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# Physics & Society

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## Editor's Comments

The Editorial Board and I are very pleased with the material that we have for this edition of *P&S*. Our main articles address a diversity of topics. Gerald Marsh and George Stanford examine the issue of enhancing nuclear stability and non-proliferation in the twenty-first century; their article also includes a brief tutorial on fast reactors. Meg Urry of Yale University writes on the often implicit continuing barriers to careers in the sciences for women. Urry's article is particularly timely in view of a recently-released National Research Council study on the status of women faculty in science and engineering which reports that while women are still underrepresented in the applicant pools for positions in math, science, and engineering at major research universities, those who do apply are interviewed and hired at rates equal to or higher than those for men; the full report is available at http://www.nas.edu/morenews/20090602.html. Students Kevin Thomas (University of Central Florida) and Zhenyaun Zhao (University of Miami) have been awarded FPS Student Fellowships in Physics and Society for summer 2009, and they describe their projects, which respectively involve surveying student pseudoscientific beliefs and a simulation of self-organized capping of carbon emissions. Book reviews examine science censorship and an AIP-sponsored short course on energy efficiency and renewability held at Berkeley in March of 2008. The Forum hosted or co-hosted a number of sessions at the APS March (Pittsburgh) and April (Denver) meetings, and we present brief summaries of the papers presented. The Forum extends its appreciation to those individuals who served as chairs or moderators of these sessions: Noemie Benczer-Koller, Barry Berman, Pushpa Bhat, Philip Hammer, Dan Kleppner, Barbara Levi, Don Prosnitz, Brian Schwartz, Philip Taylor, and Benn Tannenbaum. As this edition of *P&S* is being readied for publication, arrangements are being made to post several of the presentations on the FPS website.

As indicated by two letters, the issues of energy supply and climate change continue to engage our readership. We encourage the submission of letters and articles representing a wide variety of perspectives within the physics community. Please note that we are not set up to evaluate detailed technical articles; our mandate has been, and remains, to provide a forum for discussions of those areas where physics and society overlap. We look forward to your letters and submissions.

IN THIS ISSUE

# LETTERS

*To the Editor:*

David Hafemeister (Physics and Society, v.38, No.2, pp 17–18) presents figures and costs for electric cars. Conspicuously absent is the amount of electrical energy that would have to be generated for powering the electric cars in the U.S.

How much energy would be needed to power all 160 million automobiles in the United States? On average each automobile uses 500 gallons per year (assuming 10,000 miles driven and 20 miles per gallon). This is roughly 500x40 kWh. At an efficiency of 25%, this is 5,000 kWh per car (0.5 kWh/mile) or 0.8 x $10^{12}$ kWh energy required to move them.

Total electric energy generation in the United States in 2004 was 3.97 x $10^{12}$ kWh. (U.S. Statistical Abstracts). In other words, to power personal automobiles alone the electric power generating plant would have to be increased by at least 20%. Electrical energy does not, after all, simply come from the wall in which the electric plug is installed.

As for the batteries, there is not enough lead produced to equip all the automobiles in the United States with lead-acid batteries. It would be interesting to find out whether there is sufficient lithium or other materials for so many batteries. No one seems to address such mundane questions. In addition, researchers at Carnegie-Mellon University (L.B. Leave, C.T. Hendrikson and F.C. Michael, Science 268, 993, May 1995) have shown that lead pollution from lead-acid batteries for this many automobiles (160 million) would be about the same as it was prior to the removal of tetraethyl lead from gasoline.

Electric energy requirements for electric cars are treated at some length in the Encyclopedia of Environmental Analysis and Remediation, J. Wiley & Sons, New York 1998. By now most people realize that the electric car is a dead duck.

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*David Hafemeister and Peter Schwartz respond:*

Mr. Bevc brings up important points, which when considered further endorse the electric car as the most beneficial technology to develop for individual transportation. The bottom line is that the lithium battery, if successful, will lead us to the electric car of the future. Different sources quote somewhat different numbers, so we break our analysis into a number of issues:

***kWh/mile and vehicle miles per year:*** The industry standard is 0.35 kWh/mile as quoted from the 2009 APS study (pg. 37); Mr. Bevc used 0.5 kWh/mile. The Federal Highway Administration gives 3.029 x $10^{12}$ miles driven per year for 2007. We will use 3 x $10^{12}$ miles/year, which agrees with APS (Fig. 10, p. 34). Not all of these vehicle miles can be converted to electricity because larger vehicles will be too costly to convert. About 80% of these vehicle miles are "residential vehicle miles" so we reduce 3 x $10^{12}$ to 2.4 x $10^{12}$.

***kWh/year needed:*** The U.S. produced 4.115 x $10^{12}$ kWh/yr in 2008. Using the numbers above, the electric fleet would need (2.4 x $10^{12}$ miles/yr) (0.35 kWh/mile) = 0.84 x $10^{12}$ kWh/year. This agrees closely with Mr. Bevc's projection of 0.8 x $10^{12}$ kWh/yr and his figure of 20% of total electricity use for electric cars. As we argue in the next paragraph, however, this by no means translates to requiring a 20% increase in generating capacity.

***Power Plants needed:*** The adoption of the first 20% of the electric fleet will not need too many additional power plants since the base-load plants are not efficiently using night-time power when many facilities are idle. The Electric Power Research Institute (EPRI) examined this effect for California, which varied, typically, from a peak of 39 GW to a minimum of 23 GW. EPRI determined that the underutilized night-time power of 16 GW could fuel 5 million cars. Additional power plants would have to produce (0.8)(0.84 x $10^{12}$) = 0.67 x $10^{12}$ kWh. If the plants operated with a 100% duty factor this corresponds to 76 GWe. This could be fulfilled with 100 one-GWe traditional power plant with a duty factor of 0.8. These cars would use lithium batteries and not lead batteries, as suggested by Mr. Bevc. The world's estimated 10 million tons of lithium is sufficient to supply lithium ion batteries for more than 1 billion cars. As half of this lithium is in Bolivia, we are hopeful for President Obama's positive direction with Latin American diplomacy. Overall, it is highly likely that lithium batteries will be robust, safe, and economic when all factors are examined.

Finally, Mr. Bevc misses a crucial point in his dismissal of electric travel: We certainly do not at present need either enough electrical energy nor enough battery capacity for an entire fleet of electric cars because a transition to electric travel will not be fast, and it will not be complete. The average car remains in service for about 15 years. It is unreasonable to think that tomorrow 100% of the population will choose to buy electric cars over gasoline automobiles. Even a very ambitious market growth for the electric car will require at least 30 years for the majority of personal travel to be done with electric cars. What happens as far as charging infrastructure, energy storage, and public transportation is anyone's guess. For now, electric transportation is likely our best option.

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*To the Editor:*

In the January 2009 edition of *Physics & Society*, Robert Levine wrote a thoughtful letter objecting to the statement on climate change adopted by the APS Council on November 18, 2007. As an APS member I also strongly object to this statement. It is written below:

*Emissions of greenhouse gases from human activities are changing the atmosphere in ways that affect the Earth's climate. Greenhouse gases include carbon dioxide as well as methane, nitrous oxide and other gases. They are emitted from fossil fuel combustion and a range of industrial and agricultural processes.*

*The evidence is incontrovertible: Global warming is occurring. If no mitigating actions are taken, significant disruptions in the Earth's physical and ecological systems, social systems, security and human health are likely to occur. We must reduce emissions of greenhouse gases beginning now.*

*Because the complexity of the climate makes accurate prediction difficult, the APS urges an enhanced effort to understand the effects of human activity on the Earth's climate, and to provide the technological options for meeting the climate challenge in the near and longer terms. The APS also urges governments, universities, national laboratories and its membership to support policies and actions that will reduce the emission of greenhouse gases.*

It is mostly the second paragraph that I object to. Certainly for the past ten years, the assertion is demonstrably false; the earth's average temperature has remained about constant after a 30-year period during which the average temperature increased by about three quarters of a degree Fahrenheit. Secondly, the disruptions APS considers 'likely' are based almost entirely on models, simulations, and speculations, but are nearly devoid of any experimental justification. Can the APS really point to any existing trend, occurring today, which extrapolates to the sort of doom and gloom the second paragraph implies? The population of polar bears is increasing. Glaciers have been receding for at least the past 200 years. Ice in Greenland and the Antarctic is melting in some places and thickening in others. Humans are getting healthier, lifespan is increasing, and social systems persist (at least in the democracies). In fact, over the millennia of human civilization, warm periods have been beneficial, cold periods, harmful. Shouldn't we physicists consider today's empirical evidence as well as projections?

The paragraph then goes on to say "we must reduce the emission of greenhouse gases beginning now." Does the APS seriously believe that we can just give up carbon the way a smoker can just give up cigarettes? Civilization takes energy and lots of it. Right now, we get 85% of our energy from carbon-based sources. What does the APS propose to replace it with: solar panels, windmills, nuclear reactors? Can it make the case that this is scientifically and technically possible? Unquestionably, to eliminate carbon fuels and not replace them with equivalent energy is to end civilization as we know it. The APS statement completely ignores this vital truth.

As a middle ground between the APS statement and other statements which deny manmade contributions to global warming and climate change, I propose this statement:

*The issue of increased $CO_2$ in the atmosphere and its effect on climate is an issue of increasing concern. A great deal of this $CO_2$ comes from energy production. As physicists we realize that 85% of the world's energy comes fron carbon-based fuel. We recognize that there is no economical substitute for this fuel on the scale required, and most likely will not be one for decades. While the APS certainly advocates conservation and improved efficiency, we recognize that as the world develops, it will need more energy, not less. We recognize the inextricable link between affordable energy and human well-being, good health, education and a clean environment. Finally we recognize that eliminating carbon-based fuel before a replacement fuel is ready, on the required scale, at about the same price, constitutes at least as grave a threat to human civilization as global warming.*

*As physicists we understand the greenhouse effect. However, we also know that the earth's climate is extremely complicated and there is much more to it than the greenhouse effect. Other scientists understand this better than we do. The American Meteorological Society has come out with two statements of concern, in 2003 (www.ametsoc.org/POLICY/climatechangeresearch_2003.html) and 2007 (www.ametsoc.org/policy/2007climatechange.html). Each statement emphasizes risks of increasing $CO_2$ accumulation in the atmosphere, but each also mentions that there are great uncertainties. Each points out that much more is needed in theory, simulation and measurement. The 2007 statement even mentions that there could be benefits to global warming, and points out that while ice is melting in some parts of Greenland and Antarctica, it is thickening in other parts.*

*In 2005 the presidents of the Academies of Science of 11 countries jointly signed a letter expressing concern over $CO_2$ accumulation in the atmosphere and global warming (www.nationalacademies.org/onpi/06072005.pdf). However, they emphasized adaptation as well as prevention. Also, unlike the more dire predictions, they foresee a sea level rise of 10-90 cm during the 21st century.*

*As regards the science of global warming, APS supports the 2003 and 2007 statements of the American Meteorological Society and the statement of the 11 academy presidents.*

I hope that Robert Levine's letter, and this letter stimulate much-needed discussion in the APS as to what our appropriate role in this issue should be. Most of all, I hope the APS puts out a new statement more scientifically defensible and more balanced in its conclusions and recommendations.

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# FORUM NEWS

## Seeking Nominations for FPS Executive Committee

*Phil Taylor, Chair of FPS Nominating Committee*

The FPS nominating committee is looking for suggestions from the FPS membership for nominees (including self-nominations) for upcoming vacancies on the FPS Executive Committee. These are for the positions of Vice-Chair (who will become Chair-Elect in 2011 and Chair in 2012), Secretary-Treasurer (three-year term), and Member-at-Large (two vacancies, three-year terms). Please contact Phil Taylor, Chair of the Nominating Committee (taylor@case.edu).

## FPS-Hosted Sessions at the APS March Meeting

*Brian Schwartz, Graduate Center of the City University of New York*

The annual APS March meeting was held in Pittsburgh from March 16-20, 2009, and featured four sessions sponsored or co-sponsored by FPS. These sessions dealt with environmental renewal of Pittsburgh, alliances between university scientists and local science centers, the physics of imaging and radiotherapy, and physics and art. The following are brief descriptions of the papers presented during these sessions. The full scientific program of the meeting can be found at http://meetings.aps.org/Meeting/MAR09/Content/1369/.

***Session H8:*** The Greening of the City of Pittsburgh-The History, Science and Examples. I chaired this session which featured four papers. Joel Tarr (Carnegie Mellon University) spoke on "Devastation and Renewal: Water, Air and Land in Pittsburgh Environmental History." He focused on the metabolism of cities as a concept through which to view the environmental history of Pittsburgh. Perhaps more than any other US city, Pittsburgh reflects the impact of industrialism and of urban infrastructure on environmental quality. The talk explored these effects and attempts at remediation in three domains: water supply and wastewater disposal; smoke and air pollution; and land contamination. Cliff Davidson (Carnegie Mellon University) spoke on "Air Quality from Early Pittsburgh to the Present: The Science of Change." As described by Davidson, throughout Pittsburgh's 250-year history, coal reserves in the city and nearby have influenced its economy, demographics, and environmental quality. It was not until the 1940's that effective regulations were passed to reduce smoky conditions. Particle levels fell throughout the 1950's and 1960's, and eventually the decline of heavy industry in Pittsburgh led to relatively clean air in many parts of the city. Alan Traugott (CLJ Engineering) spoke on "Material Science and Construction using Green Science and Technology." This talk reviewed the new materials and technologies that are being applied in the construction of more efficient (green) buildings to improve energy efficiency. The roles of advanced materials and technologies, such as spectrally selective glazing, photocatalytic concrete, solar heating and cooling, and organic solar collectors were discussed. Finally, Traugott presented an overview of advanced analytic tools used in building design, including computational fluid dynamics, energy, and lighting/daylighting computer-based simulation programs. Mark Leahy (Lawrence Convention Center) addressed the audience on "The Greening of the David L. Lawrence Pittsburgh Convention Center." Leahy's talk described Pittsburgh's Lawrence Convention Center, which is the largest Gold LEED NC (Leadership in Energy and Environmental Design New Construction) certified convention center in the world. The unique green properties of this 1.5 million square foot Convention Center include the design and use of daylight, natural ventilation and other sustainable design and practices. The use of natural ventilation and extensive day lighting is designed to reduce energy consumption by nearly 35% compared to traditionally ventilated and lit buildings of a similar size.

***Session P7:*** Forging Effective Partnerships with Your Local Science Center: Outcomes from the Workshop on University/Science Center Collaborations. David Statman (Allegheny University) spoke on "Developing an Infrastructure of Partnerships with Science Centers to Support the Engagement of Scientists and Engineers in Education and Outreach for Broad Impact." This talk reviewed a workshop on University/Science Center Collaborations jointly hosted by the American Physical Society and The Franklin Institute held on May 31 - June 1, 2008. This Workshop brought together 40 leaders from science centers, universities, and federal funding agencies to explore what works and what doesn't work in university-science center collaborations. The result was a convergence of viewpoints on how a good collaboration is established, built upon, sustained, and evaluated. Leo Kadanoff (University of Chicago) spoke on "University Perspectives on Science Center/University Interactions." Kadanoff described a program that brings graduate students into informal science education. Practical nuts and bolts methods for making the program work were discussed. Eric Marshall (New York Hall of Science) spoke on "University/Science Center Collaborations: A Science Center Perspective," addressing how science centers, professional associations, corporations and university research centers share the same mission of education and outreach, yet come from "different worlds." This gap may be bridged by working together to leverage unique strengths in partnership. The talk illustrated that successful partnerships stem from clearly defined roles and responsibilities. Daniele Finotello (NSF) spoke on the "Perspective of NSF-MPS Program Directors on Educational Outreach." Her talk reviewed the National Science Foundation Broader Impacts review criterion since they were first implemented by NSF. The viewpoint of the NSF Program Officers was presented. The broader impact of different proposals can vary widely, based on different factors such as the particular research activities proposed, the interests of the PI(s), the type of institution involved in the proposal and the different opportunities available on the local area, to name just a few. This session was Co-sponsored by the Forum on Education and chaired by Philip Hammer of the Franklin Institute.

***Session V8:*** The Physics of Imaging and Radiotherapy. This session was co-sponsored by the Division of Biological Physics and chaired by Barry Berman of George Washington University. John M. Boone (University of California at Davis Imaging Center) spoke on "Dedicated CT Imaging of the Breast." Boone described dedicated breast computed tomography (CT) systems designed and fabricated in his laboratory. The breast CT scanner was designed utilizing several off-the-shelf components, including the x-ray system, a flat-panel detector, and a position encoder-bearing-motor system. As of November 2008, over 180 patients have been scanned. The ultimate utility of breast CT may include breast cancer screening, diagnostic imaging, robotically controlled biopsy, and other interventional procedures. Xiaochuan Pan (University of Chicago Cancer Research Center) spoke on "Advanced Tomographic Imaging: Visualization of the Unseeable." He described tomographic imaging, a noninvasive approach that is playing an increasingly important role in the improvement of health care by providing valuable information for diagnosis of diseases, guidance of treatment and therapy, and for assessment/monitoring of treatment response. Pan presented some recent exciting advances in tomographic imaging technology and briefly discussed some of the important applications of advanced tomographic imaging in medicine and other areas. Cedric Yu (University of Maryland School of Medicine) and David Jaffray (Ontario Cancer Institute/ Princess Margaret Hospital), respectively, spoke on "Planning and Delivery of Radiation Therapy—Principles and Recent Developments" and "Image-Guided Radiation Therapy-Application and Advancement." A panel discussion among the speakers was then held.

***Session W5:*** Physics Meets Art. Peter J. Lu (Harvard University) spoke on "Quasicrystals in Medieval Islamic Architecture." Lu discussed some of the properties of Islamic quasicrystalline tilings and their relation to the Penrose tiling. The conventional view held that girih (geometric star-and-polygon) patterns in medieval Islamic architecture were conceived by their designers as a network of zigzagging lines, which were drafted directly with a straightedge and a compass. Recent findings presented in this talk show that by 1200 AD a conceptual breakthrough occurred in which girih patterns were reconceived as tessellations of a special set of equilateral polygons (girih tiles) decorated with lines. (Tesselation is the art of covering an infinite plane without gaps by plane figures of one or a few types.) Denis Weaire (Trinity College, Dublin) spoke on "Those Bubbles in Beijing: The Story of the Water Cube." This talk presented the story of the "Water Cube" constructed for the Beijing Olympics. The origins of the Water Cube design go back to the nineteenth century, when William Thomson (Lord Kelvin) first posed the problem: What kind of foam of equal-sized bubbles minimizes area (or energy)? The structure in Beijing consists of a massive framework of steel beams that are arranged as in the Weaire-Phelan structure of an ideal foam, with an outer facing of transparent "cushions." It provokes thoughts on aesthetics, order/disorder, optimization, and the frequent recurrence of bubbles/foams in our literary and artistic culture. Katherine Jones-Smith (Case Western Reserve University) spoke on "The Drip Paintings of Jackson Pollock: Are they really Fractal?" Jones-Smith asserted that the hypothesis of "Fractal Expressionism" is fundamentally flawed and that fractal analysis as an authentication tool for Pollock paintings yields inconsistent and unreliable results. This work has also led to two new results: (1) the composite of two fractals is not generally scale invariant and exhibits complex multifractal scaling in the small distance asymptotic limit, and (2) the statistics of box-counting and related staircases provide a new way to characterize geometry. Charles Falco (University of Arizona) spoke on "Analyzing Monet." Falco presented a new approach to image analysis. He identified the precise locations where the Impressionist artists Monet, Pissarro, Renoir and others stood when making a number of their paintings. Specific deviations were found when accurately comparing these examples with photographs taken from the same locations. These deviations provide key insights into how the artists' visual skills informed new ways to represent to viewers the two-dimensional images of three-dimensional scenes. The results have implications for improving the representation of certain scientific data.


*Participants in the Panel Discussion on Global Physics Projects held at the APS "April" meeting in Denver. L-R: Lawrence Krauss (moderator), Jack Gibbons, Christopher Llewellyn-Smith, Pier Oddone, and Dennis Kovar. Inset: Session chair Pushpalatha Bhat.*

## FPS-Hosted Sessions at the APS April Meeting

*Cameron Reed, Physics & Society*

The annual APS April meeting was held in Denver, CO, 2-5 May 2009. The Forum on Physics and Society hosted or co-hosted nine sessions on a wide variety of topics, including applications of accelerators, science policy, managing nuclear fuels, contributions of physicists to the intelligence community, scientists and arms control, and geoengineering as a measure to address rapid climate change in addition to a panel discussion on large physics projects and a Town Hall meeting on science and society. The following paragraphs briefly summarize the papers presented. We hope to publish the entire text of Lewis Branscomb's talk (Session G7) in a future edition of P&S. The complete scientific program of the April meeting can be found at http://meetings.aps.org/Meeting/APR09/Content/1380.

***Session B6:*** Applications of Accelerators (jointly sponsored with the Division of Biological Physics) J. Murray Gibson, Director of the Advanced Photon Source at Argonne National laboratory, spoke on "Neutron and Synchrotron Radiation Studies for Designer Materials, Sustainable Energy, and Healthy Lives." Gibson described applications of high-x-ray fluxes in areas such as energy (imaging fuel combustion), climate change (understanding how sea animals capture carbon and phosphorous), protein structure (imaging cancer-attacking viruses), and materials science (metal fatigue). Cynthia Keppel (Thomas Jefferson National Accelerator Facility) spoke on "Medical Applications: Proton Radiotherapy." Keppel described how proton therapy is now recognized as the most effective external-beam treatment of various types of cancers since the depth-dose profile of a proton beam delivers a minimal radiation dose in front of a tumor, most within the tumor itself, and none behind it. She also described the current development status of Hampton University's Proton Therapy Institute. Richard Sheffield (LANL) spoke on "Applications in Nuclear Energy Security," addressing how accelerators can be used to transmute nuclear waste via spallation reactions, in particular minor actinides which are the primary concern with long-term waste disposal. A prime example is Am-241, which otherwise decays to the very long-lived isotope Np-237. This process would not eliminate the need for a long-term repository but would reduce the necessary repository timescale to only a few hundreds of years from thousands of years. Only two accelerators would be required to deal with the waste fuel of the entire US reactor fleet. This session was chaired by Pushpa Bhat of Fermilab.

***Session D4:*** Panel Discussion: Global Physics Projects (jointly sponsored with the Forum for International Physics) This session was also chaired by Pushpa Bhat. Prof. Sir Christopher Llewellyn-Smith (Oxford University and Former Director-General of CERN) spoke on "International Scientific Collaboration." Llewellyn-Smith remarked that international collaboration in large projects is natural given the universal nature of physical laws and the scale of effort required. He pointed out that in any such project a firm scientific foundation is essential to build political support. However, these projects face complex decision making, require dealing with differing national cultural and governmental norms, can face issues of intellectual property ownership and work permits, require stable financial support, and should ideally be located near existing facilities. The scientific community must recognize that site selections are always dominated by political factors. An issue of growing concern in large projects is that the time needed for administrative decisions may become longer than the time scale on which technology and scientific needs change. Dennis Kovar, Associate Director for High-Energy Physics in the Office of Science at the Department of Energy, remarked on the need for central leadership and a majority stakeholder for such projects. Pier Oddone, Director of Fermilab, spoke of the success of the CERN model, remarking that is difficult to conceive of another area of endeavor that could bring countries together in such a way. Following these remarks, a Panel Discussion moderated by Lawrence Krauss of the University of Arizona was held; this was joined by former Presidential Science Advisor Jack Gibbons. A variety of questions came from the audience concerning issues such as dealing with construction versus operating costs for large projects, realistically bringing minority partners and developing countries into projects, prospects for next-generation accelerators, and competition that the high-energy physics community in the United States will face for economic stimulus funding against "job-ready" projects that provide immediate employment.

***Session F2:*** Town Hall Meeting on Science and Society. This session was the first public town hall on science and society held at an APS meeting. Pier Oddone of Fermilab opened with a few brief remarks, setting the context of the evening by pointing out that 2.6% of US Gross Domestic Product is devoted to research and development (mostly in the area of defense) and that of some $60 billion allocated for science and technology, about half goes to the NIH. Lawrence Krauss of the University of Arizona then spoke on the value of esoteric science, reminding the audience that scientific facts such as the big bang do affect our cultural view of ourselves and that they are independent of the questions that motivated their discovery and the purpose of the questioner. Krauss went on to point out that America faces a serious paradox in that, while about half of the country's GDP growth over the last half-century is attributable to science and engineering, public science literacy as a whole is poor, a situation which can lead to irrational decisions such as those concerning missile defense. On the question of issues such as Intelligent Design, Krauss remarked that science is not a threat to a moral world and that society should not feel obliged to respect all religious sensibilities, particularly if they conflict with scientific findings. He closed by reminding the audience of the sense of wonder that science provides and that its underlying ethics remain honesty, creativity, full disclosure, and anti-authoritarianism. Llewellyn-Smith (see Session D4 above) then spoke concerning world energy supply. Currently, one-quarter of the world's population lacks electricity; it will be necessary to double energy supply to bring most of the world's population to a Human Development Index level of 0.9 (out of a maximum possible 1.0). The required energy supply can only practicably come from fast-neutron fission reactors, and, more distantly, fusion. At the same time, it will be necessary to capture and bury $CO_2$. Unfortunately, public funding of energy research and development is at a level of only about one-half of what it was in 1981. During the open discussion that followed, Llewellyn-Smith remarked that scientists must contribute to improving public understanding of numeracy, probability, orders of magnitude, and peak versus average quantities.

***Session G7:*** Science Policy: Yesterday, Today, and Tomorrow. This joint FPS-FHP session was moderated by Dan Kleppner of MIT and featured remarks from two former Presidential Science Advisors, Jack Gibbons (Resource Strategies, VA) and Neal Lane (Rice University), and from Lewis Branscomb, former director of the National Bureau of Standards and now at the Kennedy School of Government at Harvard University. Gibbons addressed the evolution of conservation in energy policy, describing aspects of his career which dealt with early efforts to improve the efficiency of refrigerators and air conditioners and how these efforts had to take into account marketplace realities such as houses with low-amperage fusing. He then related how national-level attention to energy efficiency became important with the Yom Kippur war of 1973. Lane addressed three topics: The role of citizen scientists, special challenges for science, and the larger role of physics in civic life. He argued that there is a pressing need for more citizen scientists and that members of the community should get involved with citizens and politicians. Historically, the physics community has contributed extraordinary individuals along these lines. Lane remarked that the last half-century has been a golden age of science and it is unfortunate that many great industrial laboratories now no longer exist. A significant challenge is that public perception of federally-funded research is most strongly linked to progress in the areas of health and medicine; winning the war on understanding fundamental laws of nature does not have the same appeal to mainstream voters. A current challenge is that many in Congress do not appreciate the importance of science and that agency self-interests can get in way of cooperation. Lane argued that the

APS has had an influential policy role for a long time, but that physicists must do more than just advocate for our own field: it is important to link across disciplines because an attack on any field of science is an attack on all science. The last panelist, Branscomb, reminded the audience how the massive infusion of "soft" government money following World War II lead to conflicting motives between science and politics. He argued that democracy benefits when it is appreciated that both science and democracy have common roots such as transparency and trust and warned that if science becomes corrupted by government, the latter will itself become suspect. It is important for scientist to share their understanding with the public in order that politicians can raise support from the public for policies. An important aspect of civic scientists is that we must partner with governments to upgrade public understanding of technical issues. Branscomb closed by outlining what he sees as various challenges that stand in the way of building a more rational society. These include reform of the election process, including science education in communications (media) skills, reducing media ownership concentration and securing government funding for long-term "Jeffersonian science."

***Session H7:*** Managing Nuclear Fuels: An International Perspective. This joint FPS-FIP session was chaired by Noemie Benczer-Koller of Rutgers University and featured three presentations on how other countries are dealing with nuclear waste. Elizabeth Dowdeswell of the Canadian Nuclear Waste Management Organization spoke on "A Contract Between Science and Society," describing how the CNWMO is currently holding public discussions to determine the terms and conditions that would make a used-fuel repository socially acceptable and how those terms will factor into the design and implementation of the project. Kazuaki Matsui (Institute for Applied Energy, Japan) addressed the issue of "Radioactive Waste Management, its Global Implication on Societies and Political Impact," describing how a fuel-reprocessing plant designed to handle about 800 metric tonnes of waste fuel per year is undergoing commissioning  in Rokkasho, Japan, following a site selection process that paid particular attention to that country's seismic situation. In a talk on "Management of Spent Nuclear Fuel at the National Institute of Physics and Nuclear Engineering, Bucharest, Romania," Lucian Biro of the Romanian National Commission for Nuclear Activities Control described how a research reactor in that country, which had started operation in 1957 and was shut down in 1997, is being decommissioned. All fresh highly-enriched uranium (HEU) has been repatriated to the Russian Federation; all HEU spent fuel will be repatriated in 2009; and  repatriation of low-enriched spent fuel is to follow.

***Session J7:*** Physics Contributions to the Intelligence Community. This session was chaired by FPS Chair Donald Prosnitz (Rand Corporation). Robert McDonald of the National Reconnaissance Office spoke on "Physicists & Engineers in the Spy Business – What Does the Record Say About National Reconnaissance?" McDonald related how individuals with backgrounds in engineering, mathematics, and physics have been and remain central to the operation of the NRO. He reviewed the development of the U2 and Corona projects, which were essential in building political confidence for undertaking arms control negotiations. Lisa Porter, Director of the Intelligence Advanced Research Projects Activity, an office of the Office of the Director of National Intelligence, spoke on "Physics, Physicists, and Revolutionary Capabilities for the Intelligence Community." She described how IARPA undertakes high-risk/high payoff research in areas such as smart collection of data, incisive analysis of intelligence, and safe and secure operations in the modern "cyberworld." Physics contributions include research in novel detectors and quantum information science. Donald Kerr, former Principal Deputy Director of National Intelligence, spoke on the interface between intelligence and policy in a talk entitled "Physicists and the Intelligence Community: The Next Decade." Kerr related that while the current emphasis of the intelligence community is to prevent violent extremism and the spread of weapons of mass destruction, these efforts do not remove from the table historically earlier emphases on global situational awareness, supporting targeting and arms control, and integrating intelligence to reveal pending threats. Areas where physics plays a particularly large role are those of nuclear forensics, cybersecurity, and balancing concerns of technology, privacy, policy and risk.

***Session Q7:*** Is Geoengineering a Possible Stop-Gap Measure to Rapid Climate Change? Barbara Levi, a Contributing Editor to *Physics Today,* chaired this session in which three talks were delivered on possible mechanisms for temporarily halting or slowing global warming via global-scale albedo engineering while effective emissions-control strategies are developed. David Keith (University of Calgary) spoke on "Solar-band Climate Engineering: Technologies, Risks, and Unknowns."  Keith discussed strategies for lofting sunlight-shielding micron-size particles into the atmosphere. Such particles could be made in bulk at a reasonable cost, and could be concentrated where the need is greatest (e.g., at the poles), and could be replenished as necessary. As the particles could be deployed on an experimental ramp-up testing basis, we would not be committed to an "all at once or not at all" program. Alan Robock (Rutgers University) spoke on "The Many Problems with Geoengineering Using Stratospheric

Aerosols." This talk complemented Keith's in that, based on simulations utilizing atmosphere-ocean circulation models, Robock considered possible undesirable side-effects of artificially-introduced atmospheric aerosols. These include precipitation reduction in populous Asian areas, changes in cloud cover, lessened river flows (particularly the Nile), a general whitening of the sky, and lowered output of solar generating stations. One possible beneficial side effect for plants is an increase in diffuse sunlight. Questions remain, however: Whose hand would be on the thermostat? Are there possible uses of such technology as military weapons? Kenneth Coale (Moss Landing Marine Laboratory) spoke on "Ocean Iron Fertilization." Coale described experiments aimed at artificially fertilizing oceans with iron. The additional iron will promote phytoplankton growth; the phytoplankton then absorbs $CO_2$ from the atmosphere. It is estimated that some 5 gigatons of $CO_2$ per year could be sequestered in this way. A political danger of any geoengineering scheme is that it might have the unintended consequence of decreasing efforts to reduce emissions.

***Session R7:*** FPS Awards Session. This session was chaired by FPS Chair Donald Prosnitz (Rand Corporation). The Leo Szilard Lectureship Award was presented to Raymond Jeanloz (UC-Berkeley) for his contributions to sound public policies on nuclear weapons and arms control. Jeanloz spoke on "Science and International Security," addressing the danger of nuclear-weapons proliferation now that technical hurdles are no longer the major "choke points" to those who would like to acquire nuclear weapons. He reviewed the status of the Comprehensive Test Ban Treaty and also described how international monitoring systems are now sufficiently sensitive to detect even small underground nuclear detonations. Jeanloz emphasized the importance of the scientific model of openness and communication in addressing problems of global concern. The Joseph A. Burton Forum Award was presented to Patricia Lewis (James Martin Center for Nonproliferation Studies, Monterey Institute of International Studies) for her contributions to arms control and international security. Lewis spoke on "Remembering our Humanity: the deep impact of the Russell-Einstein Manifesto." Lewis related that Einstein, in one of his last acts before his death, supported a manifesto written by Bertrand Russell calling for the abolition of war and renunciation of nuclear weapons, and encouraging governments to find peaceful means of dispute resolution. The manifesto led, directly or indirectly, to the establishment of numerous organizations and programs devoted to bringing together scholars and public figures concerned with reducing the danger of armed conflict and promoting cooperative solutions for global problems. Following Lewis' talk, outgoing FPS chair Andy Zwicker (Princeton Plasma Physics Laboratory) recognized new APS Fellows that had been nominated by the Forum. The new fellows are Michael Berman (Air Force Office of Scientific Research), William Hammack (University of Illinois, Urbana-Champaign), Allen Sessoms (University of the District of Columbia) and Dean Wilkening (Stanford University). Zwicker also recognized Al Saperstein and Jeff Marque for their efforts in editing Physics & Society for twelve years.

***Session X6:*** The Role of Scientists in Arms Control. This session was chaired by Benn Tannenbaum of the American Association for the Advancement of Science. Peter Zimmerman (King's College, London) spoke on "Dr. Inside and Dr. Outside: Physicists Involved with National Security and Foreign Policy." Zimmerman described real-life examples of physicists who had switched from academic careers to careers in government service, and discussed routes into public service for individuals interested in giving it a try. David Hafemeister (Center for International Security and Cooperation, Stanford University) spoke on "Progress in CTBT Monitoring Since its 1999 Senate Defeat." Hafemeister reviewed how the International Monitoring System will be able to detect an underground nuclear explosion in hard rock with a threshold of 0.1 kilotons if conducted anywhere in much of the populated world. Kory Sylvester (National Nuclear Security Administration) spoke on "Technology and Policy: Looking to the Future." Sylvester discussed how scientists and engineers must remain engaged with national security debates and think about the strategic and policy environments within which questions are posed to them.

# FPS Student Fellowships

*Kevin Thomas, an undergraduate at the University of Central Florida, and Zhenyuan Zhao, a graduate student at University of Miami, have each been awarded an FPS Student Fellowship in Physics and Society for summer 2009. Fellowships consist of a stipend of up to $4000 and are awarded to undergraduate or graduate students in physics in support of projects that apply physics to a societal issue. See www.aps.org/units/fps/awards/student-fellowship.cfm; applications for summer 2010 awards are due Dec. 15. Thomas' project involves surveying students' pseudoscientific beliefs in the context of a course that uses study of films to explore scientific theories. He is working with Prof. Costas Efthimiou at UCF and will complete his Bachelor of Science in Physics UCF this summer, after which he will begin teaching high school physics while getting his Master's degree in Education. Zhao's project involves computer simulations of capping carbon emissions; he is working with Prof. Neil Johnson at UM. These contributions have not been peer-refereed. They represent solely the view(s) of the author(s) and not necessarily the views of APS.*

## Combating Pseudoscience

*Kevin Thomas*

According to the National Science Foundation's Science and Engineering Indicators 2008, "Television and the Internet are Americans' primary sources of science and technology (S&T) information." [1] In its report, NSF concluded that although Americans display interest in science and technology, they do not demonstrate high science literacy. Many Americans fail to answer basic factual questions about science and the scientific inquiry process correctly. While Americans endorse past achievements and future discoveries of science, they continue to score low by international standards on questions concerning the Theory of Evolution and the "Big Bang." Unfortunately, American education persistently includes nonscientific views in science classrooms.

Our research seeks to further understand this lack of scientific awareness via surveys of groups of physical science students at the University of Central Florida; this summer (2009) will mark the third year of this project. Specifically, our team takes data during Professor Costas Efthimiou's "Physics in Films" course, which uses movies to help explain physical science theories and practices. During the summers of 2007 and 2008 the course focused on Pseudoscience in films, that is, false ideas and/or methods which intentionally are presented as science. Blockbuster movies such as Ghost and Premonition are used to teach physical science concepts and demonstrate how they reinforce pseudoscientific beliefs. The class also has used the two pseudoscientific documentaries, The Secret and What the Bleep Do We Know? to explain concepts in Quantum Mechanics and to debunk the extraordinary statements made in the movies. This method has been very effective as a vehicle of education. Among other outcomes, it showed students how to be skeptical of extraordinary claims and how to use the scientific method in analyzing everyday beliefs and practices such as the reading of horoscopes or the interpretation of extraordinary religious events. While the course did not intend to discuss religion, many students found this an unavoidable topic and it is thus an important link and result of our study. This summer, the course will use a mixture of movies of a various genres and themes: Sci-Fi, Superhero, Action, and Pseudoscience. My research will involve surveying the class and comparing results with data from the last two summers. The results are expected to help us improve the course further and to quantify how serious is the lack of critical thinking and science literacy among non-science college students. We will also compare our results with national data to draw comparisons of college students versus all citizens.

The methodology includes taking data through essays that the students write, poll questions asked by the teacher during lecture, group interviews, and multiple choice questions during exams. At the conclusion of the project we should be able to better understand what the students believe in terms of pseudoscience vs. science, and why they hold these beliefs. Ultimately, we hope to see that students can analyze statements they hear on television and other public media and properly judge their credibility. Preliminary results tell us that certain pseudoscientific topics have fewer believers among college students than other topics. For example, while astrology is good for teaching gravity and astronomy, the majority of the students seem not to believe in its credibility. We have noticed that the students have problems with critical thinking and often with quantitative reasoning. Since critical thinking is the major underlying focus of the study, we need to more deeply analyze the students' issues in order to understand how to engage their cognitive processes more effectively.

1 *Science and Engineering Indicators 2008 "Public Attitudes and Understanding." National Science Foundation. 5 May 2009. <www.nsf.gov/statistics/seind08/c7/c7h.htm>*

## Self-Organized Capping of Global Carbon Emissions

*Zhenyuan Zhao*

There is widespread agreement that carbon emissions need to be reduced but there is little agreement on how this should be done. Aside from the long-term goal of creating new emissions-friendly technologies, the immediate issue concerns how to globally control existing emissions. Despite many international summits on global warming and its high profile in the media, there is very limited quantitative understanding of the extent to which institutions or governments can in principle control total emissions without having to continually intervene to micro-manage daily quotas, and hence lose their free-market ethos. By building on a novel theoretical Complex Systems framework developed in part by my supervisor, my project will address this issue. In this article I describe this approach and some preliminary results already obtained.

The purpose of this project is to explore the extent to which free competition, linked with minimal global control, can lead to a self-organized capping of the global emissions. Via computer simulations I will study a model in which a population of competing, adaptive emitters make decisions on when to emit based solely on the behavior of some shared public information. My preliminary work shows that within this simple framework, the emitters can organize themselves in order to collectively hit their emissions target at the expense of some quantifiable fluctuations in the total volume emitted. Most importantly, they can achieve this without the need for any external regulation or manipulation of the market.

Specifically, our model considers an ecology of companies who are continually trying to outguess each other in such a way that they end up emitting at the right time. Our model is a generalization of both the so-called "El Farol Bar Problem" and the "Minority Game," in which agents repeatedly compete for some limited resource [1, 2, 3, 4]. The companies constitute a heterogeneous population with possibly quite different strategies but similar capabilities and who make their respective decisions about emitting based on some knowledge of past history or limited public information. In the El Farol Bar Problem [1], agents decide whether to visit a bar with a limited seating; correct (incorrect) decisions correspond to visiting an undercrowded (overcrowded) bar or not visiting an overcrowded (undercrowded) bar. In the context of the carbon market, our model assumes that the goal of the government is that the companies collectively emit no more than some predetermined total of carbon pollutants each month. If this limit is exceeded then the amount of carbon emitted into the atmosphere is too high, but if the aggregated emissions are too low then this suggests some wasted production capacity. The only information given to the companies after each day is whether or not the actual emissions level exceeded or fell below the average daily value of the monthly cap. Each company makes its decisions based on the strategies it holds, with the best-performing strategy being used at any given moment. In an ideal world, all companies want to be operating (and hence emitting) every day. But we assume that any given company will be sanctioned by the government or the national press if it emits on an overcrowded day (i.e. it emits on a day when too many others are also emitting). Likewise, the company will be sanctioned by its stockholders or customers if it fails to emit on an undercrowded day (i.e. it fails to emit on a day when few others are emitting) since this would represent a wasted opportunity. The model allows us to explore the consequences of many different forms of penalty-reward structure.

The net performance of the overall system is assessed through an analysis of the mean and maximum aggregated emissions over a fixed period of time, and the standard deviation of this aggregated emission about the mean. Based on preliminary simulations we expect the results to show that within the basic constraints of the model, companies are able to organize themselves to hit their collective monthly emissions target with relatively minor fluctuations in the aggregated emissions each month and in the absence of any external regulator controlling the market. We will explore the extent to which companies react to changes in the monthly emission limit, and the difference between this behavioral change for both an incremental and a sudden cap reduction. This will provide insight into the most efficient method for reducing the emissions cap within the carbon market.

As documented in Johnson et al. [5], we know that the underlying model concept works well for financial exchange markets and regular stock markets, that is, it reproduces quantitatively the fat-tail distributions, clustered volatility, and bursty behavior typical of markets. We are now applying this to emissions markets. Both the regular and emissions markets have the same human aspect of yes/no decisions in response to limited global information and a maximum global capacity, so it is likely to be a good first approximation in terms of emissions markets. As emissions markets are established in the next few years, we will be able to test out their behaviors in terms of our common model of collective competition, and hence refine the model according to specific regulations, etc.

Although this model setup is not unique and arguably leaves out many possible complications, we believe that it does indeed incorporate the essential ingredients and hence provides a potentially useful laboratory for exploring the dynamical behavior of future carbon emissions.

1 *W.B. Arthur. "Inductive reasoning and bounded rationality (the El Farol problem)." Amer. Econ. Assoc. Papers. Proc., 84:405, 1994.*

2 *N.F. Johnson, et al. "Volatility and agent adaptability in a self-organizing market." Physica A, 258:230, 1998.*

3 *D. Challet and Y.C. Zhang. "Emergence of cooperation and organization in an evolutionary game." Physica A, 246:407, 1997*

4 *N.F. Johnson, P.M. Hui, D. Zheng, and Tai C.W. "Minority game with arbitrary cutoffs." Physica A, 269:493-502, 1999.*

5 *N. F. Johnson, P. Jefferies, and P. M. Hui. Financial Market Complexity (Oxford University Press, 2003).*

# ARTICLES

## Initiatives to Enhance Nuclear Stability and Non-Proliferation in the 21st Century

*Gerald E. Marsh and George S. Stanford*

There is no lack of problems to be dealt with or new initiatives to be undertaken by the administration of President Barack Obama. And while high-profile issues such as the economy and the never-ending problem of the Middle East are sure to take priority, proliferation and nuclear stability should not fall into a policy abyss: in the mid to long term, they are bound to surface in ever more intractable forms.

There are three initiatives the Obama Administration can undertake that would greatly increase nuclear stability and enhance the non-proliferation regime for many years to come. The first is to ratify the Comprehensive Test Ban Treaty (CTBT); the second is to restructure our strategic nuclear forces; and the third is to create the international structures needed to implement international management of the two technological routes to the proliferation of nuclear weapons: the enrichment of uranium and the processing of used reactor fuel. We will address each of these, but since concerns about nuclear weapons proliferation underlie at least two of those initiatives, it is worthwhile first to address the general issue of non-proliferation.

While current nonproliferation efforts are primarily focused on preventing the further spread of nuclear weapons, the original objective of the Non-Proliferation Treaty (NPT) was to accomplish this while concurrently making available the benefits of nuclear energy to all nations. The existing nonproliferation regime has been quite effective—with a few notable exceptions—but it has some gaps. In particular, existing nuclear-weapon states (NWS) are allowed to retain their nuclear weapons and delivery systems—but only temporarily, at least in principle: Under Article VI of the NPT, the NWS are required to pursue negotiations to achieve nuclear and ultimately "general and complete disarmament under strict and effective international control."

That's an end that will be a long time coming. To be sure, the reduction of stockpiled and deployed nuclear weapons since the end of the Cold War can and should be viewed as a significant step in the direction called for by Article VI. However, given the political state of international relations and institutions, nuclear weapons are not going to be phased out any time soon. Realistically, "general and complete disarmament" remains a distant dream.

While it is rarely explicitly stated, the structure of the present nonproliferation regime is intended to preserve, for an indefinite interim period, a two-tiered world where existing NWS retain their nuclear forces, and non nuclear weapon states (NNWS) are offered a variety of guarantees and incentives to induce them to refrain from developing and deploying such weapons. Despite the appearance of inequity, this may well serve the best interests of all nations, and is probably the best arrangement possible, given current social and political realities. Apparently many nations agree, having chosen not to develop nuclear weapons despite possession of the knowledge and resources to do so—which is why the non-proliferation regime has been as successful as it has been since World War II. Initiatives for the 21st century must preserve and expand the success of the last fifty years.

Nor will the vast improvement in conventional precision weapons and their command and control be able to fulfill the political role of nuclear forces—a role that includes, but is not limited to, enhancing prestige and deterring conventional aggression. While conventional weapons may be far better than the nuclear variety in effectiveness and discrimination for many categories of targets, this is a technical point that will not affect the political and deterrent roles of nuclear weapons. Nevertheless, the number of deployed nuclear weapons can still drastically be reduced without compromising their effectiveness for these roles.

### The Comprehensive Test-Ban Treaty

The primary goal of the Comprehensive Test Ban Treaty (CTBT) is to discourage new entries to the nuclear club (rather than to limit further development of nuclear weapons by the NWS, conventional wisdom notwithstanding, although that might be a side effect). Realistically, the constraints imposed by such a treaty will always be trumped by national interest—two classic cases being Israel and the China-India-Pakistan interaction—but the CTBT does appeal to those NNWS who perceive that they would be more secure, with the freedom to use their resources more productively, in a weapons-free zone than in one where each state has its own nuclear retaliatory capability.

The cases of Israel and the China-India-Pakistan nuclear triangle are interesting and instructive. Israel's perception that its very existence was threatened by the Islamic world led to its developing a considerable nuclear arsenal, although, except for a possible clandestine test off of South Africa in September 1979, they have not had a test program involving significant nuclear yields. While the Israeli arsenal is a well-accepted fact, their policy of ambiguity and abstention from testing has served them well.

It was the interplay of perceived national interests that led to the nuclear triangle of China, India, and Pakistan, each of them seeing its neighbors unconstrained by a test ban. China developed nuclear weapons for historical reasons relating both to their differences with the Soviet Union and to U.S. threats during the Korean War. India, concerned about the dual political and military threat from China, developed what might be characterized as a minimal deterrent, and this in turn led to Pakistan's weapons program. Relations between these nations are rapidly evolving, and a CTBT could greatly contribute to stability during the process. In any event, the arsenals of these nations are unlikely to be eliminated until the underlying tensions that led to their development are resolved. And it should be understood that the incentives that led to their development had nothing to do with the testing of nuclear weapons by the principal weapon states.

Given the cost and commitment necessary for a nation to develop nuclear weapons, it takes a compelling sense of vulnerability to motivate such an undertaking. As shown by the examples of Israel and the Asian nuclear triangle, nations develop nuclear weapons when not doing so would put them at a serious political disadvantage, or because they perceive a significant threat to their national survival. Nonetheless, if testing of these weapons violated an internationally accepted norm of the kind that would exist under a CTBT, that would have to be an important consideration in deciding whether to initiate a testing program—with a negative decision further encouraged by the knowledge that any potentially threatening neighbors would be subject to the same political constraints.

Some observers might not believe in the efficacy of such international norms, but many nations do, and ratification of the CTBT by the United States would signal a new intent to take the provisions of Article VI of the NPT seriously. U.S. ratification would therefore have significant political value.

Arguments against ratification have been based on the asserted need for testing to assure reliability of the weapons stockpile or to develop enhanced safety features. However, it seems clear that such objections are largely red herrings, motivated by the desire to maintain funding for the weapons complex. Of course one can always introduce new safety features, but they are not required—the weapons are already very safe. The reliability of the stockpile can be maintained by remanufacture without significant design changes. A series of Lawrence Livermore National Laboratory (LLNL) reports [1] issued during 1987–1991 affirmed "a high degree of confidence in the reliability of the existing stockpile is justified. . . . [It is] sufficiently robust to permit confidence in the reliability of remanufactured warheads in the absence of nuclear explosive proof-tests." In addition, the reports reviewed the "problems encountered with the 14 nuclear weapon designs since 1958 that have been frequently and prominently cited as evidence that a Low-Threshold Test Ban (LTTB) or a Comprehensive Test Ban (CTB) would preclude the possibility of maintaining a reliable stockpile." The study concluded "that the experience has little if any relevance to the question of maintaining the reliability of the stockpile of nuclear weapons that exists in 1987."

Much has also been made of questions pertaining to predicting accurately the yield of the primaries of multi-stage nuclear weapons. In fact, the record of yield predictability is remarkably good. Such an impressive record would not have been possible if U.S. weapons were not comfortably tolerant of the small variations in materials and manufacturing that accompany any practical production process. This is particularly well illustrated by the excellent performance of new primary designs the very first time they were tested. [1]

This does not, however, mean that the computer codes used to design these weapons can be used to design new weapons with different configurations. In the codes there are too many parameters that need to be derived from a nuclear-weapons-testing database. The point is crucial: the ability to design and field an extensive and varied arsenal of nuclear weapons depends on the availability of a large weapons-testing database as well as on the requisite expertise. Only a few countries have access to such a database, and a CTB would freeze this status.

Even if safety and reliability issues have to a large extent been funding-motivated, this does not mean that such funding can be eliminated. Support must be maintained at a level that will indefinitely perpetuate the expertise needed to understand the physics and materials science related to nuclear weapons and to maintain the ability to manufacture their components. Almost all of the senior designers and engineers with hands-on experience have retired or soon will. Funding should be directed toward attracting young people to this job by allowing and encouraging part-time research in related areas such as astrophysics, stellar interiors, and the physics of dense plasmas, in return for taking on the responsibility of maintaining expertise in weapons physics.

The only facilities left for manufacturing some of the components of nuclear weapons are the limited ones at Los Alamos National Laboratory. These are completely inadequate. The United States must remain able to maintain and manufacture all nuclear-force components for as long as they are needed.

The CTBT was opened for signature on September 24, 1996. President Clinton was the first to sign the treaty, and he transmitted it to the Senate in September 1997 for its advice and consent. Consent has not come. By the end of November, 2008, 148 of the 180 signatories had ratified the Treaty. Annex 2 of the Treaty names 44 states that must deposit their instruments of ratification for it to enter into force. Of these, 35 have ratified. The nine hold-outs preventing entry into force are China, Democratic People's Republic of Korea, Egypt, India, Indonesia, Iran, Israel, Pakistan, and the United States.

The benefits of the CTBT far outweigh any risks. It is clearly in its political and strategic interest for the United States to ratify the treaty and do everything in its power to see it come into force. President Obama has called for its ratification. [2]

**Restructuring Strategic Nuclear Forces**

The second initiative for the Obama administration, the restructuring of nuclear forces, has to do with stability in time of crisis and the role of land-based intercontinental ballistic missiles. Because these missiles cannot survive a nuclear attack, there is an incentive to launch them on warning that a massive missile attack has been initiated.

That risk is minimal now, but some history is instructive: In the Spring of 1986, Donald Latham, then Assistant Secretary of Defense for $C^3$I (Command, Control, Communications, & Intelligence), told Congress that "our policy is not one of launch on warning, absolutely not." This was disingenuous at best. General Charles A. Gabriel had testified in 1985, when he was Air Force Chief of Staff, that "There are options that I won't go into. Obviously, if [the enemy] were going for our missile silos, there will be a period of time when we can see his weapons coming. We have sensors that tell us that. There are options that obviously do not make them sitting ducks."

Perhaps the least ambiguous comment on this issue came from General John T. Chain, Jr., Commander in Chief of the Strategic Air Command, in 1989. In a letter dated January 26 of that year, in response to a query from Republican senator Pete Wilson of California about a study of strategic weapons modernization done by the Washington-based Center for Strategic and International Studies, he wrote that the assumption that U.S. land-based missiles would not be fired until after enemy warheads began detonating on U.S. territory—in other words that they would ride out an attack—is "unrealistic." In his words, "Only the 'rideout' scenario was used, which is unrealistic and assumes away the value of our silo-based ICBMs."

The threat to the land-based missiles was a serious issue during the late Soviet era. Today that threat is no longer credible, primarily because Russia is no longer an enemy, but also because of the deteriorated state of the Russian nuclear forces and associated systems. It is nevertheless important for the United States to eliminate the inherent instability of silo-based missiles by unilaterally restructuring its nuclear forces as a dyad composed of nuclear-armed bombers and submarine-based nuclear missiles. This will eliminate the threat to crisis stability should the political situation change later in this century. Such a configuration is capable of riding out a nuclear attack, so that retaliation will not occur until it is known for certain that there have been actual nuclear detonations on U.S. soil. The French have already made such a transition.

The instability introduced by land-based missiles was initially accepted because submarine-based nuclear weapons did not have the accuracy of land-based missiles. This was an important consideration, because certain high-value targets in the Soviet Union that were required by national guidance to be held at risk required either weapons with very large yields, several weapons, or high accuracy. But the disparity between the accuracy of land- and sea-based forces vanished years ago, and today submarine-based missiles are perhaps even more accurate than the aging land-based missiles. They are also operationally tested on a regular basis, unlike the land-based missiles—whose success record in testing from operational silos is dismal.

The land-based missiles have served their purpose. Their continued retention is dangerous and consumes badly needed resources.

**The Technology of Proliferation**

The third nuclear-related challenge facing the administration is the need to deal with the interplay of nuclear power, nuclear waste, and nuclear proliferation. Here is the current situation:

- Although only in its initial phase in the United States, a nuclear renaissance is upon us, with nuclear power plants being proposed, planned, and built in increasing numbers around the world.
- At the 400-odd plants now operating, used fuel—currently seen as "waste" although it retains 95% or more of its original energy—keeps accumulating in temporary storage, raising concerns about safety, long-term management, and the possibility of malicious use.
- The growing demand for reactor fuel will lead to increased need for facilities to enrich uranium and to reprocess spent fuel—facilities that can be subverted to the production of bomb-grade uranium and plutonium, respectively. As the current cases of Iran and North Korea point up, it is the spread of enrichment and reprocessing capability that presents the

greatest potential for the proliferation of nuclear weapons.

Barack Obama inherited the beginnings of a program that recognized the need to deal optimally with those realities. That program, the Global Nuclear Energy Partnership (GNEP), was officially announced early in 2006. It is one of several fuel-management proposals advanced by various countries. [3] Late word is that the program has been all but abandoned.

The GNEP program was formulated at Argonne National Laboratory, a Department of Energy facility near Chicago. The Argonne scientists saw that the looming growth of nuclear electricity brought with it the urgent need to deal with two problems: the ever-larger stockpiles of used nuclear fuel, and the proliferation threat that would increase as one country after another—some of them politically unstable—found it necessary to have its own enrichment and reprocessing infrastructure to provide a reliable source of nuclear fuel. The GNEP became a two-pronged DOE initiative to deal with nuclear waste and proliferation, and one can hope that whatever replaces it will preserve those two essential features.

**Waste**. Under GNEP, a technology was to be implemented to recycle, in fast-neutron reactors (see box), the used thermal-reactor fuel that is now accumulating. That not only would make accessible the enormous energy resource that the already-mined uranium constitutes, but also would eliminate almost all of the long-lasting radioactivity in the used fuel from today's reactors. Those long-lived components, while amounting to only a little more than a percent of the used fuel, are the source of the concern in the United States about the long-term safety of the Yucca Mountain nuclear-waste repository. [4]

**Proliferation**. A properly implemented international fuel-management protocol would minimize the spread of weapons-capable technology by confining all enrichment and fuel-processing facilities to nations that already have nuclear weapons, and give all non-weapon signatories an ironclad guarantee of unhindered access to a reliable source of fuel, at a reasonable cost, for their civilian reactors. This would plug a serious hole in the NPT, a defect that is the source of most of today's proliferation risk. Under the NPT, non-weapon signatories have the right to develop a full nuclear fuel cycle, including enrichment and reprocessing—a license that is simply no longer tolerable. For such a proposal to win acceptance, the nuclear club's fuel and waste-disposal services will perhaps have to be operated under the aegis of an international entity such as the International Energy Agency or the International Atomic Energy Agency. In any event, the right to the fuel services will have to be structured so that they cannot be abrogated for political purposes. The negotiations, which are ongoing, will not be easy, but they are worth the effort.

Why has this development not proceeded more vigorously? For one thing, enriched uranium for reactors is cheap these days, leading to the perception that the recycling of spent fuel can be put off. Doing so, however, delays the only sensible resolution of the "waste problem"—using the spent nuclear fuel in fast reactors. Not only would that multiply the energy available from the originally mined uranium by a factor of more than a hundred (90% of the ore's energy never even makes it into the fuel, but remains stored as "depleted uranium"—DU), but in less than five hundred years the activity of the real waste (the fission products) will fall below any realistic level of concern. Only one U.S. geological waste disposal facility would be needed for the rest of this century—perhaps longer.

A regime of fast reactors would allow the sustainable generation of large amounts of electricity for the indefinite future, while presenting no threat to the environment in terms of emissions or waste, and would significantly reduce the potential for the spread of nuclear weapons.

A little-appreciated fact is that the DU that is now on hand in the United States constitutes an enormous energy resource, containing as it does about ten times as much energy as all the U.S. coal reserves.[5] That energy can be accessed by fast reactors, postponing for centuries the need to mine any more uranium—and eliminating forever the need to enrich uranium. The DOE recently announced plans to spend more than $400 million to dispose of the DU as low-level radioactive waste.

The potential of fast reactors is discussed in more detail in a number of places.[6],[7],[8] Unfortunately, appreciation of the fast reactor's advantages has been slow to permeate the U.S. Congress, which remains, at best, lukewarm to the idea, and the latest news is that the Obama administration has postponed indefinitely the commercial demonstration of fast-reactor technology. Thus the role to be played by the United States in the development of reactor technology remains to be seen. As of now, U.S. leadership in the development of fast-reactor technology seems to have been abandoned. Ironically, what is arguably the best of the advanced reactors—the IFR (Integral Fast Reactor)—is a U.S. design.

U.S. foot-dragging is not being emulated by other countries. Notably, India, China, Russia, France, Japan, and South Korea are fully aware that their energy mix will have to include fast reactors and the recycling of fuel, and they have active development programs.

## Summary

A vital and urgent next step in implementing rational management of nuclear power is to demonstrate the viability of the fast-reactor recycling technology on a commercial scale. To do so would cost an estimated one or two billion dollars—which could easily and reasonably come from the $30 billion, largely unspent, that ratepayers have already contributed to a government-run nuclear waste fund.

We suggest that the Obama administration would be well advised to resume the lead—to act decisively in bringing order to an otherwise chaotic and dangerous international situation. Dealing with the disheveled economy is bound to have top priority, but the initiatives proposed here should not be neglected. They would have limited financial impact and would greatly enhance nuclear stability and non-proliferation for the 21st century.

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## Fast Reactors

Reactors come in two general varieties, "fast" and "thermal." Almost all of today's nuclear power is produced by reactors of the *thermal* variety, so-called because their neutrons are *moderated*—slowed down to low "thermal" velocities before causing fuel nuclei to fission. In fast reactors the neutrons are not moderated. The fuel-consuming capabilities of the two kinds of reactor are very different.

Uranium in nature is comprised of two principal isotopes—U-238 (99.3%) and U-235 (0.7%). U-235 is likely to fission when it absorbs a neutron, and is said to be *fissile*. U-238 is called *fertile* because it soon becomes fissile (Pu-239) after absorbing a neutron. Thus plutonium is created in any reactor that contains uranium, and some of that plutonium is subsequently consumed as the reactor keeps running. In a typical thermal reactor, some 60% of the energy is coming from fissions in plutonium by the end of the fuel's useful life.

Most of today's thermal reactors are moderated by ordinary ("light") water, and hence are called LWRs. They are fueled with uranium that is enriched to 3–5% U-235. Their "spent" fuel still retains about 95% of the energy it started with. Since, further, some 90% of the energy in the original ore is left behind as depleted uranium (DU) "tailings" from the enrichment process, LWRs (along with other kinds of thermal reactor) are incapable of utilizing even 1% of the energy in the mined uranium. (Even the French reprocessing, using MOX [mixed oxides of U and Pu] can barely reach the 1% level.)

For every GW-yr of electric power, a reactor (*any* reactor) produces about a ton of fission products. Thus the annual "waste" from a 1-GWe LWR consists of about 19 tons of heavy metal and a ton of fission products. The heavy metal portion breaks down into, roughly, 18.8 tons of uranium and 480 pounds of TRU (transuranic elements—Pu and above).

It's the 480 pounds of TRU that almost all the fuss is about. First, the growing global inventory of reactor-grade plutonium raises proliferation worries (although no weapons designer would attempt to utilize it), and, second, TRU contains almost all the long-lived isotopes that get people fired up over questions of how safe a repository would be in 10,000 years.

Enter fast reactors, for which the technology has advanced markedly since the French Phénix and Superphénix reactors were designed and built. Fast reactors produce more neutrons per hundred fissions than thermal reactors do, which gives them increased ability to convert fertile nuclei to fissile ones, and that permits consumption of all the actinide elements from thorium on up. This has two very important consequences.

First, fast reactors can be fueled very nicely with the TRU from spent LWR fuel, along with some of the uranium, thereby reducing the 10,000 year waste problem to a 500 year problem. This means that fast reactors with sensible recycling—e.g. the Integral Fast Reactor (IFR) system—have the potential eventually to sequester all existing plutonium behind heavy shielding in operating power plants and all but eliminate commerce in plutonium. With on-site recycling, once an IFR has been fueled, the only input per GW-yr is a ton of heavy metal (any mix), and the only output is a ton of fission products with trace amounts of actinides.

Second, they can be operated in any one of three modes: (a) as actinide burners, consuming more TRU than they produce; (b) in a break-even cycle, generating only the fissile material they need to keep themselves going; or (c) as breeders, generating fresh fissile when new reactors are to be started up.

# Women in the Sciences

*Meg Urry*

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Everyone agrees there are too few women and minorities in science. As a graduate student, postdoc, young faculty member, and now tenured senior scientist, I have repeatedly seen women colleagues being undervalued or overlooked. But it wasn't until I became familiar with the social science literature that I could fit a viable theory to my experience. In particular, my eyes were opened by Virginia Valian's influential book summarizing this research, "Why So Slow? The Advancement of Women" (Valian 1999). Here I describe, much as she does, social science experiments that illuminate how present-day society projects its unconscious biases into the workplace. But first, a few words about why this issue is so important.

Many scientists believe that increasing diversity is a matter of social engineering, done for the greater good of society, but requiring a lowering of standards and thus conflicting with excellence. Others understand that there are deep reasons for the dearth of women (discussed below) wholly unrelated to the intrinsic abilities of women scientists which lead to extra obstacles to their success. Once one understands the bias against women in male-dominated fields, one must conclude that diversity in fact enhances excellence. In other words, the playing field is not level, so we have been dipping more deeply into the pool of men than of women, and thus have been unknowingly lowering our standards. Returning to a level playing field (compensating for bias) will therefore raise standards and improve our field. Diversity and excellence are fully aligned.

## What Data Show

Hundreds of studies across many fields demonstrate that the advancement of women lags that of men with the same qualifications. Using NSF data for a synthetic cohort corrected for time since degree, type of institution, specialty, and family status, Long (2001) reviewed the gender dependence of salary, rank and tenure in science and engineering, Women lag behind, in advancing and in getting tenure. Having children has the effect of removing women from the full-time workforce, but differences for women who remain in full-time positions are minimal (Mason and Goulden 2002).

## Why Are Women Scarce in Science?

Some of my colleagues believe women are simply not interested in science (at least, not in the physical sciences) and the loss of talent does not seem to worry them. Yet Xie & Shauman (2003) showed that interest in the sciences does not correlate with ability. Furthermore, they found that sex disparities in productivity (e.g., publication rates) were decreasing, and that productivity depends most strongly on access to resources and is independent of family status. And countries with excellent maternity and childcare benefits (e.g., Nordic countries) have some of the lowest participation of women in Physics. Women with families do participate in extremely demanding careers such as medicine.

If it is not ability or interest, what is it? There is plenty of evidence that the playing field is not level for women and men. In 1997 Wenneras and Wold published a study in Nature about applications for a prestigious Swedish postdoctoral fellowship in medicine. They showed that although 46% of the applications were from women, only 20% of the fellowships were awarded to women. Reviewers of the proposals consistently gave women lower scores for the same level of productivity, and women applicants' scores had to be 2.5 times those of men to succeed. A recent study by Budden et al. (2008) showed that the fraction of papers having a woman as first author increased significantly when a biology journal went to double-blind refereeing. While some have suggested women lack innate ability—i.e., women are simply not as good at science as men—this suggestion is contradicted by almost all available evidence. Gender gaps in performance (for example, on math exams) are decreasing in the U.S.; if they were due to physiology, they should not change dramatically on time scales of decades. Moreover, gender gaps vary enormously by country, arguing against a genetic origin. For example, Japanese women score better in math than U.S. men. (See Chapter 2 of the National Academy's *Beyond Bias and Barriers* report [Shalala et al. 2006].)

At the same time, gender gaps can be explained by culture. Research into "stereotype threat" shows that culture affects test results. For example, a class is told they will be given a difficult math test. Men do poorly, scoring 25 of a possible 100, and women do worse, with an average grade of 10 (Steele 1997, Spencer et. al. 1999). This is the kind of gender gap that makes a front-page page *New York Times* story: that at the extremes of performance, men substantially outscore women. However, another class is told the same story about a difficult math test, with the added information that the test has been designed to be "gender neutral." Now the women's score doubles to 20 while the average men's score decreases to 20. In other words, men and women score the same. When the stereotype threat is activated, people under stress conform to it.

## "Gender Schemas"

We are a biased society. It is not overt; most of us think we are unbiased and try hard to be so. It is not only men discriminating against women; it is all of us discriminating against women and minorities (in white-male-dominated fields.) There is evidence that we discriminate against men seeking to join female-dominated fields, like nursing. Valian describes the origin of this bias with "gender schemas," a set of expectations of women and of men, embedded in our culture, that influence how women and men are judged. A large body of research describes the effect of gender schemas; here I give but a few examples:

***Heights of men and women*** (Biernat, Manis & Nelson 1991) Subjects are asked to estimate an objective quantity, namely the heights of men and women in photographs, all of which include some object like a doorway or desk to offer scale. Even though the subjects were chosen so that each gender has the same height distribution, the average height estimated for men is greater than that estimated for the women. We expect men to be taller (indeed, it is true at present in our society as a whole) and so this is what we measure, even when it is not true in the particular data set.

***Leader at table*** (Porter & Geis 1981) Undergraduate students are shown photographs of people sitting around a table and asked to identify the leader. Where all the people pictured are men, the leader is nearly always identified as the person at the head of the table. The same is true when only women are pictured. When both men and women are pictured and a man sits at the head, he is identified as the leader. However, in the mixed gender case with a woman at the head, half the time a random man is identified as the leader.

***Eye gaze*** (Dovidio et al. 1988) First the experimenters establish that in a conversation between a superior and a subordinate (same gender), the superior looks at the subordinate while talking, but looks away when listening. The subordinate spends roughly equal amounts of time looking at and away from the superior, regardless of who is speaking. Then the experimenters showed that in conversations between men and women, men look primarily while talking and women look while both talking and listening, regardless of who is the superior and who is the subordinate. This reinforces the assumption that the man is more powerful than the woman. (Note to women: make eye contact while talking!)

***Rating managers*** (Heilman et al. 2004) Subjects are asked to rate two assistant vice-presidents in a fictitious (but heavily documented) aircraft company (a "male" environment). Men are rated higher than women, despite randomized resumes, but both are deemed likeable. In a second experiment, in which women are validated prior to the evaluation (e.g., subjects are told "both managers have been rated outstanding"), then men and women are rated equally competent but the woman is not likeable and is judged hostile or difficult. That is, women can be competent or likeable but not both.

Gender bias can play an important role in evaluation. For example, letters of recommendation and personal nominations are enormously important for academics in hiring, promotion, invitations to speak, fellowships, grants, and other honors and awards. Yet there are systematic differences in the letters of recommendation for women and for men, as shown, for example, in a study of applications for medical fellowships by Trix & Penska 2003). This is not widely known among science and engineering faculties. Letters for women are shorter and contain fewer standout words ( "outstanding," "ground-breaking," "superstar") and express more doubt and contain more "grindstone" adjectives such as "works hard" and "diligent." They are more likely to mention women's personal lives and, in most cases, the mention of gender is explicit. Women are more likely to be compared to other women (a sure sign that this process is not gender blind). In my own experience, women get asked to write tenure letters for women more often, and their letters are more likely to be discounted or ignored unless they are negative, in which case they are given extra weight. The presence of only a few women guarantees that bias will kick in. In studies of hiring practices, with artificial and matched resumes (Heilman 1980), it was found that women can succeed when they are more than 30% of the applicant pool, whereas they are unlikely to succeed when less than 25%. This has obvious ramifications for job searches or tenure letters that include only one woman as a token on the short list.

This has been a very brief review of what is known from the sociology and psychology research, but enough, I hope, to show that this is not a mysterious problem. Rather, it is a well-understood and tractable problem. There are known remedies. But the first, critical step is to recognize the uneven playing field. Only then can we compensate fairly, and thus have truly objective evaluation of quality.

## Remedies

Gender schemas resist change but also follow change. Change requires education, action, and further research. The first step toward change is to educate our colleagues about the impact of gender on evaluation and career progress. The National Academy of Science's Beyond Bias and Barriers study summarizes the relevant research and interventions. Many NSF ADVANCE projects have online resources, and universities can develop effective methods to teach scientists the (social) scientific literature (ADVANCE is an NSF program intended to transform academic institutions with respect to women in science; 19 institutions and consortia have been awarded ADVANCE grants; the website of the ADVANCE program is www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383. Valian maintains a very useful annotated bibliography of relevant research at www.hunter.cuny.edu/genderequity/equityMaterials/Feb2008/annobib.pdf.

To make progress, leaders must lead. Most leaders in our field (today) are men. Men therefore have to play a key role in advancing progress of women in science. Leaders must be held accountable for developing excellent staffs, which we argue cannot be excellent if they are not gender balanced. What kind of action can leaders take? First, establish norms. Make sure that colloquia, meetings, prizes, job interviews, etc., involve the appropriate fraction of women. Be articulate in explaining this issue and hold others accountable for their performance. Arrange for training and education. "Pre-validate" women in your organization. Brown and Geis (1984) showed that differential expectations by gender can be minimized if leaders establish women's credentials (see also Heilman et al. 2004). For example, a woman speaker should be introduced with a thorough review of her accomplishments, in order to establish without doubt her expertise. A woman promoted to a new position can be pre-validated in a similar way, by describing explicitly the reasons for her success. Avoid facile solutions like adding a token woman to every committee. For one thing, women are vastly overworked. Also, successful women may compete with, rather than support, younger women. In their book on affirmative action, Clayton and Crosby (1992) suggested that some successful women avoid advocacy for other women because they are deeply invested in the idea of a gender-blind meritocracy; if evaluations are not objective, their own success is invalidated.

You can educate your colleagues about how to write letters of recommendation (Trix & Penska 2003). You can teach students about teaching evaluations, which are more negative for women faculty (see www.crlt.umich.edu/multiteaching/gsebibliography.pdf). Information and mentoring are also essential. A mentoring program at the Johns Hopkins Medical Institutions dramatically improved the tenure rate for women assistant professors (Fried et al. 1996), and incidentally, also for men who took part in the program—just one example of what's better for women is often better for men. The APS has an active outreach program in this area; see, for example, their website on "Improving the Climate for Women" at www.aps.org/programs/women/sitevisits/index.cfm.

Given the common timing for building careers or building families, it is not surprising that many people assume family issues are the reason for the dearth of women in science. The academic world was not designed for people with family obligations. After all, the European academic system was originally designed for monks. Appropriate accommodations for both men and women (such as on-site childcare, sick child care, elder care, delay of tenure clocks for family obligations, travel support for caregivers helping during professional meetings, etc.) can go a long way toward humanizing the modern workplace. Nonetheless, I argue at least three reasons family issues cannot explain why there are not more women in physics or astronomy. First, women without children who remain full-time in the workplace are not more successful than women without children. (Mason & Goulden 2003 is often cited as showing that women's careers are harmed by having children, but this is because those women are more likely to go to part-time status, which indeed is a negative factor, perhaps wrongly, in their subsequent career advancement) Second, there are many women in other demanding fields, like law and medicine. Third, countries with very strong family support systems, such as the Scandinavian countries, have extremely low numbers of women in physics — just a few percent in 2002. Women in academia often complain about how hard we work and how difficult it is to raise a family under those circumstances. Certainly all of us have pulled "all-nighters" to complete a proposal or have traveled for days or weeks on end to give talks or attend meetings. It is no wonder that young people listen to us and decide they can't reasonably balance career and family. Yet I would argue that academic careers are better than most for this purpose. Our hours are flexible and in many countries salaries are better than the average citizen's, so we have the resources to get help with childcare and household tasks. Having a family is hard, no matter who you are or where you work, but it's much harder if you work at a low-wage job with inflexible hours. We should tell young women that the academic life is great for raising a family: The work is fun (so parents are happy), the rewards are great, and we have a lot of control over our lives. My new mantra: Become a professor, have a family!

Finally, advancing in our profession requires passing through an endless series of selection processes: graduate school admissions, hiring, invited talks, prizes, promotions and tenure. It is unlikely, given our societal biases, that these processes are gender-blind. Each of these selection steps requires two things: finding candidates and evaluating them fairly. It is not sufficient to wait for applications to arrive in the mailbox. A proper job search is just that. One should solicit names from colleagues, use community bulletin boards to find and investigate possible women candidates, and attend lots of talks by junior people. Many a search has turned up outstanding but somehow overlooked scientists. The second step is to evaluate all candidates fairly. This cannot be done by declaring oneself or one's colleagues gender blind. Only those who familiarize themselves with the issues of gender bias are likely to evaluate others objectively. Taking these issues into account and actively promoting the advancement of the talented women scientists we need in the modern world will lead to a stronger, better, healthier, fairer scientific community.

## Summary

Data illustrate the dearth of women in physics. The theory of gender schemas goes a long way toward explaining why this is a difficult, persistent problem. Good intentions are not enough. The status quo will not repair itself. It will take concerted, conscious action on the part of enlightened leaders. We need to transition from a "fix the woman" strategy, toward a "fix the system" strategy. The main problem is our perception of women being less good than men, when objective review says otherwise. Women are not automatically seen as leaders, or in some cases, even as competent. Yet this can be changed, by external validation by accepted authorities, often men.

What can women do for themselves and others? Gain success outside your institution. Take on highly visible jobs. Gather information on what is needed for success. Find effective mentors and mentor others. Negotiate for the resources you need to succeed. Make allies. Most of all, work to improve the system for other women. The key point is that change toward greater equity and thus a higher level of excellence take positive intervention. It will not happen without action.

*This contribution has not been peer-refereed. It represents solely the view(s) of the author(s) and not necessarily the views of APS.*

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# REVIEWS

## Physics of Sustainable Energy: Using Energy Efficiently and Producing It Renewably

*David Hafemeister, Barbara G. Levi, Mark D Levine, and Peter Schwartz, eds. (Melville, NY: AIP Conference Proceedings 1044, 2008) ISBN 978-0-7354-0572-1, ix + 438 pp. $239.*

During a recent press conference held at the National Press Club to unveil the APS Energy Efficiency Report, former APS President Burton Richter remarked that this time, the energy crisis is "for real" (*APS News*, October 2008). Policies, practices, and technologies for renewably producing and efficiently using energy will play a significant role in addressing the challenges of energy supply; the volume under review here is thus both timely and relevant.

This volume is a collection of papers presented at an AIP-sponsored short course held at UC-Berkeley on 1-2 March 2008. This course was intended to give physicists the in-depth technical background needed to teach about energy options or to become involved in energy research. The course attracted 260 attendees from academia, industry, and government. Readers familiar with energy issues will be familiar with the names of the editors, particularly that of David Hafemeister, whose *Physics of Societal Issues* was reviewed by this writer in this column in July 2007; the two volumes could probably be considered companions. As might be expected of a volume of conference proceedings, the styles of individual papers vary widely; this is not a conventional text or monograph and so cannot be read or reviewed as such.

The contributions are divided into four sections: Policies for Sustainable Energy (5 papers), Energy Use in Buildings, Appliances, and Industry (11), Energy Use by Automobiles (5), and Electricity from Renewable Energy (7). A few of the contributions are reproduced from other sources such as *Physics Today*. In some cases reproductions of Power-Point slides are somewhat fuzzy, but readers are directed to a website where originals can be accessed. A series of appendices include an Energy and Environment Chronology that covers events from the discovery of petroleum in Pennsylvania in 1859 to events in 2008, a series of "Energy Outlook" graphs from the U. S. Energy Information Administration on oil reserves, electric power generation, U.S. energy production/consumption and related issues for the time period 1980-2030, a list of World Wide Web energy sites, and an extensive table of units. The latter is marred in places, however, with what should clearly have been Greek letters being published as their English counterparts.

Flipping through this book gave me a sense of the breadth of activity on the frontiers of energy research: contributions include studies of water supply and its relation to energy security, the energy efficiency of Chinese industry, historical trends in average energy consumption, price and size of domestic refrigerators, systems analysis of heat flow in buildings, LEDs for solid-state lighting, the physics of glazings for energy-efficient windows, air quality in urban heat-islands, standby-mode energy consumption of household appliances, microbolometers for infrared cameras, electric batteries and hydrogen storage systems for vehicles, relationships between vehicle weight and crash survivability for a variety of cars and trucks, solar-energy conversion efficiency, wind-energy technology, carbon-capture methods, and biofuels. Readers with a broad command of undergraduate physics should be able to understand most of the contributions. The encouraging thing is that is that progress is happening in so many areas; the difficulty is that it will take time to bring these new technologies to significant levels of market penetration against the inertial forces of existing infrastructures, production techniques, vested political interests, and economic fluctuations. I was disappointed to see only one brief paper on the future role of nuclear energy, which must be considered as a significant intermediate-term large-scale source of energy.

The take-home message from this volume is best expressed by contributor Robert Socolow of Princeton University in his paper on Stabilization Wedges and Climate Change. His remark was with respect to mitigating $CO_2$ emissions, but applies to the whole issue of producing energy renewably and using it efficiently: "What once seemed too hard has become what simply must be done."

In summary, while the contributions in this volume are for the most part too brief to facilitate their use as tutorials to learn the fundamentals of a topic from the bottom up, they will be of interest to scientists curious to get a sense of the broad spectrum of research in a number of energy-related areas. However, at a list price of $239, you might want to have your library order it. Finally, it should be noted that this review was prepared before I was appointed *P&S* Editor.

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## Censoring Science: Inside the Political Attack on Dr. James Hansen and the Truth of Global Warming

*Mark Bowen (Dutton, New York, 2008). 324 pp. $25.95. ISBN 978-0-525-95014-1.*

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It's difficult to imagine anyone who has followed the issue of global warming who is not familiar with James Hansen. After writing a Ph.D. thesis speculating about the atmosphere of Venus in the late 1960s, he sought to follow up on it with a post-doctoral fellowship at NASA's Goddard Institute for Space Studies (GISS) near Columbia University in New York City. His work there was so impressive that he was offered a full-time job, and after founding Director Robert Jastrow retired from NASA in the early 1980's, Hansen was chosen to succeed him and has remained there ever since.

But while waiting for NASA to launch a satellite to make better measurements of the polarization of light reflected from Venus, Hansen found his interests turning to the atmosphere of Earth. His first "epochal" paper appeared in *Science* in 1981 and predicted a global temperature increase of 2.5 ºC in the 21$^{st}$ century with "slow energy growth." This led to greenhouse effect editorials in *The New York Times* and *The Washington Post*.

That the average temperature of the Earth is increasing cannot be doubted – the data speak for themselves. The same is true for the increase of carbon dioxide and other greenhouse gases in Earth's atmosphere. The difficult part is to establish a connection between the two, that is, that the latter causes the former. In fact, Bowen points out in his last two chapters that historically, global temperature change resulted from a change in the interaction of Earth and Sun, with a corresponding change in atmospheric carbon dioxide concentration lagging a few hundred years. Only since the Industrial Age has an increase in greenhouse gases *led* an increase in atmospheric temperature.

During his time at GISS, Hansen and his colleagues have been working on a global circulation model to simulate the behavior of Earth's atmosphere. The results of this model and other studies done at GISS have persuaded Hansen that, as he phrased it in 1987 testimony to a U.S. Senate committee, there is 99% confidence that global warming is occurring, high confidence in ascribing global warming to the greenhouse effect, and high confidence that a human-made greenhouse effect would lead to more frequent extreme weather events.

This is bad news and some people don't like bad news, particularly those whose livelihood is threatened by it. In this case, those threatened are the producers and users of fossil fuels. In his penultimate chapter, Bowen explains how these producers and users employed many of the same tactics used by the cigarette industry in response to the Surgeon General's Report: "In many ways, fossil fuel burning is to the biosphere as cigarette smoking is to the human body." (p. 240)

Thus, Hansen and his message through the years have been met with opposition, not only from special interests who have been threatened by it but also by political administrations beholden to those special interests. While testifying before a Senate Committee chaired by then Senator Al Gore in 1989, the first year of the George H. W. Bush Administration, Hansen discovered at the conclusion of his testimony that it had been rewritten by the Office of Management and Budget, and he related this to the Committee.

The incidents in which Hansen was obstructed in communicating the results of his work were more numerous in the George W. Bush Administration, particularly during the re-election year 2004 when a program of NASA school visits was cooked up to promote the President's "New Vision for Space Exploration."

The general theme of this book is the chronology leading toward a tipping point in Hansen's relationship with government in his crusade to avoid a dangerous climate tipping point. Were it not for the obstructions Hansen faced in communicating his message, he might not have become so well known for being the activist that he at times became. As Bowen describes him, Hansen's first love is the science that he does, but he also believes in the importance of communicating its results – "Jim Hansen was hoping to speak publicly and keep his job." (p. 165) Yet, although Hansen, as a Senior Executive Employee, does not have civil servant protection, that's exactly what he did. In reading this book, I could find no obstruction that Hansen was unable to circumnavigate; he is still the director of GISS.

As such, Hansen was a more successful "survivor" than many others. Chapter 6 details censorship of the work of scientists at NOAA (National Oceanographic and Aeronautical Administration), which David Baltimore attributed to the George W. Bush Administration's "unitary" view of government, namely that the executive branch can run independently. Chapter 5 describes the "editing" of the Environmental Protection Agency's first-ever report on the state of the environment that brought about Christie Whitman's resignation as EPA Administrator.

As books go, this one is remarkably up-to-date. Its cutoff date, indicated on p. 303, was September 2007. But there is a price to pay in trying to publish a book quickly, and it shows in lack of documentation and an incomplete index (the name of Hansen's Ph.D. thesis advisor is not even included). But the statement on p. 308 that "we decided early on to forgo footnotes and endnotes in this book" suggests that there was a desire to get this book out quickly and have it as up-to-date as possible. True, the year of publication is also the year of a presidential election, but the incumbents are not running. Curiously, the candidate Hansen would have voted for had he been on the ballot in 2004 *was* on the ballot in 2008.

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