take an independent course. To rely on investigations by the agencies that created and tolerated the conditions revealed by the disclosures is not a credible course. Most importantly, a review of the Ad Hoc Committee's report shows that a majority of the references used to reject the proposed Alternative Statement relies on work derived from individuals directly implicated by the disclosures. Therefore, the scientific credibility of the Ad Hoc Committee's report has been eroded.

Callan says he would like to set a priority "to address the question of how best to argue for societal support of science…" As a first step, the Society needs to demonstrate that it stands for the integrity and vitality of the science process itself. The Society should undertake an independent study and assessment of the global warming issue. Physics is the science best equipped to marshal the needed resources. The impact will not be modest. What we do will be important not just for the Society but also for physics and for science. The world will watch.

Roger W. Cohen
Durango CO

APS Honors Rutherford and Soddy

Photo by Jean Barrette

On November 30, as part of its Historic Sites initiative, APS presented a pair of plaques (one English, one French) to McGill University in Montréal to honor the achievements of Ernest Rutherford and Frederick Soddy. The English plaque read: "At this location, Ernest Rutherford and Frederick Soddy, during 1901-03, correctly explained radioactivity as emission of particles from the nucleus and established the laws of the spontaneous transmutation of the elements." Representing APS were the Chair of the Historic Sites Committee, John Rigden, and Associate Executive Officer Alan Chodos, a McGill alumnus. The photo of the presentation ceremony shows (l to r): Rigden, McGill Principal Heather Munroe-Blum, Chodos, Chair of the McGill physics department Charles Gale, and McGill Dean of Science Martin Grant. (The Principal of McGill is the equivalent of the President of an American university).

Africans Launch New Physical Society

As of mid-January, there is a new APS in the world. The newly formed African Physical Society held its official launching ceremony on January 12, 2010 in Dakar, Senegal. The society aims to act as a forum to bring together physicists from across the nations of Africa for collaborations and to promote the field, especially in countries that don't have a national physical society.

Officially incorporated in Ghana, the AfPS will host scientific conferences, publish a peer reviewed journal and establish a formal means to advance the status of physicists and physics research throughout the African Union. In addition, the Society includes an African Association of Physics Students as well as awards for outstanding work by African physicists. The society held its first scientific meeting following the launching ceremony.

Francis K. A. Allotey, Consulting Director of the Institute of Mathematical Sciences in Ghana, is the interim President of the AfPS. He said that his goals were to "promote and further research in physics and its applications in order to enhance technological, economic and socio-cultural development in Africa; to promote effective contacts and cooperation among Africa physicists; and to collaborate with other physical societies and international organizations in promoting scientific activities in Africa."

Last December, APS president Cherry Murray sent a letter of congratulations to the society on the announcement of its formation. Sections of the letter were read at the launching ceremony.

"The African Physical Society has the potential to serve as an invaluable resource to all African Physicists and help leverage their communications, research, and collaborations," the letter read, "In particular, we applaud the creation of the *African Physical Review*, which will increase the visibility of the physics research conducted throughout Africa."

In addition the American Physical Society donated $3,000 for travel assistance so physicists from around Africa could attend the launching ceremony.

African physicists have been calling for the formation of a multinational professional society dedicated to African physicists for years. In August of 1983, thirty-four leading African physicists and mathematicians convened to form the Society of African Physicists and Mathematicians, the precursor to the AfPS. The SAPM served as the primary professional organization for practicing physicists and mathematicians.

In January of 2007, after grassroots efforts of the Society's membership to change the focus of the organization, the SAPM resolved to reform and rename itself the African Physical Society. In November 2009, at a summit of the numerous national physical societies in Africa, the SAPM formally announced that it would become the African Physical Society. The conference in Senegal was the first official meeting of the new AfPS.

The National Society of Black Physicists has been a major supporter of the AfPS since its first inception. Charles McGruder, a professor of astronomy at Western Kentucky University and former president of the NSBP, was at the 2007 meeting in South Africa and voted for the resolution to form the AfPS.

"Right from the inception we've been part of it," McGruder said, "The main goal is to increase the number of physicists, increase the number of physics students, and increase the amount of African physics, which of course means more funding…We want to develop physics because it will lead to the economic development of Africa."

At the conference, members of the AfPS began to lay the groundwork for the formation of both the African Astronomical Society and the Optics and Photonics Society of Africa.

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the Soviet Union.

Some early accounts of the incident reported that the lasing disrupted communications onboard, and caused discomfort among the crew including temporary blindness. However Payload Commander Kathryn Sullivan and Payload Specialist Marc Garneau both said that there were no such disruptions on board the flight, and the crew was apparently unaware of the event at the time.

Current Efforts

Paul Kintner of Cornell saw the original article in *APS News*, and has decided to pursue the subject at the State Department. He is currently spending a year there as part of the Jefferson Science Fellowship. The fellowship brings tenured scientists into the Agency for International Development for a year to advise on defense policy and technical issues. These subjects generally include policy concerns over global positioning and navigation systems, space weather, space debris and communications issues.

In an interview with *APS News*, Kintner said that he wanted to focus also on the restrictions placed on the use of laser guide stars. He expressed concern at the prospect that the restrictions could hurt the US's scientific competitive edge.

"When we saw your article, sort of a light bulb went off over our heads," Kintner said, "There's sort of a broad confluence that… says this should be part of the discussion."

Leaders of the scientific communities in the United States and the European Union are starting discussions about the long term sustainability of satellite infrastructure. The nations hope to identify potential dangers to the network and come up with ways to protect the orbiting infrastructure. Kintner said he plans to bring up the issue of laser guide stars with the nations at a meeting of Europe's scientific leaders this month.

He said he would not seek to bring European and other nations under the regulation of the Laser Clearing House. Instead he hopes that by raising the issue there, the nations can work together to come up with some kind of multinational system less restrictive than the Laser Clearing House to protect orbiting spacecraft from any accidental damage.

Kintner said also that part of his work would be to find out how serious a threat lasers actually pose to orbiting spacecraft. Right now there are no definitive studies evaluating the likelihood of a satellite randomly running into a beam, and what would happen if it did.

Astronomers are not the only scientists to use lasers that fall under the purview of the Laser Clearing House. Researchers studying high atmosphere winds and other weather conditions likewise track atmospheric distortions using high powered lasers. Gary Swenson of the University of Illinois at Urbana-Champaign has been developing tools to study the turbulent upper atmosphere. He said that while the restrictions weren't hindering research, the restrictions were a nuisance.

"We're putting quite a bit of time into making sure we can shut our beam down," Swenson said, "It becomes a cost for us, we have to put extra time into these nuisance factors."

In addition, he said that the additional time and paperwork needed to secure permission to use the laser was cumbersome. It takes several months to register a laser with the Laser Clearing House. Once registered, they have to fill out requests days in advance for each use, call in and double check if there have been any changes fifteen minutes before switching on the laser and put together a follow-up report each night. They have also had to develop software to account for any interruptions. He said that without more information from the Clearing House, there would likely be no way to avoid these interruptions. With more information, it might be possible to plan observations that would avoid any passing satellites.

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better known) was designed to map the subtle variations in temperature in the background radiation. Launched in June of 2001, it carried instruments that could measure the cosmic microwave background information 40 times more accurately than its predecessor, the Cosmic Background Explorer Satellite (COBE). After a single year of observation, WMAP returned a map of the cosmic background so accurate, scientists were able to make precise measurements of the Hubble constant and the composition of the universe and were able to pin down the age of the universe at 13.7 billion years. Since then, WMAP has continued further to improve the accuracy of its measurements, and is scheduled to continue to operate until September 2010.

Quantum Teleportation. Taking advantage of the so-called spooky action at a distance inherent in quantum entanglement, physicists have been able to transmit quantum information from one system to another across macroscopic distances. The first such teleportation took place in 1998 at Caltech when two photons were entangled with each other. Over the next decade teams working all over the world moved on to magnetic fields and eventually entire atoms. In February of 2009 the team at the UMD/NIST Joint Quantum Institute announced they had been able to teleport information between two atoms separated by more than a meter. With any mention of teleportation, once again comparisons to Star Trek abound in the news media.

Quark-Gluon Plasma. For the first three minutes after the Big Bang, a strange form of matter known as quark-gluon plasma permeated all of space. Essentially a thick soup of high-energy quarks and gluons loosely interacting with each other, quark-gluon plasmas require such immense energies that they haven't existed since the beginning of the universe. In February of 2000, CERN announced compelling evidence that they had finally recreated this exotic form of matter by colliding high energy lead ions into gold and lead targets. The resulting temperatures, over 100,000 times hotter than the center of the sun, were enough to dissolve the powerful bonds between the quarks and gluons inside some of the nucleons for a fraction of a second. The discovery was confirmed in 2005 by teams at Brookhaven's RHIC, and will also be a major area of research at the LHC.

Gravity Probe B. Launched in April 2004 with much fanfare, Gravity Probe B carried onboard four spherical superconducting gyroscopes to measure the geodetic effect and frame dragging in general relativity. The four gyroscopes were touted as the most perfect spheres ever created, completely round with a variation of no more than the widths of 40 atoms. However after launch it became apparent that the coating on the spheres was less perfect, inducing subtle torque on the spinning spheres that threatened to ruin the entire experiment. The team persisted, painstakingly working to extract valuable data. At the 2007 APS April Meeting, the team announced that for the first time they had observed the geodetic effect in the data. However in May of 2008, NASA was forced to pull the plug on funds for the team. After contributions from outside sources including the founder of Capital One Financial and the Saudi Royal Family were secured, the team continued to work, cleaning up their measurement of the geodetic effect by a factor of seventeen as well as finally managing to detect frame dragging.

Light Stopped. In a vacuum, light is the fastest thing in the universe, travelling at nearly 300,000 kilometers per second. When it travels through other materials, such as water or glass, it slows down slightly. In 2001 two independent teams of physicists, one at Harvard, the other at the Harvard-Smithsonian Center for Astrophysics, actually stopped light altogether. The teams shone a coupling laser through a cloud of super-cooled rubidium atoms. The energy of the light beam was stored as an atomic spin wave within the excited atoms, which could be recalled at a later time. Since the first experiment, light has been effectively stopped and stored for up to 20 milliseconds.

Direct Evidence for Dark Matter. Astronomers tracking the movements of two colliding galaxies in the Bullet Cluster announced in August of 2006 that they had the first direct evidence of dark matter. By using computers to help model the movements of observable stars and gas in the collision, physicists were able to demonstrate that there was a substantial amount of mass that visual detection couldn't account for. These observations only confirmed the presence of dark matter, not what actually might comprise the mysterious substance. Currently research teams around the world are hoping that specially designed detectors will soon observe an actual particle of dark matter.

Advances in Computing. High speed supercomputers are changing the way that modern physics is done. The world's fastest supercomputers are now able to perform over a quadrillion calculations per second. Using these tools, biophysicists have been able to map complex biological structures like the human circulatory system or neural networks with unparalleled precision. Physicists are now able to calculate turbulence and fluid flows better than ever thought possible. Supercomputers are an indispensable tool for physicists, one likely to only become more important as time goes on.

CORRECTION

In the report on the Division of Nuclear Physics meeting that was published in the December *APS News*, we mis-identified the person who spoke about the Japan-United States Theory Institute for Physics with Exotic Nuclei. The speaker was James Vary of Iowa State University, not David Dean of Oak Ridge National Laboratory. *APS News* regrets the error.

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who works as a Senior Analyst at the Department of Energy. She oversees strategic planning and analysis for the DOE's Energy Efficiency and Renewable Energy (EERE) division. She previously was an APS Congressional Fellow where she helped draft legislation entitled the "Solar Technology Roadmap Act" (H.R. 3585), a bill that establishes a comprehensive plan for solar technology research, development, and demonstration activities conducted by the federal government in partnership with the private sector and focused on the DOE.

At the DOE, her projects run the gamut from examining the economics of renewable energy programs, to investigating different types of storage technologies, to developing an open energy information platform on the web. She regularly works with analysts from the National Labs. One of her recent assignments dealt with behavioral economics, or, as Ulrich describes, "how to design energy efficiency programs that people will actually stick to."

She credits her physics education with instilling in her strong skills in critical thinking, building logical arguments, pouring over minutiae (like that in legislative language, she says), and thinking about possible ramifications while solving a series of problems. Physics also gave her the stamina to work long hours, she says with a laugh.

"Physicists in EERE are respected," affirms Ulrich. But that admiration doesn't cease in the DOE, she says. There are "huge opportunities in green jobs" for professionals with physics degrees. In fact, there is a much wider array [of jobs] than people realize," she argues.

Owens sees physicists as an asset in the solar cell sector. "Physicists are incredibly well-rounded people," she asserts. Physics-educated pros have the "ability and the desire to get dirty up to their elbows in the lab," says Owens, which translates well to green technical jobs.

Ulrich's advice to find these green opportunities is to have an open mind and think beyond one's comfort zone. "My personal physics network would not have been able to connect me with people in this arena," she recognizes. She got her job by networking with other policy professionals and APS Fellows. She recommends looking at trade associations such as the American Wind Energy Association and the American Solar Association, think tanks, lobbying and consulting firms, and of course, government contracting companies. And within the federal government, don't limit yourself to the DOE, she urges. Agencies such as the EPA, Department of Agriculture, and Department of Interior all need physicists to conduct green projects. The DOD is particularly enthusiastic about being green: the agency is focusing efforts on national security issues pertaining to fuel convoys and the means to make military bases and grids more energy efficient and secure, for example.

It would seem that physicists are distinctly positioned to make the green industry grow. "Some people say this is a renewable energy renaissance," says Ulrich. "There are so many opportunities to transform our country." The green revolution "enables so many scientists to contribute to society using the technical skills they have."

Alaina G. Levine is a science writer and President of Quantum Success Solutions, a leadership and professional development consulting enterprise. She can be contacted through www.alainalevine.com.

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only in the context of what we now call patents and copyrights. Discovery, serendipitous or not, had worth in their minds only if it had economic worth.

Much has changed in the 222 years since New Hampshire became the requisite ninth state to ratify the Constitution. Today's policy makers recognize the importance of science for defense, medicine, energy, and the economy, just for starters. And today's polls show strong public support for science.

So why am I worrying? Because if you dig a bit deeper into the polls what you find is that apart from medicine, the public has little or no recognition of the benefits of science. And scientists, more often than not, see no reason why they need to justify their work to a scientifically illiterate public.

When times are good economically, science can get away with its elitist aura. But when people are without jobs and paychecks, when parents fear their children will not have better lives than they do, when populism becomes the political mantra, scientists better climb down from their pedestals and pay heed to the need to make themselves relevant. If they don't, they shouldn't expect elected officials to make the case for them. Washington officialdom won't, and the consequences for science and the nation's future could be profound.

ANNOUNCEMENTS

Looking for a job?
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For more information contact Alix Brice at 301-209-3187 or at abrice@aip.org

Now Appearing in RMP: Recently Posted Reviews and Colloquia

You will find the following in the online edition of *Reviews of Modern Physics* at http://rmp.aps.org

Modern theory of nuclear forces

E. Epelbaum, H.-W Hammer and Ulf-G Meißner

The nuclear forces acting between protons and neutrons, that are responsible for the nuclear binding, are residual color forces, much like the van der Waals forces between neutral molecules. The effective field theory allows for a systematic and model-independentderivation of those forces in harmony with the symmetries of quantum chromodynamics (QCD). This review addresses the key concepts, in particular, the spontaneously and explicitly broken chiral symmetry of QCD, and discusses applications to light and heavy nuclei at various resolution scales.

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year will feature nine leading physicists expounding some of today's most important topics in physics. John Carlstrom of the Kavli Institute will speak on the cosmic microwave background. Rob Roser of Fermilab will give an update on the search for the Higgs boson at the Tevatron collider. Naomi Makins from the University of Illinois at Urbana-Champaign will bring everyone up to speed on the latest work to unravel the nucleon spin puzzle. Retired chairman of the Lockheed Martin Company, Norman Augustine will speak about the future of NASA's space program.

Judith Lean from the Naval Research Laboratory in Washington will present an overview of how Earth's climate has changed throughout history, and what effects the current increase in average global temperature might have on the world. William Borucki of NASA's Ames Research labs will update attendees on the Kepler mission's search for Earth-like extrasolar planets.

The Large Hadron Collider. Kicking off the April Meeting will be a session (A1) devoted to the latest information coming out of CERN as the LHC continues increasing its beam intensity. The meeting will also feature sessions (B9, D9, P12) with some of the first scientific results from these early collisions.

Physics and Secrecy. From the early days of the Manhattan Project to modern military institutions, secrecy has always been a part of modern physics research. A constant question is when is secrecy necessary to national security and when does it inhibit scientific discovery? At session B5, Peter Galison, historian of physics at Harvard University, will explore how the legacy of secrecy surrounding physics research during the Cold War manifests itself in this post-Cold War world. Steven Aftergood, of the Federation of American Scientists, will highlight recent controversies when nuclear research was released to the public. William Happer of Princeton will delve into how balances are struck between the national security need for secrecy and the scientific need for openness.

Powerful Emissions from Massive Galaxies. In recent years, astronomers discovered that massive radio galaxies broadcast more than just radio waves. Energy emissions from their giant lobes show that they act as efficient particle accelerators. Lukasz Stawarz of Stanford University will present the current understanding of the extraordinary environs inside of these lobes that produce the highest energy cosmic rays ever detected (H3.3). Using data taken from the Chandra X-ray Observatory, the Pierre Auger Observatory, and the Fermi Gamma-Ray Telescope, Stawarz will explain how particles inside these active lobes accelerate to the ultrarelativistic speeds required to produce these intense cosmic rays.

The Sounds of the Little Bang. Ever wonder what it sounds like when large nuclei collide inside of a particle accelerator? Agnes Mocsy of the Pratt Institute will show how it is possible to "hear" colliding particles (Y14.7). When two high-speed nuclei collide, they form a small cloud of matter through which acoustic waves propagate. By analyzing these acoustic signatures and shifting their frequencies into an audible range, it is possible to recreate what it sounds like when two particles collide.

Balloon Listens to South Pole Radio. Ultrahigh energy neutrinos are elusive particles. They are thought to form in distant galaxies when cosmic rays collide with the cosmic microwave background, but detecting them is extraordinarily difficult. Once in a while, one interacts with an atom in ice and releases a telltale radio signal. In 2008 the ANITA Long Duration Balloon flew several flights over Antarctica listening for these radio signals, essentially turning the icy continent into a gigantic neutrino detector. Steven Hoover of UCLA will present the latest results of these balloon flights, which may include the first detection of these radio signals.

Getting a Look at the Galactic Black Hole. Most astronomers believe that at the heart of the Milky Way Galaxy lies a tremendous black hole many thousands or even millions of times more massive than the Sun. Laleh Sadeghian and Clifford Will of Washington University in their session (H14.6) lay out exactly what kinds of observations are needed to prove the existence of such a massive central black hole beyond any doubt. Other sessions (D4) also look at what strange physics may lurk around this gravitational behemoth. David Merritt of Rochester Institute of Technology will show how tracking the motion of nearby stars can offer insights into the strong field gravity near the black hole. Sheperd Doeleman will show how astronomers are getting very close to being able to observe a black hole's event horizon using a technique called very long baseline interferometry. Avery Broderick of the Canadian Institute for Theoretical Astrophysics will describe what a super massive black hole would look like using the VLBI technique.

Tornado Tracks. Tornados are both devastating and short lived. Some reach wind speeds of over 300 miles per hour, leveling everything in their path. However it is often difficult to determine after the fact exactly how powerful a tornado was. Michael Zimmerman and David Lewellen of West Virginia University developed a 3D computer simulation of a tornado's debris cloud. Using this model, Zimmerman and Lewellen can recreate a debris trail left by tornados of different strength. The team hopes that scientists in the field will be able to use these simulations to gauge the strength of a tornado after it dissipates by looking at the trail of debris it left behind.

Enrico Fermi as a Mentor. This year, renowned physicists are coming together to celebrate the inspiration Enrico Fermi had on an entire generation of physicists (J1). In a session chaired by Nobel Laureate James Cronin, three eminent physicists remember their time spent with one of the most distinguished physicists of the twentieth century. One of Fermi's students at University of Chicago, Nobel Laureate Tsung-Dao Lee of Columbia University, recalls Fermi's early days at Chicago. Richard Garwin shares his experiences of working with Fermi to develop the hydrogen bomb at Los Alamos. Nobel Laureate Jerome Friedman of MIT was also a student of Fermi's at Chicago and recalls his time spent with him in the early 1950s.

The Back Page

Theater Deepens the Vision of Physics

By Virginia Corless

Physics and theater may seem strange companions for an article, particularly one in a scientific publication. Physicists and their colleagues in the other sciences explore realms far smaller than the senses can probe and others vaster than imagination can grasp, while theater takes places on a stubbornly human scale, set on a small stage of metal and wood and equipped only with human bodies and voices. One is a largely solitary pursuit of thought, calculation, and observation, its participants linked in collaboration and debate that seeks to rid their work of subjectivity, while the other is conjured in crowded auditoriums, its meaning built out of the human relationships between actors and those they portray and the audience and those they are witness to.

Despite these differences, this has never felt an unnatural pairing to me; I have spent most of my life running between stage and lab, a fact to which many a director and research supervisor can grudgingly attest. But more than a dual passion, physics and theater–or rather, physics *in* theater–is a vital, rich, and necessary partnership, and holds great potential for both the art and the science.

Both theater and physics–or science more broadly–are something of misfits in modern society. Science is widely recognized as important, but polling consistently shows that much of the public understands and trusts little the real process of science or the key concepts underlying even vitally important scientific findings. Science and its practitioners struggle to find a place in the lives of the many who count on it for their health, safety, and continued prosperity, but who feel no personal connection to its process or content.

Theater may be an even more displaced discipline. Though one of the oldest in the world–the direct descendant of storytelling traditions that are as ancient as humanity–it confronts a modern world full of the hyper-realism of gaming, films, and television. In this age in which a fictional world can be portrayed in perfect detail, what place do stage representations of life have? How, for example, to capture the finality and tragedy of a life ended on stage, when all involved can see the still-heaving chest of the "dead" body as it lies prone on the floor, when all know the actor will rise again in the next blackout, that the stage blood will wash off in the dressing room sink, that the cries of grief will turn to laughter in the post-show celebrations?

What makes theater relevant to the world as an art and to science as a voice is the act of collective creation that is at the heart of every performance. Every actor, every audience member, every stage manager and crew member, knows that this performance tonight is different from that on any other night, for it is conjured in the moment, by the actors alive on that stage at the very instant of performance, by the dreams and fears and expectations brought into the theater by the individuals of the audience, by the conjunction of a few thousand words, a few hundred people, and a few hours of time to create a shared vision that transcends the humble stage on which it is made. A play cannot provide the whole story, the whole image, the illusion of reality. It requires an act of imagination, and, unlike reading a book, it must be a *collective* act of imagining. Tonight, in this theater, we together in this room create a shared vision of the human condition.

It is this collective vision that links theater to science. For what else is science but the painstaking construction of a shared view of the Universe? Its practice is very different from that of theater, guided as it is by strict rules and characterized by hypothesis, observation, testing, argument, repetition, and revision. But at the end of that rigorous process it adds one more piece to an ever-evolving collective vision of the world in which we live.

Despite many years researching dark matter, I have never seen it–nor has anyone else. And yet I share with my colleagues scattered across six continents a concept of a Universe filled with massive halos of invisible matter, each dwarfing the shining galaxies housed within them, shielded and held together by the halo's gravitational strength. And so over many years, and across many fields, we have built a collective vision of the natural world that makes us as we are, that forms the blood and bones of the human condition.

And where better to explore more broadly that collective vision than the theater, that other place of collective imagining? Theater is a visceral exploration of the complex and often bewildering contours of our world. It is a point of contact between the deeply abstract and the utterly tangible– the human body and voice. And it is this that makes theater a vital place to explore the meaning of science. On the scale of a stage nothing can remain theoretical and universal–it must become human-sized and personal. In a setting that by its very nature gives a share of ownership in its ideas to all present, science on stage allows actors and audience together to explore the meaning of the physical facts of our world–be they our isolation in a Universe utterly foreign to us, or the awesome processes underway at every instant in our bodies to keep us alive and thinking, walking and dreaming, acting and watching.

Plays about scientists, such as Bertolt Brecht's famous *Galileo*, are the most prevalent scientific contributions to the stage, but tend to focus primarily on the nature of genius rather than on that of nature itself. Rarer within the canon of theatrical texts are plays that grapple with scientific ideas in a direct and intense way. In recent years, however, complex scientific concepts have indeed found central roles in several major productions, and these serve as excellent examples of the potential the fusion of science and theater holds.

First on the scene was Michael Frayn's *Copenhagen*, which explores the relationship between Werner Heisenberg and Niels Bohr, old friends on opposite sides of the Second World War each faced with the potentially devastating nuclear consequences of the quantum physics they had developed together. At its very best, the play grapples with the unexpected, fundamental importance of the act of observation in quantum physics and relativity–and explores what that means for humans as actors in, and witnesses to, the Universe. What better place for such a question than a theater, full of actors and witnesses?

Copenhagen enjoyed a long Broadway run and garnered multiple Tony Awards, including Best Play, and has since been performed many times all over the world. However, even with this success, a typical audience response–gathered from both my own experience of performing in a university production of the play and from anecdotes of Blair Brown, the original Margrethe Bohr in the Broadway production–was "I liked it, but I'm sure I didn't really understand it." We have a long way to go in convincing people that the science of the world they live in belongs to them.

A very recent addition to the theatrical scientific canon is *The Tragedy of Thomas Hobbes* by Adriano Shaplin, jointly commissioned by the Royal Shakespeare Company (RSC) and MIT. I was lucky to work on some of the initial research for the project while a student at MIT, and to witness its debut years later at the RSC last fall. Set in 17th century England at the end of the golden age of Elizabethan theater and the dawn of modern science, it is a play of many themes. One of the most original and fascinating is its detailed exploration of the development of the scientific method, framed as a battle between the deductive reasoning of Thomas Hobbes and the inductive experimentation of Robert Boyle and Robert Hooke. In the midst of that battle, Boyle claims for his new science the aim to create "a democracy of seeing." And indeed, bringing meaningful scientific ideas and concepts into the theater, as *The Tragedy of Thomas Hobbes* does, broadens that still-developing democracy, allowing audiences to see, to witness, to participate in the collective imagining of the world.

A truly excellent example of physics in theater is the production recently created and performed by the world-renowned British theater troupe Complicite, *A Disappearing Number*. It is primarily the story of Ramanujan, the Indian savant who, at the start of the 20th century, entirely untrained, developed advanced mathematics that is now at the heart of string theory. Interwoven with his life are two modern love stories–love between a man and a woman, and love between that woman and mathematics. That mathematics becomes the bedrock of the play, singled out in the opening moments of the performance as the one real thing in the entire theater. The underlying reality of physics and mathematics is forefront again at the very end of the play, when one of the lovers has died and left behind a simple piece of chalk for her beloved together with a note explaining its significance as a token of hope. The note describes an imagined future scene in which the bones of the lovers are reunited in death, mingled together haphazardly on the ground. She writes to her beloved that "it is strange that this image of our proximity, concerning as it does mere phosphate of calcium, should bestow a sense of peace. Yet it does. With you I can imagine a place where to be phosphate of calcium is enough." A requiem of chemistry and physics–ashes to ashes, dust to dust. I cannot recommend this play highly enough for any who wish to see science in theater at its very best.

While at the University of Cambridge I had my own experience taking difficult scientific ideas all the way from textbook to stage when I adapted and directed a production based on a 10th century miracle play called *Dulcitius*, written by a nun named Hrotswitha of Gandersheim. From that play's foundation I built a performance that explored the sublime through myths of old, miracle stories of the medieval age and the science that today seeks to understand the very origins of the Universe. The production began with creation stories from Ovid's *Metamorphoses*, Milton's *Paradise Lost*, and modern cosmology, and continued in that blended world to the very end, when an excerpt from Steven Weinberg's classic account of the Big Bang, *The First Three Minutes*, became an epilogue to Hrotswitha's medieval miracle tale. The performance ended as the Nobel Prize winner's reflections on how fundamentally alien the Universe is to us–how vast and awesome and empty – echoed across the darkening stage.

While the cast found texts from 2000 years ago quite straightforward, they found scientific stories very difficult. Despite bringing beautiful interpretation to her other roles in the play, the very talented actress assigned Weinberg's closing text stubbornly read it as though it were a textbook, flat and lifeless. She did not feel comfortable–justified–interpreting the text as she would any other. To her, as to so many, this was science, foreign and forbidden to any but those inducted into its study. Finally, she and I talked at length with the rest of the cast about the meaning of those scientific words. As we discussed galaxies and the vacuum of space, the alternative fates of a forever expanding or bouncing Universe, the big bang and its relics, the actress slowly curled up, knees against her chest, head down, arms wrapped tightly around herself. "Stop," she said. "I don't like to talk about these things–they frighten me." Here was the emotional response that the act of imagining in the theater had allowed her to access. Her moment on stage talking about the fate of the Universe was as human, as beautiful, and as deeply personal, as any monologue about falling in love or losing one who is beloved.

Theater is one of humanity's oldest tools for comprehending the incomprehensible. Bringing physics to the stage allows us–all of us who share this complex and indifferent and magnificent world–to explore and begin to come to terms with the reality of our home. To access the visceral sublime. Together, we–artists and scientists, actors and audience–should seize the opportunity to deepen the shared vision of science with the collective imagining of the stage.

Virginia Corless is a 2009/2010 APS Congressional Science Fellow. She received a PhD in astronomy from the University of Cambridge in 2009 and a BS in physics from MIT in 2005. She has been deeply involved in theater as an actress and director for more than ten years and across two continents.

APS News welcomes and encourages letters and submissions from its members responding to these and other issues. Responses may be sent to: letters@aps.org