APS NEWS

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FEATURED ON THE BACK PAGE: **David Goodstein on Education**

Council Statements Focus on Missile Defense, Science Funding

At its April meeting, the Council of the APS approved a statement on issues relating to the technical feasibility and deployment of the proposed National Missile Defense (NMD) program. President Clinton is scheduled to make a decision by this October as to whether to begin deployment of such a program, although a decision could be made as early as August. Some members of Congress, of both parties, have urged the President to defer a decision until the next administration. The text of the statement follows.

"The United States should not make a deployment decision relative to the planned National Missile Defense (NMD) system unless that system is shown-through analysis and through intercept tests- to be effective against the types of offensive countermeasures that an attacker could reasonably be expected to deploy with its long-range missiles. The planned NMD system is intended to defend U.S. territory against tens of long-range ballistic missiles carrying biological, chemical or nuclear weapons. The ability of the NMD system to deal with countermeasures is a key factor in determining whether the system will be able to defend against the threats it is intended to meet.

A decision on whether or not to deploy the NMD is scheduled for the next few months. The tests that have been conducted or are planned for the period fall far short of those required to provide confidence in the 'technical feasibility' called for in last year's NMD deployment legislation.

This statement implies no APS position with respect to the wisdom of national missile defense deployment and concerns itself solely with its technical viability."

Background information relating to the NMD statement can be found on the APS website at http://www.aps.org/statements/00.2.html.

Believing that broad-based funding for physics research is critical to preserving national competitiveness, the APS Council also approved a statement to that effect at its April meeting, singling out the Department of Energy (DOE) for particular support. The statement reads:

"The Council of the American Physical Society applauds and strongly supports the significant funding increases for science contained in the President's FY2001 budget.

The nation's research in physics is broadly supported through several agencies, principally DOE, NSF, NASA, and DOD. The ability of U.S. physics to continue contributing to the nation's economic growth and its national security depends critically on adequate funding for all these agencies.

The DOE provides the majority of the funding for a wide range of basic research in the physical sciences. Therefore, the Council is particularly concerned that the DOE's science funding remain healthy.

The DOE Office of Science is responsible for the construction and operation of most major facilities in particle and nuclear physics, and for many other facilities needed in multidisciplinary research programs relevant to materials sciences, energy sciences, biology, and medicine. These efforts have been instrumental in the success of important national scientific programs.

The Council urges, therefore, that the DOE share fully, in FY2001 and in subsequent years, in the funding increases aimed at maintaining the health of the U.S. scientific enterprise. Present concerns regarding management and security issues should not obscure the need for sustaining and enhancing the essential DOE-supported science programs."

Physics Chairs Meet at APS Headquarters

More than 120 physics department chairs spent two days in April at the American Center for Physics in College Park. With a conference emphasis on undergraduate physics education, presentations focused on the need for better teaching techniques, curricular issues, careers, responses to the new engineering accreditation requirements, and ways to improve the physics taught to prospective teachers. Rounding out the program were talks on NSF and DOE funding priorities by Bob Eisenstein, Assistant Director for Mathematical and Physical Sciences (NSF) and Pat Dehmer, Acting Deputy Director of the Office of Science (DOE), and an overview of the Washington science policy scene by Mike Lubell, APS Director of Public Affairs. In the photo above, Steering Committee co-chair Peter Collings of Swarthmore addresses the gathering. The conference was cosponsored by APS and AAPT.

Inside...

Re- "Creating Copenhagen" at CUNY Symposium

Why did Werner Heisenberg make the risky journey to Copenhagen in 1941 to visit his former mentor, Niels Bohr? What did the two discuss, and why did it end their friendship? Was Heisenberg trying to learn about Allied progress on the atomic bomb? Was he seeking Bohr's input on the ethics of applying physics to construct a weapon of mass destruction? And should history view Heisenberg as a hero for purposely slowing or sabotaging the German bomb effort, or an incompetent engineer who failed to understand the key design principles involved?

These unsolved mysteries provided the thematic framework for a special symposium in March, sponsored by the City University of New York Graduate Center, entitled "Creating Copenhagen." Both the American Physical Society and the American Institute of Physics were cosponsors of this event. Physicists, historians, theater professionals, and members of the general public alike crowded into the new Proshansky Auditorium for the free, day-long series of events, which included lectures on the science and history of the so-called "Copenhagen Interpretation" of quantum mechanics and the subsequent development of the atomic bomb.

The CUNY symposium was timed to coincide with the Broadway opening of "Copenhagen," an award-winning drama by British playwright Michael Frayn that won the prestigious Evening Standard Award for Best Play in 1998. The play is inspired by actual events that have intrigued and baffled historians for more than 50 years — a 1941 meeting between Bohr and Heisenberg, both brilliant physicists and longtime friends whose work together had paved the way for the atom, but who were now on opposite sides of World War II. Heisenberg, then chief scientist on the German atom-bomb project, made a covert journey at great personal risk to see his former Danish mentor and his wife Margrethe in Copenhagen, but the meeting ended in acrimony. Nothing is known of why Heisenberg made the visit, or what the two men said to each other, yet it remains a defining moment of the modern nuclear age.

Photo by Gerald Cyrus

Hans Bethe (right) picks up some acting tips from Michael Blakemore.

Frayn's play extends the concept of quantum uncertainty to the realm of human motivations through a series of cyclic re-tellings of the same event from differing perspectives, and in Blakemore's staging the actors move about the stage as if they are particles in a quantum system. Michael Cumpsty, the actor who plays Heisenberg in the Broadway play, was on hand for the symposium, along with actress Blair Brown, who plays Margrethe Bohr. A sold-out evening session featured a panel discussion with Frayn and the play's Broadway director, Michael Blakemore.

The first session on science offered a technical exploration presenting the basics of quantum mechanics and of the contributions of Bohr, Heisenberg and others. Speakers discussed specifics of the Copenhagen Interpretation of quantum mechanics and of present views of how the wave function yields definite states. They included former APS president Eugen Merzbacher, Faye Ajzenberg-Selove of the University of Pennsylvania, Anton Zeilinger (University of Vienna), and Brian Greene, a physicist at Columbia University and author of *The Elegant Universe*, a discussion

Continued on page 7

March 2000 Meeting Prizes and Awards Recipients

(Left to right) Seated: H. Kumar Wickramasinghe, Mildred Dresselhaus, Fay Ajzenberg-Selove, Calvin Quate, Sharon Glotzer. First Row Standing: J. Michael Kosterlitz, Wesley R. Burghardt, Paul Hansma, M. Brian Maple, Marc Kastner, Theodore Fulton, Gerald J. Dolan. Second Row Standing: Michael Falk, Michael Fayer, Robert Birgeneau, Bertram Battlog. Absent from photo: Lewis J. Fetters, Paul L. Richards, Chauncey Starr, David J. Thouless.

April 2000 Meeting Prizes and Awards Recipients

(Left to right) Seated: Sidney Coleman, Steve Fetter, Donald Jacobs, Govind Krishnaswami, Raymond Arnold. Standing: Curtis Callan, Jr, Brian Gerke, Mei Bai, Igal Talmi, Martin Breidenbach, Michael Creutz. Absent from photo: John Arrington, Philip Phillips, Jeremiah Sullivan, Maury Tigner

That's It Folks! For the Last Time: Even More Top Ten Physicists

About your list of "top ten physicists": I think that although Heisenberg, Feynman, Schrödinger were very important, they are in the list because of either their charisma (Feynman – why not Tomonaga or Schwinger, then ?) or because they summed up the advances of debates at their times (Heisenberg and Schrödinger : without de Broglie, Born, Planck, I do not think they would be there). I suggest to replace them with people like Faraday, Ampère, Coulomb, Gauss, who were more "stand-alone" geniuses, working as well in experimental as theoretical physics. The Curies, Fermi, etc, should also belong in the list, which looks Anglo-German, quantum-mechanical, and XXth century biased to me.

Florent Calvayrac
Laboratoire de Physique de l'Etat Condense; Universite du Maine-Faculte des Sciences

The *Physics World* survey (not only the first 10 physicists) reveals a double bias. First toward modern times and second in favor of theoreticians. Further, while it is in order to make a rank-list after a poll, there is no need for that in an individual choice. Here are my top ten physicists who have contributed to physics the most:

1. Archimedes (great physicist, engineer, and mathematician), who laid the foundations of statics and hydrostatics.
2. Isaac Newton (great physicist and mathematician), who laid the foundations of dynamics and hydrodynamics, and the theory of gravitation.
3. Michael Faraday (arguably the greatest experimentalist of all time), who laid down the foundations (together with James Clerk Maxwell) of the physics of electromagnetism, the cornerstone of modern civilization.
4. James Clerk Maxwell, who by formulating the electromagnetic theory not only made a unification of two formally disparate fields, but introduced the notion of the physical field, probably the most important concept of modern physics.
5. Albert Einstein (arguably the greatest theoretical physicist of all time), who has revised at the most fundamental level Newton's concepts of space and time, his dynamics and theory of gravity.
6. Galileo Galilei (great physicist and astronomer), who laid the foundations of modern science, by introducing both mathematical and experimental methods into science and thus separated it definitely from scholasticism and metaphysics.
7. Ludwig Boltzmann (great theoretician and epistemologist), who has laid down foundations of thermodynamics, with Maxwell's electromagnetic theory, considered the crown of 19-century physics.
8. Ernest Rutherford, who has, by elucidating the structure of atomic systems, opened the door of the microworld, previously inaccessible to our experience.
9. Erwin Schrödinger (great theoretician and polymath), who has formulated his equation, with Newton's one the most important in the history of science and contributed decisively to the overall development of quantum mechanics, arguably the greatest theoretical achievement of science in general.
10. Paul Dirac (great theoretician), who laid down the foundations of relativistic quantum mechanics and quantum field theory, the latter being, as such, the most advanced achievement of physics of our time.

Petar Grujic
Belgrade, Serbia, Yugoslavia

While the names on the list are certainly among the outstanding physicists in history it seems strange that one name has been left out. A man who discovered not one, not two, but three universal laws, who was as responsible as Maxwell in unifying fields, who outgrew his accomplishments in physics and became a statesman, whose name is familiar among physicists from Seoul to São Paulo, who founded an institution which has benefited tens of thousands of the most under-privileged physicists, who kept open a channel to the West to physicists from behind the Iron Curtain when no one else would have them, certainly belongs on any list of ten outstanding physicists in history. I refer of course to Abdus Salam.

Munawar Karim, Professor
Department of Physics, St. John Fisher College

I think it's an omission not to have Enrico Fermi on the list. He made fundamental contributions to both solid state and particle physics. Sometimes, it's hard to believe that the concepts of fermions and Fermi surfaces (as well as a host of others) are attributable to the same physicist. It seems to me that he could replace a number of those on the list: Schrödinger, Heisenberg, Dirac, perhaps even Feynman. The ancients are more sacrosanct, and it's hard to compare their work with that of the modern physicists anyway, so I'd leave Newton and Galileo on.

Bruce Schumm
University of California, Santa Cruz

More on "Who were the top ten physicists?" Don Lichtenberg (April issue) made some good points but, like most others, he neglects experimentalists and underestimates the contributions of prequantum physicists. Was it easier to establish Coulomb's law or discover electricity (both circa 1790) than to observe the scattering of alpha rays (1913) or measure the speed of neutrons (~1940)? Was it less significant for Laplace (also the inventor of cosmology) to formulate classical mechanics in terms of his equations than to derive a Laplacian formulation of quantum mechanics? What was more astounding: that light could be shown to produce very puzzling shadows indeed when passed through Young's slits, or that "matter waves" also interfered? Inexcusably also, one would get the impression that this most impressive achievement of classical physics, thermodynamics, was not an essential part of physics. Maybe the problem with thermodynamics is that, like quantum mechanics, it was a collective sort of achievement. Don Lichtenberg could not choose between Heisenberg, Schrödinger and Dirac, similarly after hesitating between Carnot, Clausius, Gibbs, etc., I chose Boltzmann! Experimentalists I order chronologically because the available technologies of their respective times makes them uncomparable.

Here I go then (after much agonizing)—**Top five theorists:** Newton, Einstein, Schrödinger, Maxwell, Boltzmann. **Top five experimentalists:** Galileo, Coulomb, Young, Faraday, Rutherford.

And how about old Archimedes? Wasn't he the first of them all?

Bernard Terreault
Université du Québec

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Scientific Community Speaks Out on Behalf of FY2001 NSF R&D Budget

March and April were busy months for scientists working on behalf of the proposed Presidential science R&D budget for FY2001, which calls for an increase of 17.3% for the National Science Foundation. The Presidential request also calls for balancing the increase between focused research initiatives in nanoscience, information technology, biocomplexity and science education, on the one hand, and the core research programs in the traditional disciplines on the other. The scientific community has been quick to speak out in favor of the proposed NSF increase, as evidenced by a three-pronged effort this spring.

In March, the APS Executive Board agreed to co-sign a statement supporting the FY2001 proposed NSF budget generated by the Coalition for National Science Funding (CNSF), which maintains that such an increase "is imperative to expanding the opportunities for more successful science and technological breakthroughs in the future." The CNSF statement cited the major role federal R&D support has played in sustaining U.S. economic growth, along with its belief that the NSF is badly in need of a generous increase.

For instance, throughout the 1990s, the NSF's basic research budget grew at an annual rate of between 1.9% and 3.2%-less than the 5.1% (in constant dollars) annual growth rate enjoyed by the agency during the 1970s. "It is clear that many of the technology innovations enjoyed today are based upon research done 20-30 years ago, and that innovations 20-30 years in the future will be based upon present-day research." Along with a recognition of the cross-disciplinary nature of much of present-day frontier scientific research, the statement also spoke of the importance of maintaining the "knowledge continuum," expressing concern at the declining number of U.S. students opting to study science, mathematics and engineering.

APS President James Langer also weighed in with his support in a personal letter to NSF Director Rita Colwell on April 19th, assuring her of the Society's active commitment to convincing Congress of the need for such a generous increase to ensure the nation's continued economic health. "There is little doubt that nanoscience and information technology will be at the cutting edge of future research, and we therefore strongly support the new initiatives identified in the President's request," he wrote. "At the same time, we are much encouraged by your goal of using half of the NSF increase for the improved funding of core research. Only by maintaining a wide base of scientific knowledge can we prepare ourselves to tackle the new frontiers, wherever they may appear."

Finally, Robert Richardson of Cornell, Chair of the APS Physics Policy Committee, represented the APS during April Congressional hearings before the House Subcommittee on VA, HUD and Independent Agencies Committee on Appropriations. His testimony was part of a collaborative presentation with representatives from the American Chemical Society, the American Mathematical Society, and the Federation of American Societies for Experimental Biology, and echoed many of the same sentiments as the CNSF statement and Langer's letter, particularly on multidisciplinary research. "The boundaries between the traditional disciplines have become increasingly blurred, and the advances in the different disciplines have become increasingly interdependent," he told subcommittee members. "The scientific frontier no longer seems to fit conveniently into one discipline or another. For this reason, we strongly support initiatives that cut across disciplines, such as those the President identified this year."

This Month in Physics History

The Shelter Island Conference • June 2 - 4, 1947

In 1947, physics in America was just getting back to normal after the disruption of World War II. Duncan MacInnes, a physical chemist at the Rockefeller Institute, Karl K. Darrow, the permanent secretary of the American Physical Society, and others conceived the idea of organizing a series of small conferences to address the most important research questions of the day. The Shelter Island Conference was the first of these, and the main topic was the status of quantum electrodynamics (QED), the theory that describes the interaction of electrons with photons, and therefore underlies all of chemistry, atomic physics, and optics.

The rules of QED had been known since the early days of quantum mechanics, having been formulated by Fermi, Dirac and others. But it was also known that as soon as one went beyond the lowest order of perturbation theory, the predictions ceased to make sense, seemingly giving divergent answers for physical quantities. Physicists had wrestled with these issues during the thirties, and had largely put them aside during the wartime period. At the Shelter Island Conference, 24 scientists, most of them theoretical physicists, gathered to take serious stock of the situation.

The trip to the conference site was not uneventful. The meeting was to take place at the Ram's Head Inn on Shelter Island, located between the twin forks of Long Island. Most of the participants gathered on June 1 in Manhattan, and boarded a bus that then headed east. As it proceeded across Long Island, it was accosted by a police escort, which eventually led it to a restaurant where a banquet had been prepared for the scientists—a tribute organized by a member of the local chamber of commerce, who, having served in the Pacific during the war, felt that the atomic bomb had saved his life and wanted to express his gratitude. At that moment physics may have reached the apogee of its public reputation in this country.

The conference itself brought together established physicists who had made their reputations in the thirties, such as Bethe, Weisskopf, Rabi and Oppenheimer, together with the emerging stars of the next generation, like Feynman and Schwinger. Among the most interesting news was the report by Willis Lamb of his recent work at Columbia in which he had measured a tiny difference in energy between the 2S and 2P levels of hydrogen. The Dirac equation predicts an exact degeneracy; it was known that QED gave a correction to this, but it was, of course, infinite. However, stimulated by this report, on the train ride back from the conference Bethe was able, with the aid of a few ad hoc assumptions, to perform a calculation in agreement with Lamb's result. Within a year or two, the work of Schwinger, Feynman, Dyson, and Tomonaga (much of whose work had been done in isolation in Japan during the war) brought QED into a fully relativistic and consistent form, with prescriptions for renormalization that removed all infinities from observable quantities. Today QED is the most successful theory science has ever produced, having been verified in some cases to an accuracy of 12 decimal places.

Reprinted from *Shelter Island II*

Discussing physics informally (left to right): R. Feynman, H. Feshbach, J. Schwinger

To read more about the Shelter Island Conference, see the essay by Silvan S. Schweber in "Shelter Island II," R. Jackiw et al. eds, MIT Press, Cambridge MA (1985).

Birthdays for June:

13 James Clerk Maxwell (1831)
13 Luis Alvarez (1911)
14 C. A. de Coulomb (1736)
28 Maria Goeppert-Mayer (1906)

INSIDE THE BELTWAY

A Washington Analysis

Crunch Time

By Michael S. Lubell, APS Director of Public Affairs

A lame-duck presidency is like Joe Six Pack: a few ripples still defining the triceps but little more than flab showing in the gut. As the Clinton Administration nears the end of its tenure, the big question in Washington is whether this president, who only a year ago suffered the ignominy of impeachment, will break the conventional mold.

Intelligence sources in both parties think he will. Democrats, who loyally stood by him last year, see his staying power as ironic. Republicans, who gunned him down, view it as insulting. But privately, they all acknowledge that the White House is a master performer in the political arena.

What will the presidential scorecard look like when crunch time comes next fall? In the loss column: the Comprehensive Test Ban Treaty and the Kyoto (global warming) Protocols. In the win column: the federal budget. Here's why.

For every member of Congress, getting out of town early to campaign for reelection is highest on the list of priorities. That means precious little time for legislation.

In the case of treaties, Congress holds all the cards. The Senate can simply refuse to take them up, and all the president can do is sputter.

In the case of the budget, the White House has all the trumps. If the president doesn't like what Congress sends down Pennsylvania Avenue, he can send it back promptly with a veto. With insufficient votes for an override, Republican leaders will have four choices: shut the government down, strike a deal or pass a Continuing Resolution.

Shutting the government was a losing strategy the last time it was tried, and it still is. Passing a Continuing Resolution, which would allow the next president to call the shots, is a "no go" for this president. The only option is to strike a deal. And, as the past two years have demonstrated, when deal-making time comes, this White House wins.

For the Republicans, getting through the final negotiations without humiliation will be difficult. But getting from June to October without committing political suicide will be their biggest challenge.

As they enter the appropriations arena, the Republican leadership has left itself little wiggle room. In February, President Clinton proposed a discretionary budget amounting to $622 billion. The Budget Resolution that made it through both houses of Congress puts the spending at just over $600 billion.

In addition, Senate Majority Leader Trent Lott (R-MS), at the prodding of Senator Phil Gramm (R-TX) nixed the presidential request for Fiscal Year 2000 supplemental spending for foreign and domestic emergencies. In fairness to the GOP leadership, it should be noted that by the time the request was about to reach the Senate floor, the $5 billion or so request from the White House reportedly had grown to more than $20 billion.

Still the Senate action, or, more properly, the lack thereof, leaves Congress with a gaping $27 billion dollar hole to repair. For civilian programs, the hole is a chasm, since Congress added more than $10 billion to the presidential request for defense spending.

For science this means a shortfall of at least $100 million in DOE research accounts, compared to present spending. And in NSF accounts, it could mean even more.

Will these numbers stick after all the dust settles? Probably not, but it will be a cliff hanger. The only certainty is that Arlen Spector (R-PA) and Tom Harkin (D-IA) will hold sway in the Senate, and John Porter (R-IL) will do the same in the House, as they successfully nudge their colleagues to deliver another $2-billion increase for NIH.

OPINION

LETTERS

Explosive Arithmetic

Your third "Physics Product Warning" (*APS News*, February 2000, p. 5) said that the product "contains the energy equivalent of 85 million tons of TNT per net ounce of weight."

I have two problems with this:

1) Einstein's equation is for the equivalence of mass and energy, not weight and energy.
2) When I do the arithmetic, I get 21 thousand tons of TNT per gram or 607 thousand tons of TNT per ounce, not "85 million tons." (1)

Have I done the arithmetic correctly?

Albert A. Bartlett
University of Colorado, Boulder

Sympathy for Wen Ho Lee is Misplaced

While I agree the poor treatment of Wen Ho Lee (*APS News*, April 2000) in prison seems out of proportion to his alleged crimes, I am made highly uncomfortable by the protestations from our society and others about his treatment. Have we lost a sense of perspective here? Lee didn't just happen to be at a weapons laboratory; he was actually contributing to the design and development of weapons of mass destruction - objects whose purpose in use is to destroy the lives of millions of people. In that context, Lee's prison conditions seem trivial. Those who work in our country's armed forces understand that, in the line of duty, bad things can happen — among other things they can be mistaken for the enemy, and hit by "friendly fire." Perhaps that is what has happened here. If Lee's imprisonment is causing recruitment difficulties at the weapons laboratories, surely this is only because of its effect as a reminder of what those laboratories are really intended for.

Newt Gingrich has called upon scientists to take more seriously their responsibilities as citizens. Our reaction to this case seems to only provide more evidence of how divorced our priorities are from real civic responsibility. Do we think the law that governs and regulates the communities and country where we have such freedom to work should have no application to us?

Arthur Smith
Selden, New York

Earth Science Not Given Its Due

The supplement to the April 2000 edition of *APS News* entitled "Physics News in 1999" shows a poor understanding of the category "Earth Science, Geophysics." In that section are listed five items that are supposed to be important stories in that category. But two of these, "coronal mass ejections" and solar wind disappearance, relate to solar physics, not earth science, and a third on supernova material found in South Pacific, has to do mostly with astrophysics.

Earth science is a separate discipline from solar physics or astrophysics. There were many important news events in 1999 in earth science. For example, the first satellite rain radar flew on TRMM, and the Landsat 7 satellite launched on 15 April, 1999, began a global dataset of the Earth's surface of unprecedented detail and global coverage. Both TRMM and Landsat inaugurated EOS, the "Earth Observing System," a comprehensive array of satellites, continuing with 1999 launches of QuikScat for measuring winds, ACRIMSAT to measure solar irradiance, and the 18 December 1999 launch of Terra, the flagship satellite of EOS, that gives three-dimensional information on clouds, aerosols, and Earth's radiative energy distribution.

Thus, 1999 was a watershed year for earth science, and you missed an important opportunity to report it, replacing major earth science stories with ones that, important though they are, have no direct bearing on observations of the Earth.

Robert F. Cahalan
NASA Goddard Space Flight Center

Park Goes Off the Deep End

This letter concerns your front page article "...March Meeting Madness" especially in regard to the Robert Park spinoff on this theme on page 3 (*APS News*, March 2000). Park is to be congratulated for the courage he has shown in taking on pseudoscience and the paranormal. But in one important respect he has gone off the deep end and needs to "get it right" himself. Things get pretty shaky when he claims expertise in fields he knows very little about.

For example, his objections to the L5 society and the colonization of space. He would have to base that claim on the certain knowledge that there will never be a cheap way to get into orbit. But many alternative technologies already exist for lowering the cost of space travel. Does he know for sure that none of this can work?

On cold fusion there are some fine points that Park probably isn't aware of. Certainly the Pons and Fleischman results are phony. But in the late 1980s there were WKB quantum mechanical studies done of the probability of deuterium tunneling in a metallic lattice. The end result was that the hamiltonian gave too high a potential barrier for significant tunneling and therefore fusion. But it didn't look all that impossible to raise the tunneling probability to the required levels. One wonders whether high pressure or temperature would do it. Is Park an expert on these WKB studies and how to interpret them, too?

People like Park are creating an atmosphere of intolerance to new ideas such as this. He is an advocate of what you might call "negative science;" science that results in new and non-establishment challenges to the mainstream are being summarily and superficially dismissed without even an attempt to determine whether they are right or not. From my perspective both "negative" science and pseudoscience are equally disreputable.

Who really are the inmates in this asylum? I'm having a difficult time distinguishing the staff and the patients these days.

Joel Maker
Huntsville, Alabama

Newt Gingrich Corrected

I think Mr. Gingrich (March 2000 *APS News*, page 5) has his WWII history a little wrong. The Battle of the Atlantic was finally won by about May 1943, with short wave radar and long range aircraft each being a much more significant contribution to victory than sonar.

Walter Baker
Hartsdale, New York

VIEWPOINT...

Cultural Differences

This month's "This Month in Physics History" describes the Shelter Island Conference of June 1947, a landmark event that led to deeper understanding of quantum field theory, in particular quantum electrodynamics, and to impressive agreement between that theory and experimental results. It set the agenda for a whole program of research in both theory and experiment in the immediate post-war period. Feynman looked back on it as the most important conference he had ever attended.

The venue for that conference was a beachfront hotel on an island off the eastern tip of Long Island in New York. The hotel was just opening for the summer season, and it most certainly was in a "resort area." In that light, it is interesting to contemplate DOE regulation O 110.3, which lays down a set of rules for DOE-sponsored conferences. In one section, conference organizers are admonished to "avoid selecting resort or recreational sites unless true cost savings will result." This is just one of a host of restrictions and prohibitions contained in this document, but it serves to illustrate the attitude of its author toward the scientists to whom it applies. One is not being told to avoid a resort or recreational site if it will be more expensive; rather, if there are two sites, equally expensive, one is being instructed to choose the less attractive one.

What is the rationale? I can think of two. First, says the DOE, even if money is not actually being wasted, one must avoid the appearance of enjoying oneself at government expense. Second, scientists are inherently irresponsible creatures, and if you turn them loose in a recreational area, they won't spend every waking hour attending the meeting, which is what the DOE wants them to do.

One could just shrug one's shoulders at this attitude, were it not for real-life examples of conferences, typically ones with organizers who are DOE employees or DOE contract employees (e.g. physicists at national labs), that may be affected by O 110.3. The accumulation of restrictions and prohibitions on who may attend these meetings, where they may be held, and what may be reimbursed is so onerous that their very existence can be placed in jeopardy.

Other instances of burdensome government regulations are not hard to find. After carefully considering competing sites, the APS decided to hold its March meeting in Montreal in 2004. The favorable Canadian exchange rate made this a particularly economical choice. Recently, though, travel to Canada has been reclassified as "foreign travel." (The reader may think that of course travel to Canada is foreign travel, since Canada is a foreign country. But this is really an administrative classification, independent of national boundaries. For example, travel to Hawaii could be designated as "foreign travel.") The consequent bureaucratic entanglements will make it much more difficult for some of the participants to be reimbursed for their expenses. The reason for the classification is presumably that travel to a foreign country has the ring of an exotic boondoggle even if it is actually less expensive, and therefore must be actively discouraged.

After 50 years of dealing with this kind of government regulation, scientists are by now inured to the irritating and the illogical. Still it is tempting to daydream a little about the simpler times of 1947 when, newly released from the shackles of wartime security, a group of two dozen scientists could avail themselves of a couple of thousand dollars from the National Academy, isolate themselves in a pleasant locale, and spend three days attending one of the most productive and historic conferences of the twentieth century.

—Alan Chodos

Letters, *continued*

Physics Can Lead to Divine Truth

I am deeply disappointed in the opinion piece by David Markowitz (*APS News*, March 2000), in two key ways. First, it is clear that Markowitz knows nothing about the role of women in the Catholic Church. What a shame for a distinguished educator to make such statements out of ignorance. Were he to do that in physics, he would lose all respect.

Second is the statement that "I think reference to God in this enlightened age is largely a ploy." I am truly sorry if Markowitz has known only religious hypocrites. Shame on his hubris to assert that we who search to know something about our God are charlatans, and that the only way to truth is through physics. This narrowness of thinking is considerably less than enlightenment, and an offense to many who find faith another way to truth. We are more than mere physical beings. While faith can lead to truth, I generally don't depend on my faith in God to lead me to truths in physics; but I do revel in physics leading me to still more truths about God.

David W. Knoble
Tupelo, Mississippi

"What Is Science" Statement Ignores Religious Element

The 2 April 1989 issue of the London Sunday newspaper *The Observer* published an article by Michael Ignatief under the heading "Defenders of (Salman) Rushdie (are) Tied Up in Knots." The explanation ran briefly as follows: The Islamic (and other religious) fundamentalists have a dogma, and they are absolutely certain about their dogma. On the other hand, the western intellectuals have a so-called "philosophy," but they are not even certain about their own "philosophy." Therefore, the western intellectuals cannot really believe in whatever they say. For the same reason, Clifford Longley, the then religious affairs correspondent of the London daily *The Times*, could boldly claim that the scientific "philosophy" of the modern secular western world is now dead, and he could thus carry out, with evident delight, the "Inquest on the Enlightenment" (*The Times*, 25 March 1989).

I note that the article on the APS Council approval of the revised "What is Science?" statement (*APS News*, January 2000) does not address the above objection. It thus regrettably fails to convince the significant proportion of Americans who are religious (mostly Christian) fundamentalists.

Theo Theocharis
London, England

Topsy Turvy: Researchers Announce First True "Left-Handed" Material

Scientists at the University of California, San Diego have devised the world's first truly "left-handed" material, they announced at the APS March Meeting in Minneapolis. In this medium, light waves are expected to exhibit a reverse Doppler effect. That is, the light from a source coming toward you would be reddened and the light from a receding source would be blue shifted. The UCSD composite material, consisting of an assembly of copper rings and wires, should eventually have important optics and telecommunications applications.

To understand how a reverse Doppler shift and other bizarre optical effects come about, consider that a light wave is a set of mutually reinforcing oscillating electric and magnetic fields. The relationship between the fields and the light motion is described picturesquely by what physicists call the "right hand rule": if the fingers of the right hand represent the wave's electric field, and if the fingers curl around to the base of the hand, representing the magnetic field, then the outstretched thumb indicates the direction of the flow of light energy. Customarily one can depict the light beam moving through a medium as an advancing plane of radiation, and this plane, in turn, is equivalent to the sum of many constituent wavelets, also moving in the same direction as the energy flow. But in the UCSD composite medium this is not the case. The velocity of the wavelets runs opposite to the energy flow, and this makes the UCSD composite a "left handed substance," the first of its kind.

Such a material was first envisioned in the 1960's by the Russian physicist Victor Veselago of the Lebedev Physics Institute, who argued that a material with both a negative electric permittivity and a negative magnetic permeability would, when light passed through it, result in novel optical phenomena, including a reverse Doppler shift, an inverse Snell effect (the optical illusion which makes a pencil dipped into water seem to bend), and reverse Cerenkov radiation. Permittivity (denoted by the Greek letter epsilon) is a measure of a material's response to an applied electric field, while permeability (denoted by the letter mu) is a measure of the material's response to an applied magnetic field. In Veselago's day, no negative-mu materials were known, nor thought likely to exist. More recently, however, John Pendry of Imperial College has shown how negative-epsilon materials could be built from rows of wires and negative-mu materials from arrays of tiny resonant rings.

Now, Sheldon Schultz and David Smith of UCSD reported that they had followed Pendry's prescriptions and succeeded in constructing a material with both a negative mu and a negative epsilon, at least at microwave frequencies. The raw materials used, copper wires and copper rings, do not have unusual properties of their own and indeed are non-magnetic. But when incoming microwaves fall upon alternating rows of the rings and wires mounted on a playing-card-sized platform and set in a cavity, then a resonant reaction between the light and the whole of the ring-and-wire array sets up tiny induced currents, which contribute fields of their own. The net result is a set of fields moving to the left even as electromagnetic energy is moving to the right. This effective medium is an example of a "meta-material." Another example is a photonic crystal (consisting of stacks of tiny rods or solid material bored out with a honeycomb pattern of voids) which excludes light at certain frequencies.

At a late-breaking press conference in Minneapolis, Schultz and Smith said that having demonstrated that their medium possessed a negative mu and epsilon, they were now proceeding to explore the novel optical effects predicted by Veselago. Furthermore, they hope to adapt their design to accommodate shorter wavelengths. As for applications in microwave communications, a medium which focuses waves when other materials would disperse them (and vice versa) ought to be useful in improving existing delay lines, antennas, and filters.

Outside commentators at the press conference showed interest and curiosity. Marvin Cohen of UC Berkeley said that until he read the UCSD paper he had not thought a negative-mu material was possible. Walter Kohn of UC Santa Barbara, winner of the 1998 Nobel Prize in chemistry, considered the UCSD work "…an extremely interesting result. I would be surprised if there weren't interesting applications."

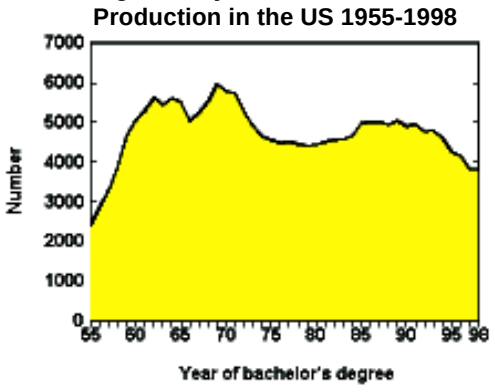
—Phillip F. Schewe; AIP Public Information

Editor's Note: *A figure can be found online at www.aip.org/physnews/graphics), along with an animated video illustrating the concept at www-physics.ucsd.edu/~rshelby/lhmedia.*

Satisfaction High for Undergrad Physics Bachelors

After many years of steady decline, the number of undergraduates earning bachelor's degrees in physics appears to have finally stabilized, according to a recent report on the graduating senior class of 1998, compiled by the American Institute of Physics (AIP). U.S. colleges and universities awarded a total of 3,821 B.S. degrees in physics, according to Patrick Mulvey of AIP's Education and Employment Statistics Division. However, the decline persists in larger physics departments that also maintain graduate programs in physics. Among these schools, the cumulative drop in degrees has now reached 27% since 1992.

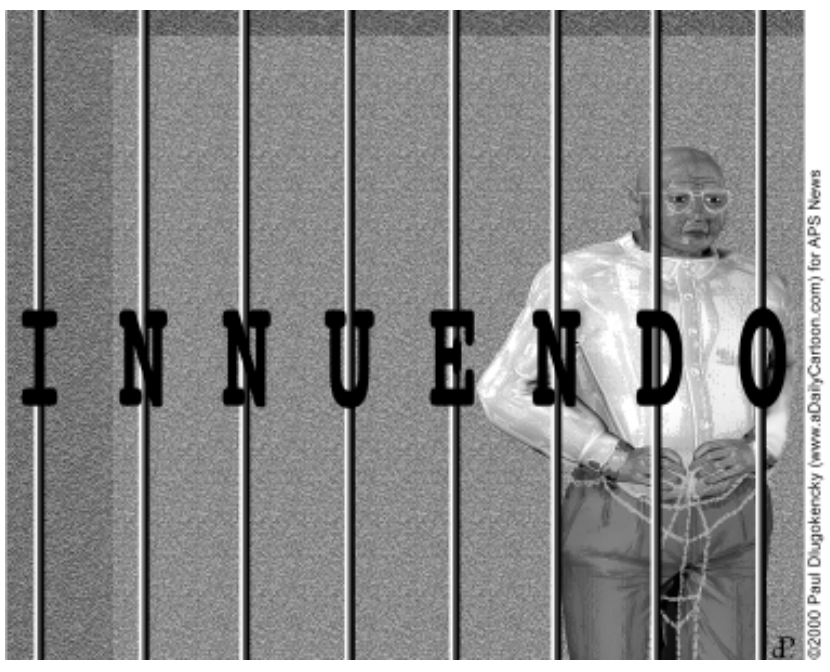
Figure: Physics Bachelors Production in the US 1955-1998



Mulvey says satisfaction levels among physics bachelor recipients are quite high, with 86% indicating they would still major in physics if they had to do it over. An overwhelming majority of the respondents said they chose to study physics because they enjoyed the subject, not because of the potential career opportunities it offered, although physic seniors believe they will have strong employment prospects with their degrees.

As in years past, roughly half of the new physics bachelors said they intend to enter graduate school immediately, with 31% planning to study physics or a related field and an additional 19% choosing to pursue other disciplines, most commonly engineering. The AIP survey found that of those going on to graduate school, most were optimistic about their job prospects, with 86% intending to earn a PhD and 61% hoping to secure a career as a college or university professor.

Wen Ho Lee Awaits His Day in Court



zero gravity

Fourth Annual Pigasus Awards

Awarded by the James Randi Educational Foundation

On April 1st of each year, we at the James Randi Educational Foundation (JREF) award the coveted Pigasus Awards in four categories, for accomplishments in the year previous. The awards are of course announced via telepathy, the winners are allowed to predict their winning, and the Flying Pig trophies are sent via psychokinesis. We send; if they don't receive, that's probably due to their lack of paranormal talent.

This year we honor the following individuals:

Category #1, to the scientist who said or did the silliest thing related to the supernatural, paranormal or occult: The award this year goes not to a specific scientist, nor to a scientific body. We generously award it to Linda Holloway and the entire Kansas Board of Education for their decision to forbid evolution to take place in the State of Kansas. In August, the Board ruled that the teaching of evolution must be removed from the state's educational agenda. "In voting to downgrade and discourage the teaching of evolution, the board is moving schools in Kansas backward toward ignorance and obscurantism," scolded the *Los Angeles Times*. While this may appear to the casual observer to be a move with no redeeming qualities, we at the JREF differ with this assessment. Consider the potential boon to future generations of anthropologists that this can provide; two thousand years from now, groups of students can be taken to Kansas to observe "in vivo" how humans lived twenty centuries earlier. Kansas can be a living museum, culturally and intellectually.

***Category #2, to the funding organization that supported the most useless study of a supernatural, paranormal or occult claim*:** This year's award goes to the Human Resources Administration of the City of New York, who via their Business Link division finds and trains workers from welfare rolls and puts them in touch with businesses needing employees. A company called Psychic Network, one of the 1-900 networks, hired 15 of the city's unemployed, those with "a caring and compassionate personality" and the ability "to read, write and speak English," to take phone calls from troubled callers who paid $4.99 a minute to have their problems psychically solved. Ruth Reinecke, a spokeswoman for the HRA, said that applicants were trained to read tarot cards at the city's Business Link office by a Psychic Network representative. Efforts to locate and contact the Psychic Network were unsuccessful, we're told, since their telephone number was disconnected last July. On January 28th of this year, the city reacted to unfavorable publicity on this matter, and pulled the plug on the operation. But they probably saw it coming.

***Category #3, to the media outlet that reported as fact the most outrageous supernatural, paranormal or occult claim*:** The 2000 prize goes to the host of the "Politically Incorrect" TV show, Bill Maher. Despite an Ivy League education and an obviously quick and perceptive mind, Mr. Maher has for some reason cast common sense aside and endorsed a series of "psychics," most of whom say they speak to dead folks. His own experience of the supernatural, he says, includes a "haunted house" and he tells us that only ghosts could account for what he observed there. This widely-watched program satirizes politics, Hollywood, the media, and generally popular subjects — but apparently takes seriously any hare-brained claim that will catch the public fancy. Mr. Maher squeaked to a win over the Roseanne Show this year; her gushing acceptance of a "flying" demonstration by Transcendental Meditators almost landed her the prize.

***Category #4, to the "psychic" performer who fooled the greatest number of people with the least talent*:** The award is given this year posthumously to Michel de Notredame, Nostradamus, the 16th-century French prophet who predicted back in 1558 that the world would suffer a major catastrophe in July of 1999, if not the end of the world as we know it. While major panic reigned and timorous but not-too-bright folks worldwide laid in stores of water, food, and arms, when the time came and went, the reaction was the same as always, "Ah, but wait till next time!" Meanwhile, in Salon de Provence, where the great prophet's bones lie in a vault in a small church, reports of disembodied chuckling from behind the wall have been noted.

Writing Workshops Teach Basics of Communicating with Public

Physicists with a penchant for communicating science to the public received a crash course in the fundamentals of writing for the general interest media during special workshops held at both the March and April meetings of the APS. Originally suggested by a special APS task force on informing the public, the workshops were hosted by Robert Park, APS Director of Public Affairs, whose weekly electronic newsletter "What's New" reports on science policy developments and other science-related public issues. He is the author of numerous articles and editorials for the general media, as well as the recently released book, *Voodoo Science: The Road from Foolishness to Fraud* (see *APS News*, March 2000).

> "Don't be even-handed…you need to have some bite for an Op-Ed."

Park drew on his considerable experience and success in this area to offer helpful tips to scientists aspiring to write for their local media, from the generation of an idea to the finished product. Not surprisingly, breaking in is the hardest step in the process. Aspiring writers can either write an Op-Ed and call an editor to discuss and gauge the level of interest, length, etc., or call to "pitch" a potential Op-Ed — something which can be difficult for first-time writers. A guaranteed formula for failure is to send out articles blindly to an editor without making personal contact.

The most common obstacle encountered is a misunderstanding of what editors want in opinion articles, routinely known as "Op-Ed" pieces because they traditionally appear opposite the editorial page in most newspapers. For example, "Arrogance doesn't fly well," says Park, although passion certainly does. He believes that one shouldn't write an Op-Ed unless one feels passionately about a topic, and has something useful to say about it. While an Op-Ed should be more substantive than an 800-word emotional rant, Park says that most physicists have a bigger problem with over-qualifying their statements, watering down their point of view to the point of being ineffective. Op-Eds differ in this respect from the more objective style of traditional newswriting; negativity can be a welcome attribute. "Don't be even-handed," he admonished. "You need to have some bite for an Op-Ed. Don't give the other guy's point of view; give *your* point of view and only mention the opposition to knock it down."

The ability to "write to length" — that is, produce a specific number of words to fit available space—is a highly valued quality, and over-writing is a common mistake. "An editor knows how much space he has, and sometimes he will edit down an Op-Ed, but he may also reject it because of the extra work," said Park.

> "The science community has not taken seriously its responsibility to inform the public."

Editors also tend not to accept "pleading" articles simply asking for more funding because "science is good." There needs to be a powerful issue under debate to draw their interest. Park has found that the strongest hooks tend to be related to safety or effectiveness of consumer products, such as the power line cancer scare or magnet therapy. While these might not form the substance of the Op-Ed, they are a good "news peg" to draw the interest of the reader and concretely illustrate one's points, he said.

Of course, jargon should be eliminated, and such articles should focus mostly on simple concepts accessible to the general public. "Physicists are so accustomed to thinking in physics principles, it can be difficult to put themselves in the shoes of a general reader ignorant of those principles," said Park, and suggests vetting draft articles with non-physicists. "Physicists are afraid to make it simple, because it won't sound sophisticated enough, but you can never over-simplify" when writing for the public. Unlike addressing an audience of physicists, snappy sentences that encapsulate complex issues and deliver emotional impact work best with the general public—a skill Park has developed through years of experience. Above all, an Op-Ed should tell a story. "All good writing is story-telling," he said, adding that it is much easier to weave in illustrative anecdotes with a consumer hook. Local news can also provide a useful hook for local publications, which can then be extended to a broader science-based issue.

Given the rise in so-called pseudoscience over the years, Park believes scientists have a social obligation to become involved in communicating with the public, and that the problem is with them, not the public's scientific illiteracy. "The science community has not taken seriously its responsibility to inform the public," he said, pointing out that many non-scientists cannot read the simplest graph and don't understand the basics of energy conservation. "But that doesn't lessen our responsibility. The public is completely defenseless (on matters of science) without our input, and we haven't been doing this very well."

Career Liaisons Gather for Workshop on Professional Development

Representatives from university physics departments around the country were on hand at the APS March Meeting in Minneapolis to attend a special workshop on careers and professional development for physicists, organized as part of the APS Careers and Professional Development Liaison (CPDL) program. Established in 1998, the program's objective is to establish a nation-wide network of liaisons in academic physics departments to better disseminate current career information and help physics students compete more effectively in today's rapidly changing job market.

"With the range of jobs available in today's job market, it has never been more important for physics students to have an accurate and comprehensive view of their career options and the skills necessary to compete," said Fred Stein, APS Director of Education and Outreach. "This program is an attempt to help physics departments develop programs that better prepare their students for many different careers."

Interested in the CPDL program?

Go to **http://www.aps.org/jobs/** for more information or e-mail Arlene Modeste Knowles: **knowles@aps.org**

A large fraction of the program's activities is the dissemination of current, relevant information on career and employment trends through an exclusive website. In the CPDL program, each physics department identifies a liaison who acts as a point of contact through which current information is disseminated to students and faculty. Liaisons are provided with the latest career and employment information and also benefit from the ability to network with their colleagues at other institutions to bring new ideas to their department.

The meeting opened with a poster session featuring programs at physics departments around the country, followed by introductory remarks from

> "With the range of jobs available in today's job market, it has never been more important for physics students to have an accurate and comprehensive view of their career options and the skills necessary to compete."

Stein, giving a brief background of the CPDL program and a summary of the day's agenda. Roman Czujko of AIP's Education and Employment Statistics Division provided the backdrop for the day's events with some statistics. Using the most recent data available, Czujko reviewed the numbers of Bachelors, Masters, and PhD physicists in the workforce and put those numbers in context with career opportunities, needed job skills, titles and salaries.

Czujko was followed by a panel session featuring institutions and individual scientists who have succeeded in modifying their academic programs to account for the changing employment environment for physicists. Three focused on better preparing students for jobs in industry, through innovative master's degree programs and industrial internships, for example. Dave Berilla, Director of Career Services at the University of Delaware illustrated how university career services departments have automated their systems so as to serve students and employers virtually 24 hours a day. He also gave examples of how the university career services department can work closely with local and national industrial companies and the physics departments to link students with industrial jobs. John Rigden of the American Institute of Physics, who teaches a course at the University of Maryland, discussed the importance of bringing departmental alumni back to campus periodically to speak to current students regarding their career options. Brian Schwartz of CUNY Graduate Center emphasized the usefulness of one- or two-credit mini-courses in educating students on how to market themselves for employment. The keynote luncheon speaker was Jan Herbst of General Motors Research, who illustrated the different perspectives of industrial companies and academic departments with some real-life examples from his experiences at GM.

Most of the participants enjoyed the presentations by the invited speakers and felt the program obtained a good mix of physicists from all types of university backgrounds. "It was good to see that the issues that are important to me are also shared by others across the country," wrote one. Some participants said they would like to hear from more physicists in industry about what employers in that sector are looking for in candidates. Several also said that they would like to see more departments participating in future workshops, especially small departments at non-PhD granting institutions. Members of the APS Committee on Careers and Professional Development agreed that more liaisons should attend workshops and remarked that future workshops will likely have sessions where attendees from each type of university background can separately discuss issues relevant to them. They remarked that they want these workshops to give the liaisons the information they need in order to make a difference to students in their departments.

Aspects of the workshop rated most useful by participants were the importance of alumni in establishing industrial contacts and illustrating

> Liaisons are provided with the latest career and employment information and also benefit from the ability to network with their colleagues at other institutions.

different physics career tracks, as well as increased awareness of employment resources currently available. Many participants were especially interested in the concept of providing more focus on those with undergraduate physics degrees who choose to go directly into the workplace.

From the APS viewpoint, this workshop provided information on how the APS can help physics department show their students a return on their educational investment, and help its industrial and applied members develop a skilled a workforce. The liaisons reported especially benefitting from the information provided speakers and other liaisons who have worked on career issues and gotten through the pitfalls.

Future plans for the Career & Professional Development Liaison Program include more workshops, perhaps at APS section meetings, consistently updating the CPDL website, and working with other scientific societies to provide the liaisons the best information available.

Announcements

APS UNDERGRADUATE PHYSICS STUDENT COMPETITION

2000 APKER AWARDS

For Outstanding Undergraduate Student Research in Physics

Endowed by Jean Dickey Apker, in memory of LeRoy Apker

DESCRIPTION

Two awards are normally made each year: One to a student attending an institution offering a Physics PhD and one to a student attending an institution not offering a Physics PhD

- Recipients receive a $5,000 award; finalists $2,000. They also receive an allowance for travel to the Award presentation.
- Recipients' and finalists' home institutions receive $5,000 and $1,000, respectively, to support undergraduate research.
- Recipients, finalists and their home physics departments will be presented with plaques or certificates of achievement. The student's home institution is prominently featured on all awards and news stories of the competition.
- Each nominee will be granted a free APS Student Membership for one year upon receipt of their completed application.

FURTHER INFORMATION

(See **http://www.aps.org/praw/apker/descrip.html**)

DEADLINE

Send name of proposed candidate and supporting information by **16 June 2000** to:
Dr. Alan Chodos, Administrator, Apker Award Selection Committee
The American Physical Society, One Physics Ellipse, College Park, MD 20740
Telephone: (301) 209-3268, Fax: (301) 209-3652, email: chodos@aps.org

APS MATCHING MEMBERSHIP PROGRAM

Relief is at hand for physicists living in developing and hard-currency-poor countries through the APS Matching Membership program. Established in 1983, the program allows individuals residing in eligible countries — especially those who are members of their national physical societies — to apply for a reduced-cost APS membership. Membership is available in one of two categories, with the associated benefits of each outlined below:

- A half-price membership at $45 is available for those with an individual or institution willing to co-sponsor them and provide payment. Members at this level can subscribe to a maximum of one (1) journal at member rates and register for APS meetings at member rates. They will also receive *APS News* and *Physics Today*.
- A graduated, reduced-cost membership beginning at 20% of the full membership rate in the first year is available to individuals on a limited basis. Applicants who are unable to pay and who do not have a sponsor may request APS support. Members in this category will receive *APS News* and *Physics Today* and may register for APS meetings at member rates. No journal privileges are included, but members who have difficulty accessing APS journals may apply to the APS Office of International Affairs to enroll their institutional libraries in the APS Journal Outreach Program. In each of the next three (3) years, membership dues will increase by 10%. Upon reaching 50% in the fourth year, a maximum of one (1) journal is available at member rates.

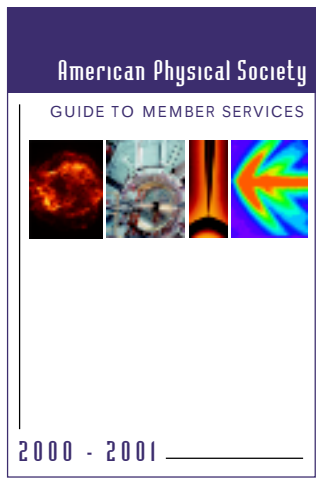
Membership will be renewed on a yearly basis via invoice. Each member sponsored through this program may participate for no more than six (6) years in order to accommodate as many physicists as possible. At the completion of the six-year term, all participants will be billed at full member rates. Enrollment is limited to 1.5% of the current APS membership level. Thus, in 2000, the program can accommodate 640 participants.

For further information about the APS Matching Membership Program, please contact the Membership Department at (301) 209-3280 or membership@aps.org

Membership News...

SENIOR LIFE MEMBERSHIP is now available to those members qualifying for Senior membership at 15 times the current Senior dues rate, for a total of $712.50. All Life members, including the new Senior Life members, have the option of one free life membership in a dues-requiring unit. Life members may also add life memberships in dues-requiring units at a rate of $90 (15 x the current unit rate).

See the Guide to Member Services in your next renewal packet, visit us online at www.aps.org/memb/, or contact the Membership Department at 301-209-3280 or membership@aps.org for more information.



American Physical Society marketplace

The **APS MARKETPLACE** is now open for business. Visit this new member benefit on www.aps.org/memb/ and checkout the safe, secure online shopping that offers member discounts. Special deals are offered by Barnes & Noble.com, HardwareStreet.com, ToysRUs.com, and more.

Feedback on this new benefit can be sent to Trish Lettieri, Director of Membership, at lettieri@aps.org or APS Membership, One Physics Ellipse, College Park, MD 20740.

Winner of Physics Trivia!

In the February *APS News*, we reprinted from *Physics World* their list of the top ten physicists of all time. In the April issue, we presented our own, completely different, method of scoring these physicists, as sampled below:

Newton 0
Maxwell 1
Einstein 2
Feynman 3

and we asked our readers to figure out what the scoring system was. We have received just one correct answer, from ***Jeffrey Winkler***, who writes:

"In your physics trivia section, the scoring system is the number of times they were married."

Winkler will receive a copy of the handsome souvenir volume "Physics in the 20th Century" by Curt Suplee.

In a story on DOE travel restrictions in the April issue, reference was erroneously made to the DOE High Energy and Nuclear Physics Division. The correct name is the Office of High Energy and Nuclear Physics. *APS News* regrets the error.

Re- "Creating Copenhagen," *continued from page 1*

of superstring theory geared for a general audience. Speakers at the second session offered broad-based analyses of the scientific and historical events of the era in which the play takes place, including the reasons why the Germans did not achieve the atomic bomb, and included David Cassidy, author of the seminal Heisenberg biography, *Uncertainty*.

Perhaps the most poignant presentations were made by Hans Bethe and John Wheeler, both eminent physicists who themselves worked on the Allied bomb project and knew both Bohr and Heisenberg personally. Bethe declared that "Heisenberg had no interest in atomic bombs," citing as evidence the famous "Farm Hall" tapes: secretly recorded conversations of Heisenberg and the other German atomic scientists while in British custody after the war. News of the Hiroshima bombing was a great shock to the Germans who, while not very far along in the development of a genuine atomic bomb, had nevertheless felt they had gone further than the Allies. Bethe also said that Heisenberg had told him his main intention for remaining in Germany had been to save a few young physicists from going to war by employing them in the uranium project, adding, "I believe that motive."

Heisenberg's initial attempt to account for the Allied success in an impromptu tutorial for his colleagues seems to indicate that he was very far from understanding how a bomb would work, although Bethe believes such scientific mistakes demonstrate that Heisenberg was not primarily interested in building a bomb, rather than merely incompetent, as less charitable sources have maintained. Wheeler spoke of several meetings with Heisenberg, including one at the University of Michigan in 1939 from which Heisenberg left early in order to return to Germany for military training. Not surprisingly, the reception of Heisenberg among physicists in the postwar years was often chilly, he reported. As the play makes clear, and speakers confirmed, Heisenberg tried in later years to defend his honor, and on several occasions hazarded to explain the purpose of his 1941 visit. In one such explanation, he maintained that he had come to Bohr to suggest that an atomic bomb would be too unmanageable to produce, that the German effort would not succeed, and that (by implication) the Allies should also give up the attempt. On this crucial point, historian Gerald Holton referred to a recently discovered letter written by Bohr to Heisenberg, but never posted. Holton has read the letter but it is otherwise sealed for another 12 years at the request of the Bohr estate. Without revealing the exact contents of the letter, Holton hinted that Bohr (in the unsent letter) took exception to what Heisenberg had been saying in public about their 1941 meeting.

A highlight of the day's events was the evening discussion by Frayn and Blakemore about the process of creating the play. Frayn's research included reading Heisenberg's original 1927 paper on uncertainty, and although he has no formal training in science, he says he was impressed by the clarity of the paper. He was particularly struck by the concept of irreducible quantum fuzziness which makes it impossible to know simultaneously both a particle's position and its momentum, which he extrapolated to form the thematic underpinning of his play. "Human intentions have their own irreducible fuzziness," he said. Frayn also weighed in with his own views on Heisenberg's motives for the 1941 visit; specifically, he believes the physicist had at least some intention of alerting Bohr of the unlikelihood that Germany would succeed in building a bomb. The ambiguity, he says, resulted from the need for Heisenberg to be extremely guarded in his words to avoid arrest for treason. According to Blakemore, the staging of "Copenhagen" is similar to a scientific experiment in uncertainty, and in fact, the act of attending such a performance supports many of the play's propositions. He compared the actors to busy particles, circling around the nucleus during rehearsals until they feel ready to be seen. The audience acts as photons, shining the light of their attention onto the actors, and something that has been rehearsed a hundred times is magically altered by the impact. "The energy an audience brings to (the performance), the energy of their laughter, and rapt attention, changes what is there," he said. "Throughout 'Copenhagen,' it was extraordinary the way the act of theatergoing supports the various concepts in the play."

Philip F. Schewe of AIP's Public Information Division contributed to this coverage of the "Creating Copenhagen" symposium.

For a website with more information on Creating Copenhagen go to: http://web.gsuc.cuny.edu/ashp/nml/copenhagen

THE BACK PAGE

The Coming Revolution in Physics Education

By David Goodstein

This essay will end on an optimistic note, but first, the bad news. Let me be blunt. The profession of teaching physics at the college level in America today has only two purposes. One is to produce physicists, and the other is to act as a gatekeeper, keeping the unworthy out of certain other professions such as medicine and engineering. We will always need physicists, but not very many of them. And, indeed, the number of physics majors in colleges all across the country today is said to be at its lowest point since Sputnik, more than forty years ago. Our other role, as gatekeeper, is the dark side of our profession, and it is, frankly, unworthy of us. The simple fact is, if teaching physics were a business, we would be filing for bankruptcy.

Of course, those of us who teach in universities have another educational role, mentoring our graduate students. Here the situation seems profoundly different. The American PhD is the only part of our entire system of education that the rest of the world admires. Yet this role too has its dark side. On the average, each professor in an American university turns out about 15 PhD's in the course of a career. In a steady-state world of science (the best we can hope for at any time in the foreseeable future), each professor need produce only one professor for the next generation. If each of those 15 PhD's want to become professors and turn out 15 more PhD's, it's easy to see why physics has become a profession of widespread frustrated expectations. And, since the undergraduate physics major is largely perceived as preparation for graduate school, it's also easy to see why there are so few undergraduate physics majors. Let's face it: the system is broken.

> The undergraduate physics major should be the liberal arts education of the twenty-first century!

All right. Let us, for just a moment, pretend that our profession *is* a business, and take stock of our situation. Our production line is obsolete, and there is little demand for our product. What can we do about it?

The first step is to turn the problem around and ask, do we have any valuable assets that might be worth saving?

You bet we do! What we have is nothing less than the wisdom of the ages. It is that vast body of knowledge, the central triumph of human intelligence, our victory over mystery and ignorance; and to go with it we have the methods of inquiry and analysis that have produced that body of knowledge. Our assets, in fact, are so valuable that we have a solemn duty *not* to let our profession go down the drain.

The purpose of teaching physics should not be merely to clone ourselves and keep a few poor souls out of medical school. A solid education in physics is the best conceivable preparation for the lifetime of rapid technological change that our young people face. The undergraduate physics major should be the liberal arts education of the twenty-first century! Every physics department in the country ought to inscribe that motto on its walls and march under that banner. But to make that motto into a reality would take nothing less than a revolution in the way we do our jobs.

> …if teaching physics were a business, we would be filing for bankruptcy.

Everything about the way we teach physics is useless for the purpose I have in mind. The methods, the textbooks, the language we use, all of it is designed more to get rid of the unworthy than to throw open the doors. What we need most of all is to change the mindset that says that real education takes people like we once were, and turns them into people just like us.

I suspect that most of us knew at a very early age that we were destined for some sort of technical career. We were different from other children. We had more facility with numbers, and perhaps less with other graces, than our peers. The education system somehow discovered us and channeled us into the physics apprenticeship, or maybe I should say the rites of passage that qualified us to be the keepers of the flame, subjecting our students to the same arduous rituals that we had passed, to assure that the next generation of us would be as pure and noble as we are.

Throughout most of our history that system worked brilliantly. The first American PhD in physics was granted after the Civil War, around 1870. By the turn of the century we were producing about 10 physics PhD's per year, by the 1930's, 100 per year, and by 1970, 1000 per year. During that century of exponential growth the absolute numbers were small, and only the chosen needed to know anything about physics. Then, around 1970, the crunch occurred. Exponential growth stopped abruptly. We in the universities soldiered on, producing our 15 PhD's and pretending nothing had changed. To be sure, the best American students were no longer going to graduate school, so we replaced them with foreign students, and since our graduates could no longer find jobs so easily, we started hiring more postdocs. Still, at least until the end of the Cold War, we could hang on and wait for the good times of exponential growth to return. We would have been better off waiting for Godot.

To many astute observers, the end of the Cold War, welcome as it was, did not augur well for physics. The unspoken reason why the government supported research in physics had vanished. Many of the National Laboratories had lost their missions. The country was 5 trillion dollars in debt, and scientific research was among the few discretionary items in the budget available for cutting. The situation looked grim.

Then something quite unexpected happened. The country entered an unprecedented period of sustained prosperity. When we looked around to see why we were doing so well, we discovered that we were enjoying the technological fruits of all those years of research that we thought we were doing in support of the Cold War. It was realized, and not only by us physicists, that research is an investment that pays handsomely. Suddenly, physics has a brilliant future again.

Unfortunately though, those of us who teach physics are still living in the past.

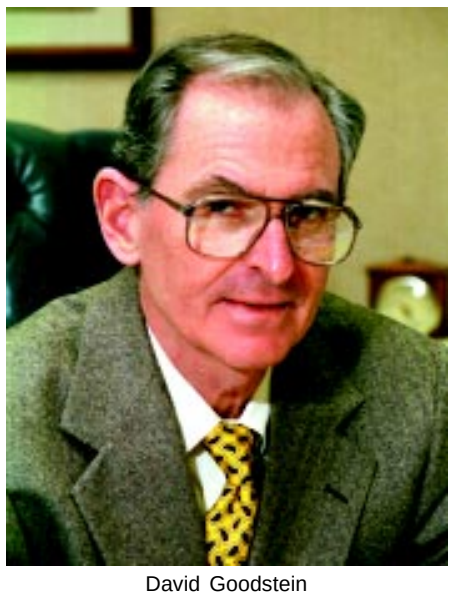
Is it conceivable that physics education could be restructured to serve purposes beyond choosing the elect and discarding the rest? The obstacles are immense. We are part of the problem, but we are not the whole problem. It seems to me that the problem has three tightly linked components: societal, educational and pedagogical.

> What physics needs is something that plays the role that the GUI plays for computers.

The societal part has mostly to do with one's expectations. We physicists have gained a pretty good understanding of how the world works. Imagine a society in which it is routinely expected that every person in every serious profession shares that knowledge, at least in reasonable measure. Could such a thing happen in America, where nearly everyone (two-thirds of all high school graduates) goes to college and is therefore "educated?" I don't know the answer to that, but if the purpose of education is to render our citizens capable of coping with an increasingly complex technological world, something like it may just become necessary.

For the educational part, picture a world in which every high school teacher (not just physics teachers) commands the pay and professional status that would justify a doctoral-level education in whatever subject they teach. Approximately that was true in large part in Europe before World War II, but then far fewer people got as far as the equivalent of high school. Could it happen here? Maybe not everywhere and for everyone, but that's the road we have to go down. If that were true, then the need to provide those teachers would utterly transform university education at both the undergraduate and the graduate level. Let me be very clear: I am not talking about merely plunking today's excess PhD's into high school classes. What I am imagining instead is a truly profound societal transformation.

Finally, we come to the pedagogical part. Is it possible to teach physics to those who weren't born to it? There has been much research, over the past couple of decades, into physics pedagogy, much of it directed at overcoming the obstacles to turning people who are not like us into people who are like us, that is to say, into proficient solvers of physics problems. That, I suspect, is the wrong approach. What we need to do instead is to figure out ways to show them the high ground and to teach them a few of our more useful tricks, without the slightest intention of turning them into physics foot-soldiers.



David Goodstein

Just a few years ago, the computer was a device used by nobody but the likes of us. Then the graphical user interface (GUI) was developed and in no time, tens of millions of people were using computers. The GUI makes the computer less efficient, less flexible, less suitable for real, hard-core professionals, but it makes the computer available to nearly everybody. What physics needs is something that plays the role that the GUI plays for computers.

That does not mean dumbing physics down. In the 1980's, I directed the production of a television series called The Mechanical Universe, that was intended to be the basis of a physics course, with calculus, for nearly everyone. The idea was that we could help teachers overcome the barriers by giving them real physics, in a rich historical context, with beautiful images and terrific computer animation to show their students. There was considerable skepticism that this could be done, so a test was arranged, in which the material was taught to non-physics majors at a liberal arts college. It turned out that the students had no trouble at all with the derivatives and integrals that we taught them how to do. In fact, they quite liked our little mathematical tricks. The experiment failed however, because, although we assumed we would have to teach them calculus, we also assumed, wrongly, that they had learned some trigonometry in high school. Of course, that problem might get solved if we were to undergo the societal transformation I've tried to outline.

We physicists cannot produce that transformation all by ourselves. But we are in a better position than anyone else to take the first few steps. So here is my challenge to us: Let us devise ways to teach physics that will make the subject so vital and appealing that it will be unthinkable for any educated person in the twenty-first century not to have mastered its elements. If we can manage that, it's just possible that the rest of that transformation might follow.

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