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Physicists Head to Florida Coast for 2005 APS April Meeting

Physicists will be heading down to the Sunshine State later this month for the 2005 APS April Meeting, to be held in Tampa, Florida, April 16-19. The scientific program will feature about 75 invited sessions and more than 100 contributed and poster sessions, on topics ranging from astrophysics, nuclear physics, particles and fields, plasma physics, and computational physics.

This meeting also serves as the 2005 divisional meeting of the Division of Particles and Fields.

Among the highlights of the technical program are a series of plenary lectures on a wide range of topics. Nobel Laureate Carl Wieman, of the University of Colorado at Boulder will talk about different perspectives demanded by research and teaching. Other speakers include Stanford University's Leonard Susskind, who will talk about the black hole information paradox, and his Stanford colleague, Patricia Burchat, who will discuss the mysteries of heavy quarks. Additional speakers will cover the use of gamma rays to probe supernova remnants, black holes and dark matter; the physics of nanoscale structures; the physics of accreting neutron stars; a new way of envisioning particles and their interactions; and probing subatomic matter with polarized electrons.

Other topics at the meeting include the physics of extra dimensions and warped fermions; various viewpoints on current visa restrictions on international exchange; recent developments in string theory, including a talk by bestselling author Brian Greene of Columbia University; extrasolar planets; communicating physics to non-physicists; and a special session of award presentations that will feature the annual Lilienfeld lecture by Robert Austin of Princeton, and the retiring presidential address, given this year by APS Past President Helen Quinn of Stanford University.

Photo Courtesy of Tampa Bay CVB

Even More Einstein. The World Year of Physics marches on in celebration of Einstein's "miracle year," and several sessions at the meeting are Einstein-centric. There will be a special public lecture by Case Western Reserve University's Lawrence Krauss, bestselling author of *The Physics of Star Trek*, on the mysteries surrounding Einstein's cosmological constant, which he once called his "biggest blunder." A Saturday evening session will review Einstein's scientific legacy, outlining what is currently known and unknown. On Sunday, various speakers will discuss Einstein's friendships and collaborations with such eminent figures

See APRIL MEETING *on page 5*

Photo Credit: Colella Photo

On February 20, the APS helped kick off the World Year of Physics by sponsoring an International Gala at the annual meeting of the American Association for the Advancement of Science (AAAS), held this year in Washington. AAAS was a co-sponsor of the event. An ice sculpture of Einstein, pictured here, was one of the decorative elements. A page of pictures from the gala, including some of surprise "guests," can be found on page 3.

AIP Report: Women, Men Progress at Same Rate

By Ernie Tretkoff

A report released in February by the Statistical Research Center of the American Institute of Physics (AIP) shows that women in physics progress at the same rate as their male peers. The percentage of women in faculty positions in physics and astronomy is consistent with the percentage of women who earned degrees in the past, the report says. While women are still a minority in physics, the representation of women in physics at all levels continues to increase.

"While almost half of high school physics students are girls, less than one-fourth of bachelor's degrees in physics are earned by women. After this initial 'leak' in the pipeline, women are represented at about the levels we would expect based on degree production in the past," says the report. "There appears to be no leak in the pipeline at the faculty level in either physics or astronomy."

See AIP Report *on page 5*

DHS Is Rare Bright Spot in FY2006 R&D Budget

Homeland security is one of the few areas that will see substantial increases in the proposed FY2006 federal budget, according to Penrose C. ("Parney") Albright, assistant secretary for science and technology in the Department of Homeland Security (DHS). Speaking at a March 1 briefing hosted by the American Association for the Advancement of Science (AAAS), Albright provided an overview of the FY2006 budget and future plans for R&D within the DHS, which is the fastest growing sector for R&D in the federal budget.

The FY2006 budget request for the DHS Science and Technology (S&T) Directorate is about $1.4 billion, a significant increase from three years ago, when the total budget was $640 million. Albright attributed this growth to the interest of Congress and the Bush administration in science and technology as it applies to homeland security.

See DHS *on page 7*

US Could Soon Be Playing Second Fiddle In Areas of Science and Technology

By Ernie Tretkoff

The US is in danger of losing its leadership role in science and innovation, according to a group of leaders in academia and industry who released a report on February 16 at a press conference in Washington, DC.

The report was issued by the Task Force on the Future of American Innovation, a group that includes the APS and 13 other organizations associated with business and academia.

Titled "The Knowledge Economy: Is the United States Losing its Competitive Edge?," the report presents a set of benchmarks in several key areas meant to help policymakers assess US high-tech competitiveness. In each of the six key areas—education, workforce, knowledge creation, research and development investment, the high tech economy, and specific high tech sectors–statistics show that the US is in danger of falling behind other countries.

The Task Force made these announcements shortly after President Bush released his FY06 budget proposal, which proposed cuts in many areas of research and development while leaving the overall budget for R&D nearly flat. The Task Force called for increasing federal spending on basic research in the physical sciences and engineering.

According to the report, the fastest growing economies are gaining on the US in R&D investment. In fact, as a percentage of GDP, funding for physical science research in the US has been in decline for 30 years. In contrast, between 1995 and 2002, China doubled the percentage of its GDP invested in research and development, and intends to continue to increase spending. Furthermore, since the 1980's, in the US there has been a shift in the source of funding from government to private funding, with the private sector now providing more than 68 % of R&D funds. Private funding tends to cycle with business patterns and focus on short-term results rather than basic research.

In a written statement about those trends, Burton Richter of SLAC said, "The knowledge creation that leads to publications, patents, and products begins with R&D. In an environment of heightened global competitiveness, the federal government must provide the investment capital for long term research."

"It is easy to ignore long-term

See PLAYING SECOND *on page 7*

Highlights

Members in the Media

First, some quotes relating to Hans Bethe, Nobel Prize winner and former APS President, who died in March:

"The thing that impressed me the most was that he had very muddy shoes and all the students called him Hans. So he was just the opposite of a European professor. That was part of his greatness. He was totally unpretentious and never tried to be bigger than he was."
—Freeman Dyson, Institute for Advanced Study, The New York Times, March 8, 2005

"Hans came in with a pencil and paper and made more sense of what was coming out of the computer than the people who wrote the code."
—Edward Kolb, Fermilab, The Los Angeles Times, March 8, 2005

"Bethe systematically laid the theoretical foundations for nuclear physics with such clarity and care that they could be used to support major applications: stars and, later, reactors and bombs."
—Frank Wilczek, MIT, The Los Angeles Times, March 8, 2005

" The biggest piece of advice he gave me—and my success is partly due to that—is that you should be able to use mathematics, but don't use more than you need for a particular problem. He always went for simplicity."
—Edwin Salpeter, Cornell University, The Los Angeles Times, March 8, 2005

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"That creates a new way to control the properties of materials. Instead of changing composition, you can change size."
—Paul Alivisatos, UC Berkeley, on quantum dots, The New York Times, February 22, 2005

"The most romantic goal is to be able to see signals from the early universe with gravitational waves. They would be the most valuable of all, because they're not absorbed like photons or electromagnetic waves are. It allows you to probe back to the very first instants after the Big Bang."
—Barry Barish, Caltech, on LIGO, MSNBC.com, February 19, 2005

"It's crazy to think that it's an innate difference. It's socialization. We've trained young women to be average. We've trained young men to be adventurous."
—Howard Georgi, Harvard University, on Harvard President Larry Summers' suggestion that innate differences might explain the low numbers of women in science, The New York Times, February 18, 2005

"All of a sudden, all these wires started heating up. Basically, I had created a bathroom heater."
—C.J. Ransom, on an experiment he did in his home when he was a child, the Star-Telegram (Fort Worth, Texas), March 6, 2005

"I think they are almost overtaking the men."
—Lilia Woods, University of South Florida, on the progress being made by women in science, St. Petersburg Times, February 26, 2005

"If you could actually make a quantum computer, you could solve problems that would take the age of the universe to solve."
—Ray Simmonds, NIST, Denver Post, February 25, 2005

"He is very interested in the foundations of religion and faith-based concepts and he discusses them in a manner that is very attractive for fellow scientists. He really thinks before he speaks. If there is an opposite of a loose cannon, that would be Charles Townes."
—Marvin Cohen, UC Berkeley, on Charles Townes, who won this year's Templeton Prize for progress or discoveries about spiritual reality, Christian Science Monitor, March 10, 2005

"They are much more similar than people generally accept. Science has faith. We make postulates. We can't prove those postulates, but we have faith in them."
—Charles Townes, UC Berkeley, on science and religion, Christian Science Monitor, March 10, 2005

"Anybody can go to Soudan during the summer, take the MINOS lab tour led by Minnesota state parks and go one-half mile underground and see exactly what scientists from all over the world are doing."
—Marvin Marshak, University of Minnesota, Minneapolis Star Tribune, March 4, 2005

This Month in Physics History

Energy and Mass are Equivalent

In September 1905, Einstein reported a remarkable consequence of his special theory of relativity: if a body emits a certain amount of energy, then the mass of that body must decrease by a proportionate amount. As he explained in a letter to a friend, "The relativity principle in connection with the Maxwell equations demands that the mass is a direct measure for the energy contained in bodies; light transfers mass... This thought is amusing and infectious, but I cannot possibly know whether the good Lord does not laugh at it and has led me up the garden path."

Einstein was not the first scientist to propose a relationship between mass and energy. As early as 1881, J. J. Thomson, who would later discover the electron, introduced the concept of the electromagnetic mass, establishing a connection between a particular kind of energy and a contribution to a body's mass. Theories of this sort were pursued by various physicists in the late nineteenth and early twentieth centuries, most notably by Max Abraham in Göttingen, who considered a model of the electron as a rigid sphere of uniform charge density. Lorentz modified this to allow the sphere to contract along its direction of motion. Poincaré showed that to make Lorentz's model consistent required the addition of a new force, the Poincaré stress. These works hoped to use the observed relation between the energy, mass and velocity of the electron to determine which model was correct. Relativity swept this all away by showing that the correct relation,

$$E = \gamma mc^2, \qquad (1)$$

where $g^{-2} = 1 - v^2$, is purely kinematical and holds for any particle of rest mass m whatever its internal dynamics.

In June of 1905 Einstein submitted the paper that contained the basic concepts of the special theory of relativity. In September, he submitted a brief sequel, in which by means of a simple argument based on kinematics and the known energy-momentum relation for electromagnetic radiation, he derived the equation that is forever associated with his name. A particularly nice version of Einstein's argument is given by Julian Schwinger in his book *Einstein's Legacy* (Dover Publications, 2002), pages 93-98.

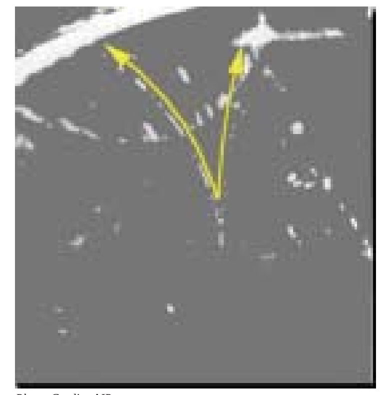

Photo Credit: AIP

The first photograph showing the creation of a pair of particles, revealed by the fog spots they make in passing through the wet air of a "cloud chamber." The two particles, curving apart under the influence of a magnet, were created in the annihilation of a particle of light (coming invisibly from below).

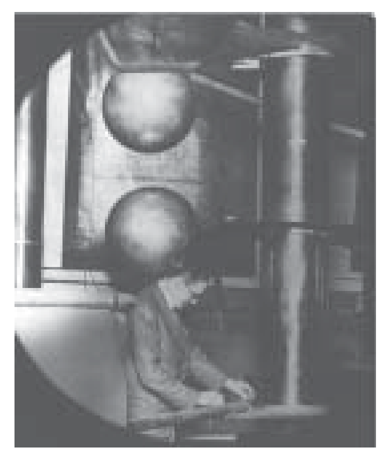

Photo Credit: AIP

Atomic nuclei could be split apart in "atom-smashers" like this one built by Cockcroft and Walton.

$E=mc^2$ is the limit of equation (1) for v = 0. E is the energy of a body in its rest frame, m the rest mass, and c^2 the square of the speed of light. In his September paper, Einstein already recognized that the energy of particles emitted by radioactive substances might cause the mass of these substances to decrease, and he advocated careful measurement of radium salts as a possible means of confirming his equation. Because c is so large in laboratory units, however, a small decrease in mass produces a lot of energy, so the reduction of mass in such processes proved much too small to observe.

Confirmation was in fact slow in coming. It was not until 1933 in Paris that Iréne and Frédéric Joliot-Curie obtained direct photographic evidence of the conversion of energy into mass. (See top photo). Meanwhile, in Cambridge, England, the reverse process was seen in 1932: the conversion of mass into energy. With their apparatus John Cockcroft and E.T.S. Walton bombarded a ^{7}Li nucleus with a proton of energy 125 keV. The resulting fragments, 2 α-particles, had slightly less mass in total than the original ^{7}Li + p, but they flew apart with an energy of 17.2 MeV. Using the known masses of the incoming and outgoing particles, it was possible to verify Einstein's equation explicitly.

$E=mc^2$ is the underlying principle behind nuclear fission and fusion. In fission, an atomic nucleus splits apart into two or more fragments. But the masses of the fragments sum to less than the mass of the original nucleus. The missing mass is released in the form of heat and radiation. The release of energy in naturally occurring substances is too gradual to be of much practical use. Hungarian physicist Leo Szilard first proposed that a chain reaction could occur in a critical mass of uranium, due to the absorption of neutrons by the uranium nuclei, which would then fission and produce more neutrons, leading to an exponentially escalating series of decays. After many technical innovations and theoretical breakthroughs, this ultimately led to the first atomic bomb, as well as the nuclear reactors that convert mass energy to heat and thence to electric energy.

Energy is also released in the nuclear fusion of light atoms. At extremely high temperatures, the atomic nuclei fuse together to form the nucleus of a heavier atom, whose mass is less than the combined masses of the original atoms. This missing mass is released as kinetic energy. As shown by the masterly analysis of Hans Bethe and others, various fusion reactions enable us to understand how the sun and other stars shine, an achievement for which Bethe received the Nobel Prize in 1967.

$E=mc^2$ is Einstein's most famous contribution, but not his greatest. Next month we discuss his supreme achievement, the general theory of relativity.

Sources for this article: the American Institute of Physics online exhibit: http://www.aip.org/history/einstein/; "Einstein's Legacy" by Julian Schwinger; "Subtle is the Lord", by Abraham Pais, and "Einstein 1905" by John S. Rigden.

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World Year of Physics International Gala

See picture caption on page1 for more details.

APS President Marvin Cohen (center) and his wife Suzy share refreshments and an anecdote or two with "Paul Ehrenfest".

"Lise Meitner" and "Hendrik Antoon Lorentz" reminisce about bygone days.

Alan I. Leshner (left), CEO of the AAAS, is on the same wavelength as "Prince Louis de Broglie."

Souvenir caricatures provide gala attendees with a memento of the World Year of Physics.

The young "Albert Einstein" looks relatively the same as his picture on the poster.

S. Peter Rosen (left) of the DOE's Office of Science chats with Marvin Goldberg of the National Science Foundation.

"Erwin Schroedinger" (left) smiles a catlike smile as Neil Baggett of the Department of Energy's Office of Science contemplates the entangled state of next year's budget for physics.

"Lise Meitner" with Nancy Thorndike Greenspan, author of the recent acclaimed biography of Max Born, "The End of the Certain World," and Robyn Williams of ABC.

"J. Robert Oppenheimer" (right) can't fool William T. Golden (center), treasurer emeritus of AAAS, adviser to Presidents, and pre-eminent philanthropist of science. He knew the REAL Robert Oppenheimer. Shown with Golden and "Oppie" at left is Gilbert S. Omenn, the incoming President of AAAS.

Magician Bob Friedhoffer delights the crowd with the old flaming wallet trick. The man has money to burn.

Photo Credit: Colella Photo

The Cotillion Ballroom of the Marriott Wardman Park Hotel in Washington hosts the throng celebrating the World Year of Physics. Among the guests are approximately 20 famous scientists of the 20th century. In the captions to the pictures on this page, these scientists, portrayed by local actors who remained in character all evening, are identified by names in quotes.

The older "Albert Einstein" (center) poses for the camera with S. James Gates of the University of Maryland and AAAS President Shirley Jackson. Earlier that evening, Gates had delivered a plenary lecture at the AAAS meeting on "Einstein's Lessons for the Third Millennium."

Brian Schwartz of the City University of New York (right) was one of the chief organizers of the gala. He is shown here with (l to r) Iris Ovshinsky and Stanford Ovshinsky of ECD Ovonics, and Franmarie Kennedy of MacNeil/Lehrer Productions.

Sorrel Fisher and her husband, Michael E. Fisher of the University of Maryland, wonder what Einstein would have thought of the renormalization group.

Even chemists celebrate the World Year of Physics. Distinguished research chemist Leland Burger (center), who worked on the Manhattan Project, recalls those exciting times with "Enrico Fermi" (left). Listening in is "H. A. Lorentz" (right).

LETTERS

Bicycling in Santa Barbara

Here is a further comment to Mark Jackson's letter published in the January 2005 issue of *APS News*: The famous picture of Einstein on a bicycle was taken on February 6, 1933. According to the Caltech archive, the picture was taken at the home of friends in Santa Barbara.

It ended up in the Caltech archive through a gift by Evelina Hale in 1959. A book by Kenji Sugimoto contains this picture as well as another one with Einstein and friends Ben Mayer and Judith Magnes, all on bicycles. Presumably Einstein was visting them in Santa Barbara.

Paul Lee
Northridge, CA

Time to Confront Political Asymmetry in Physics

The January "Inside the Beltway" column by Michael Lubell argued the case for building bridges to red-state America. This drove home the obvious fact that Republicans are an under-represented group in the physics community. My guess is that, percentagewise, Republicans are even more under-represented than women. The APS should do something about this.

The APS has a very active Committee on the Status of Women in Physics (CSWP). It is time to establish a parallel CSRP, and to develop a pro-active strategy to recruit more Republicans. Surely the reason for the dearth of Republicans is cultural. Not even Larry Summers would argue that Democrats are innately more capable of doing physics than Republicans. We need to determine when young Republicans start leaking out of the pipeline, and take aggressive countermeasures. Do physics teachers naturally expect more from the nerdy unkempt Democrat than from the neatly dressed Republican? Do they steer such students away from science and toward more faith-based education? We must correct this. America cannot afford to deprive itself of half the potential talent pool in physics.

A little marketing could go a long way. Students should be reminded that a force derivable from a potential is conservative. And anyone attracted to the Republican credo of smaller government should find the Principle of Least Action very congenial. Although parity is not conserved, the difference between left and right is weak in physics, but strong among physicists. If Nature is practically even-handed between left and right, shouldn't physicists be the same?

By making the atmosphere in physics more Republican-friendly we can begin to address the imbalance and make the political demographics of the APS look more like America. Both the country and the physics community will be the better for it.

Andrew Warden
Loco Road, Colorado

Erratum

In the call for nominations in the March *APS News*, the deadlines for the Panofsky Prize and the Sakurai Prize were erroneously given as July 1. The correct deadlines are May 1, 2005.

zero gravity

Ask the Ethicist

A graduate student (whom I have decided to call Plato) faced with an ethical dilemma recently contacted the APS editorial offices. Here is a portion of the correspondence that resulted between the student and an APS editor (whom I will call Anaxagoras), in lieu of my usual ethics column. I'll get back to work next month.
-Jordan Moiers

***

Dear Anaxagoras,

I'm a grad student in physics. I recently stopped working for an advisor who always talks about publishing to motivate his students, but rarely publishes any of the work they do.

Whenever a student completes some set of measurements and analysis that the professor had previously agreed should constitute a paper, that student is told that he cannot publish. The reasons given are as diverse as they are mysterious: "Oh. That wasn't the goal of the project anymore. Didn't I tell you?", "The results are good, but since I want to sell these widgets, I don't want to give away the secrets of their fabrication.", and "Hey let's hold off on writing for a while so we can get started on this other project!" The reason given is rarely scientific.

I spent about a year on one particular project. When I finished and wanted to publish I was given the usual runaround. When I pressed the issue, my samples were mysteriously destroyed and I was given a choice between leaving and changing to a different project. I feel that the work is worthy of publishing and I'd hate to simply forget about it.

Would it be legal and ethical for me to publish a paper on the work on my own? Does my former advisor have any legal authority to block it, or control its content? (He obtained the funding, and is responsible for the lab where the experiment took place.) Should I include his name on the paper? Would it be legal and ethical for me to include or exclude his name against his will? His participation in the project was minimal.

Regards,
Plato

***

Dear Plato,

Your professor (surely you don't mean Socrates) has been behaving in a way that is undoubtedly contrary to the guidelines of your institution, and you have every right to complain to a Department chair or to a Dean. I realize that this is easier said than done, since it will open you to possible retaliation by the professor, but you should go to the higher authority with a simple statement of the situation and ask for advice. You can express your concern that you will put yourself in a difficult position with the professor and ask that your complaint be kept confidential until you decide otherwise.

It is legal and ethical for you to publish the work on your own, provided that the Professor has not made "a significant contribution to the concept, design, execution or interpretation of the research study" (This is quoted from the APS Guidelines for Professional Conduct: http://www.aps.org/statements/02_2.cfm).

Obtaining the funding and having responsibility for the Laboratory is by itself not a significant contribution. However, if the funding was obtained because he described the concept of the experiment, he might have a legitimate case for authorship. Finally it is unethical and unacceptable for you to put his name on or exclude him without cause from authorship without his agreement. Your best recourse is to discuss this with a trusted higher authority at your institution.

Sincerely,
Anaxagoras

***

Dear Anaxagoras,

I appreciate the response. It is extremely helpful. However, the difficulties of reporting my professor's behavior (who may or may not be Socrates, I'd rather not say) to a dean or chair may be greater than you suggest. My professor brings in a fair amount of grant money, which is in the interest of the department, the school, and the university. Although I don't understand his sketchy behavior, I think it's about increasing and maintaining grant money. It may not be in the interest of higher authorities to fix the situation. What other recourse do I have?

Plato

***

Dear Plato,

I do not underestimate the difficulty of getting a hearing because of the great influence, financial or otherwise, of your professor (even if he is not the renowned, and somewhat self-absorbed, Socrates) at your institution... I do have the belief that there must be at the higher levels of authority an ethical sense that transcends financial considerations. If you have acted on that belief and it is incorrect there is always the possibility of going to the funding agency. All of my advice is based, of course, on the assumption that the situation is precisely as presented by you. You will have to understand, though, that professors are entitled to a hearing at which they may defend themselves, perhaps disputing your view. As I stated in my first responses, none of this is likely to be easy.

I think the story of your experience would be very helpful to others in similar situations. May we submit this email exchange to the *APS News* "Ask the Ethicist" column?

-Anaxagoras

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Anaxagoras:

Thank you for all the advice. This discussion has shown me a way to proceed with publishing my work, without violating any ethical guidelines. That's exactly what I was looking for. I suppose that people in positions of higher authority do have a greater stake in enforcing ethical behavior, if only because they work under greater scrutiny and risk their own job by tolerating abuse.

I get the sense that a lot of graduate students are in similarly difficult situations and get burned because they're not aware of their rights and responsibilities, and those of their advisor. People need to be educated about these things. Maybe that's a task for grad student labor unions...

Feel free to publish my questions and your responses in the "Ask the Ethicist" column in *APS News.* I doubt Socrates (alright I confess, you guessed right the first time) reads it, and I hope someone else can benefit from my experience.

Regards,
Plato

New Users Flock to Einstein@Home

The Einstein@Home distributed computing project is enlisting a rapidly growing army of computer users in a search for Einstein's elusive gravitational waves. Within three weeks of its February 19th kickoff, the program—which allows home computer users to help confirm Einstein's predictions about gravity—became one of the fastest growing distributed computing projects in the world, adding roughly a thousand users a day. More than 55,000 people from over 115 countries had signed up for the Einstein@Home program as of March 14, 2005–the126th anniversary of Albert Einstein's birth.

"I'm thrilled with the response we've gotten in such a short time," says Einstein@Home principal investigator Bruce Allen of the University of Wisconsin–Milwaukee. "The growing number of participants increases the computing power available to us, and improves our odds of finding something. Were we to find a signal in this way, it would be an exceptional moment for both theoretical and experimental physics. It would also be the first such scientific breakthrough that was enabled by public distributed computing."

Einstein@Home allows anyone from elementary school children to the most advanced astrophysicists to participate in the quest for gravitational waves. These waves are subtle ripples in space and time predicted by Einstein's general theory of relativity. The software necessary to join in the search can be downloaded and run by anyone with Internet access.

Einstein@Home searches the vast amounts of data collected by the US Laser Interferometer Gravitational Wave Observatory (LIGO) and the British/German GEO-600 gravitational wave observatory for waves coming from compact objects such as quark stars and neutron stars. Einstein@Home is available for Windows, Linux, and Mac operating systems. The program provides a screensaver that shows the celestial sphere with the major constellations outlined. A moving marker on the screensaver indicates the portion of sky that your computer is searching.

Einstein@Home web page: http://einstein.phys.uwm.edu/

Washington Dispatch

A bi-monthly update from the APS Office of Public Affairs

ISSUE: RESEARCH FUNDING

President Bush's budget request for FY 2006 contains cuts to key research budgets. The DOE Office of Science budget would decline 3.8%; the NSF budget would increase 1.5% (after accounting for the transfer of a Coast Guard program), below the rate of inflation; basic research at the Defense Department would decline 12.8%; and NASA's basic research would decline 7.1%. The NIST Labs would climb 12.4%, although the increase could vaporize once closeout costs for the Advanced Technology Program are accounted for. Please refer to the AAAS R&D Website (www.aaas.org/spp/rd) and AIP budget page (www.aip.org/gov/budginfo.html) for more details.

* * * * *

ISSUE: VISAS

The U.S. State Department has announced that the duration of security clearances ("Visas Mantis" clearances) required for certain foreign science students and scholars applying for visas has been extended from one year to up to four years. Senators Norm Coleman (R-MN) and Jeff Bingaman (D-NM), meanwhile, have reintroduced a bill (S. 455) designed to further streamline the visa process for foreign science students and scholars entering the U.S.

* * * * *

ISSUE: ENERGY AND NATIONAL SECURITY

The APS Panel on Public Affairs (POPA) will be issuing a Discussion Paper on nuclear power and proliferation resistance titled: "Securing Benefits, Limiting Risk". The report reviews three current federal programs: Technical Safeguards, Gen IV, and the Advanced Fuel Cycle Initiative. Several recommendations are made that would enhance the proliferation resistance of nuclear power. Roger Hagengruber chaired the study. Other authors include: John Ahearne, Robert J. Budnitz, Steve Fetter, Ernest Moniz, Burt Richter, Tom Shea, Francis Slakey, Jim Tape, and Frank von Hippel. When issued, the report will be available for download from the APS Washington Office website: http://www.aps.org/public_affairs/index.cfm

Log on to the APS Web Site: (http://www.aps.org/public_affairs) **for more information.**

APRIL MEETING *from page 1*

as Michele Besso, Ernst Mach, and Satyendra Nath Bose.

Catching a Gravitational Wave. Two major scientific collaborations are well on their way to testing Einstein's predictions in general relativity by searching space for gravitational waves. Various scientists from the LIGO collaboration will present new results in the search for black holes and gravitational waves from neutron stars and radio pulsars, among other objects. On the horizon is the planned space-based Laser Interferometer Space Antenna (LISA), which will be sensitive to gravitational waves in the mHz band. Several speakers will discuss potentially powerful sources, including massive black hole binaries and globular cluster systems.

Deep Galaxies. The DEEP2 project, headquartered at UC Berkeley and UC Santa Cruz, is a large galaxy-redshift survey mapping the location of 50,000 galaxies. Unlike the Sloan Digital Sky Survey and 2dF, prominent surveys which look at relatively nearby galaxies, DEEP2 centers its attention farther out, to a time about halfway back to the Big Bang. Marc Davis will report on new findings about the clusters of galaxies at that redshift and might, depending on the progress of data analysis, be able to provide the best astrophysical test yet of the proposition that the fine structure constant has been changing down through the eons.

Quantum Loops and the Black-Hole Information Paradox. Like its rival, string theory, loop quantum gravity aims to reconcile the venerable but incompatible theories of general relativity, which describes the universe at large scales, and quantum mechanics, which describe nature at the atomic scale. Unlike string theory, which starts off by assuming space-time is smooth and continuous, loop quantum gravity assumes fundamentally that space-time at the smallest scales is discontinuous and chunky. The fabric of space-time is literally woven by quantum threads and is best described by a "quantum geometry." Abhay Ashtekar, the director of Penn State's Institute for Gravitational Physics and Geometry, will present a detailed solution to the so-called "information-loss paradox" associated with black holes.

Mouse Thyroids Go Radioactive. In parts of the US and elsewhere potassium iodide (KI) tablets have been made available for use by humans so as to load the thyroid with stable iodine in the event of an accidental or terrorist-triggered release of radioiodine. An interdisciplinary collaboration among physicists and biologists at the College of William and Mary and the DOE's Thomas Jefferson National Accelerator Facility has been studying the effectiveness of ordinary KI in blocking the absorption of radioactive iodine in the thyroid of a mouse. The research has shown that the human-recommended KI blocking dose, when scaled to a mouse, mostly blocks uptake of radioactive iodine.

Search for ExaVolt Neutrinos. Neutrinos made inside the sun from nuclear fusion reactions typically have energies of mega-electron volts (MeV). But theorists expect that other, more powerful processes might endow ν's with energies of 10^{18} eV or more. The Antarctic Impulsive Transient Antenna (ANITA) is designed to detect exactly this sort of particle. ANITA consists of an array of antennas mounted on a balloon flown above the Antarctic icecap. Peter Gorham will present the first ANITA results.

Do We Really Understand Gravity? Some physicists wonder whether the evidence in favor of dark matter and dark energy isn't pointing to a breakdown in an understanding of gravity. The answer is probably "no," but physicists are speculating on alternatives. Hiranya Peiris of the University of Chicago will cover some of the best cosmological observations, especially of the microwave background, and how they can be used to constrain novel theories of gravity. Arthur Kosowsky of Rutgers will discuss dark matter and possible alternatives. And Mark Trodden of Syracuse University will take a similar tack towards the acceleration of the universe, which is usually taken to indicate the presence of dark energy.

Is the Pentaquark an Endangered Species? For decades, physicists had only seen evidence that quarks clump in groups of two and three. In the last three years, however, experiments produced evidence for exotic four- quark (tetraquark) and five-quark (pentaquark) states. On the heels of a dozen "positive" sightings of the pentaquark, there has been a flurry of negative ("null") results, most containing better statistics, from experiments including CDF at Fermilab, BaBar at SLAC, and collaborations at CERN in Switzerland and DESY in Germany. Curtis Meyer of Carnegie Mellon will review the current evidence for and against the pentaquark.

Plasma Acceleration. Accelerating charged particles to high energies is usually achieved by boosting the particles in powerful electromagnetic fields supplied by microwave devices. An alternative method, with a potentially much higher acceleration gradient, is to use waves moving through a column of plasma to boost electrons to high energies. Chandra Joshi of UCLA, working at the SLAC machine at Stanford, will report on the present ability to impart energy gains of 4 GeV over only a 10-cm length of plasma and plans for achieving soon a gain of 10 GeV over a length of a third of a meter.

Politics vs. Science. Many American scientists have alleged that the current administration manipulated the process through which science enters governance for political gain. Kurt Gottfried (Cornell University) and Lawrence Krauss (Case Western Reserve University) will discuss examples and evidence to support this claim, and what the scientific community might do to ensure that politics does not trump science. Presidential science advisor John Marburger will be on hand to offer the Bush administration's perspective.

Special Events

Friday, April 15
High School Physics Teachers' Day
8:30 am – 3:45 pm
Professional Skills Development Workshop for Women Physicists
8:30 am – 5:00 pm
Career Workshop
7:30 pm – 10:00 pm

Saturday, April 16
Einstein's Legacy: What We Know and What We Don't Know
7:30pm-9:30pm

Sunday, April 17
APS Journal Editors Panel Discussion
2:30 pm – 3:30 pm
Awards Session
5:15 pm – 6:45 pm

Special Symposium
Neutrinos, Particles and Underground Labs: Big Plans
8:00 pm – 10:00 pm

Monday, April 18
Students Lunch with the Experts
12:30 pm – 1:00 pm
Public Lecture
"Einstein's Biggest Blunder: A Cosmic Mystery Story"
Lawrence Krauss,
Case Western Reserve University
7:30 pm – 9:30 pm

AIP REPORT *from page 1*

This data should not be taken to mean that there is no discrimination against women in physics, cautions Rachel Ivie of AIP, the study's author.

"This doesn't mean there's no problem in physics," said Ivie. "Women have persevered in spite of obstacles," she said. For instance, women are more likely than men to be hired into temporary positions, and many women experience a hostile climate in their departments. "There's all kinds of discrimination, but it doesn't show up in these numbers."

The report did find that even when working in the same sector for the same number of years, women's salaries are lower than men's in physics and related fields. "Across all sectors, women with comparable years of experience working in the same sector as men make $3050 less annually. This is equal to almost 5% of the base annual starting salary for men in academe," says the report.

Among the other highlights of the report:

- The representation of women in physics and astronomy at all levels continues to increase. At the high school level, almost half of physics students are girls. During 2003, women earned 22% of the bachelor's degrees in physics and 18% of the PhD's.
- Estimates of the retention rates for physics graduate students show only small differences in the dropout rate for male and female students.
- African American and Hispanic women still earn very few of the physics degrees in the US.
- Internationally, the representation of women in physics is also very low. Most countries award less than 25% of their first-level university physics degrees to women, and most grant less than 20% of their physics PhD's to women.

Ivie said she is optimistic that the representation of women in physics will continue to increase. "There are a lot of people working to make that happen."

The report can be found at www.aip.org/statistics .

PHYSICS AND TECHNOLOGY FOREFRONTS

Photovoltaics: clean electricity for the 21st Century

By Alvin Compaan

Microprocessors, semiconductor memories, light-emitting diodes and other solid-state electronics typically have high commercial value and small sizes ranging from a few square microns to a few square centimeters. Thus they can be made in large quantities and often can be individually tested before being incorporated into the consumer product. Although early photovoltaic (PV) cells and modules were used in space and other off-grid applications where their value is high, currently about 70% of PV is grid-connected which imposes major cost pressures from conventional sources of electricity. Yet the potential benefits of its large-scale use are enormous and PV now appears to be meeting the challenge with annual growth rates above 30% for the past five years.

More than 90% of PV is currently made of Si modules assembled from small 4-12 inch crystalline or multicrystalline wafers which, like most electronics, can be individually tested before assembly into modules. However, the newer thin-film technologies are monolithically integrated devices approximately 1 m^2 in size which cannot have even occasional shunts or weak diodes without ruining the manufacturing yield. Thus, these devices require the deposition of many thin semiconducting layers on glass, stainless steel or polymer and all layers must function well a square meter at a time or the device fails. This is the challenge of PV technology—high efficiency, high uniformity, and high yield over large areas to form devices that can operate with repeated temperature cycles from –40 C to 100 C with a provable twenty-year lifetime and a cost of less than a penny per square centimeter.

Solar cells work and they last. The first cell made at Bell Labs in 1954 is still functioning. Solar cells continue to play a major role in the success of space exploration—witness the Mars rovers. Today's commercial solar panels, whether of crystalline Si, thin amorphous, or polycrystalline films, are typically guaranteed for 20 years—unheard of reliability for a consumer product. However, PV still accounts for less than 10^{-5} of total energy usage world-wide. In the US, electricity produced by PV costs upwards of \$0.25/ kW-hr whereas the cost of electricity production by coal is less than \$0.04 /kW-hr.

It seems fair to ask what limits the performance of solar modules and is there hope of ever reaching cost-competitive generation of PV electricity?

The photogeneration of a tiny amount of current was first observed by Adams and Day in 1877 in selenium. However, it was not until 1954 that Chapin, Fuller and Pearson at Bell Labs obtained significant power generation from a Si cell. Their first cells used a thick lithium-doped n-layer on p-Si, but efficiencies rose well above 5% with a very thin phosphorous-doped n-Si layer at the top.

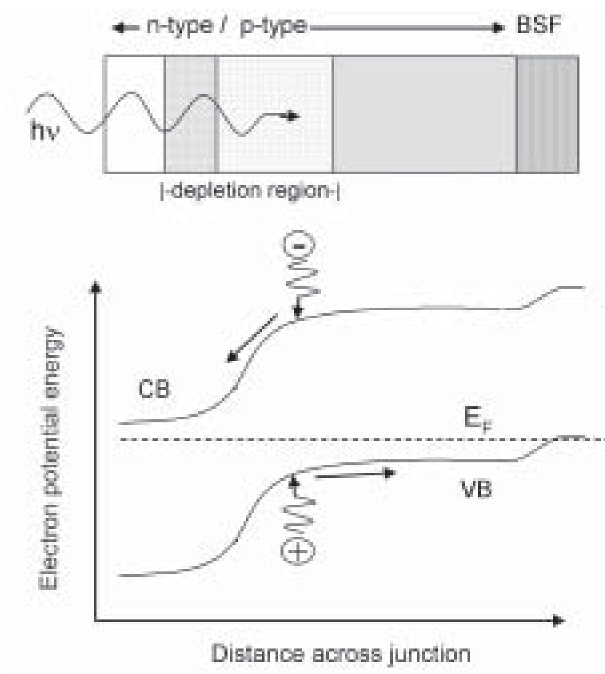

Fig. 1. Solar cell structure and energy band diagram showing valence (VB) and conduction bands (CB), Fermi level (E_F), photoabsorption, electron-hole pair generation, thermalization, and drift.

The traditional Si solar cell is a homojunction device. The sketch of Fig. 1 indicates the typical construction of the semiconductor part of a Si cell. It might have a p-type base with an acceptor (typically boron or aluminum) doping level of NA = 1 x 10^{15} cm^{-3} and a diffused n-type window/emitter layer with ND = 1 x 10^{20} cm^{-3} (typically phosphorus). The Fermi level of the n-type (p-type) side will be near the conduction (valence) band edge so that donor-released electrons will diffuse into the p-type side to occupy lower energy states there, until the exposed space charge (ionized donors in the n-type region, and ionized acceptors in the p-type) produces a field large enough to prevent further diffusion. Often a very heavily doped region is used at the back contact to produce a back surface field (BSF) that aids in hole collection and rejects electrons.

In the ideal case of constant doping densities in the two regions, the depletion width, W, is readily calculated from the Poisson equation, and lies mostly in the lightly doped p-type region. The electric field has its maximum at the metallurgical interface between the n- and p-type regions and typically reaches 10^4 V/cm or more. Such fields are extremely effective at separating the photogenerated electron-hole pairs. Silicon with its indirect gap has relatively weak light absorption requiring about 10^{-20}µm of material to absorb most of the above-band-gap, near-infrared and red light. (Direct-gap materials such as GaAs, CdTe, $Cu(InGa)Se_2$ and even a-Si:H need only ~0.5µm or less for full optical absorption.) The weak absorption in crystalline Si means that a significant fraction of the above-band-gap photons will generate carriers in the neutral region where the minority carrier lifetime must be very long to allow for long diffusion lengths. By contrast, carrier generation in the direct-gap semiconductors can be entirely in the depletion region where collection is through field-assisted drift.

A high quality Si cell might have a hole lifetime in the heavily doped n-type region of τ_p=1µs and corresponding diffusion length of L_p=12 µm, whereas, in the more lightly doped p-type region the minority carriers might have τ_n=350 µs and Ln=1100 µm. Often few carriers are collected from the heavily doped, n-type region so strongly-absorbed blue light does not generate much photocurrent. Usually the n-type emitter layer is therefore kept very thin. The long diffusion length of electrons in the p-type region is a consequence of the long electron lifetime due to low doping and of the higher mobility of electrons compared with holes. This is typical of most semiconductors so that the most common solar cell configuration is an "n-on-p" with the p-type semiconductor serving as the "absorber."

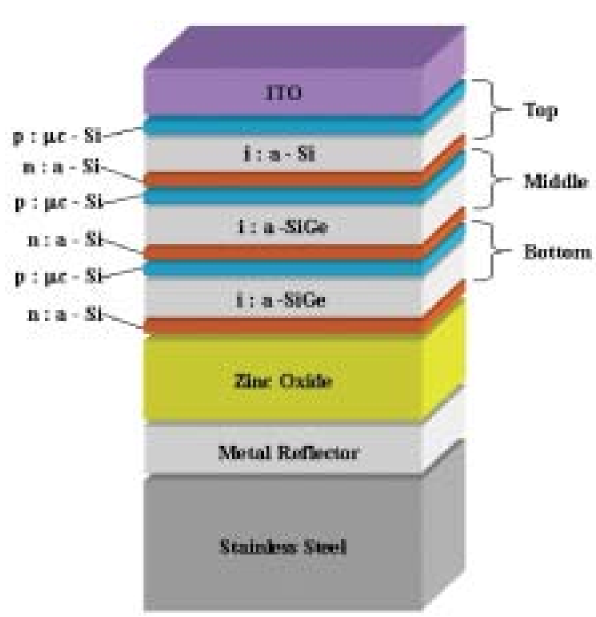

Fig. 2. Triple junction a-Si/a-SiGe/a-SiGe cell structure (courtesy X. Deng/U. Toledo)

Current generated by an ideal, single-junction solar cell is the integral of the solar spectrum above the semiconductor band gap and the voltage is approximately 2/3 of the band gap. Note that any excess photon energy above the band edge will be lost as the kinetic energy of the electron and hole pair relaxes to thermal motion in picoseconds and simply heats the cell. Thus single-junction solar cell efficiency is limited to about 30% for band gaps near 1.5 eV. Si cells have reached 24%.

This limit can be exceeded by multijunction devices since the high photon energies are absorbed in wider-band-gap component cells. In fact the III-V materials, benefiting like Si from research for electronics have been very successful at achieving very high efficiency, reaching 35% with the monolithically stacked three-junction, two-terminal structure, GaInP/GaAs/Ge. These tandem devices must be critically engineered to have exactly matched current generation in each of the junctions and therefore are sensitive to changes in the solar spectrum during the day. A sketch of a triple-junction, two-terminal amorphous silicon cell is shown in Fig. 2.

Polycrystalline and amorphous thin-film cells use inexpensive glass, metal foil or polymer substrates to reduce cost. The polycrystalline thin film structures utilize direct-gap semiconductors for high absorption while amorphous Si capitalizes on the disorder to enhance absorption and hydrogen to passivate dangling bonds. It is quite amazing that these very defective thin-film materials can still yield high carrier collection efficiencies. Partly this comes from the field-assisted collection and partly from clever passivation of defects and manipulation of grain boundaries. In some cases we are just lucky that nature provides benign or even helpful grain boundaries in materials such as CdTe and $Cu(InGa)Se_2$, although we seem not so fortunate with GaAs grain boundaries. It is now commonly accepted that, not only are grain boundaries effectively passivated during the thin-film growth process or by post-growth treatments, but also that grain boundaries can actually serve as collection channels for carriers. In fact it is not uncommon to find that the polycrystalline thin-film devices outperform their single-crystal counterpart.

In the past two decades there has been remarkable progress in the performance of small, laboratory cells. The common Si device has benefited from light trapping techniques, back-surface fields, and innovative contact designs, III-V multijunctions from high quality epitaxial techniques, a-Si:H from thin, multiple-junction designs that minimize the effects of dangling bonds (Stabler-Wronski effect), and polycrystalline thin films from innovations in low-cost growth methods and post-growth treatments. These laboratory successes are now being translated into success in the manufacturing of large PV panel sizes in large quantities and with high yield. The worldwide PV market has been growing at 30% to 40% annually for the past five years due partly to market incentives in Japan and Germany, and more recently in some U.S. states.

Recent analyses of the energy payback time for solar systems show that today's systems pay back the energy used in manufacturing in about 3.5 years for silicon and 2.5 years for thin films.

The decline of manufacturing costs follows nicely an 80% experience curve—costs dropping 20% for each doubling of cumulative production. (See Fig. 3.) The newly updated PV Roadmap (http://www.seia.org) envisions PV electricity costing \$0.06/kW-hr by 2015 and half of new U.S. electricity generation to be produced by PV by 2025, *if* some modest and temporary nationwide incentives are enacted. Given the rate of progress in the laboratory and innovations on the production line, this ambitious goal might just be achievable. PV can then begin to play a significant role in reducing greenhouse gas emissions and in improving energy security. Some analysts see PV as the only energy resource that has the potential to supply enough clean power for a sustainable energy future for the world.

Alvin Compaan is Professor of Physics and Department Chair, and Director of the Center for Materials Science and Engineering at the Department of Physics and Astronomy, the University of Toledo.

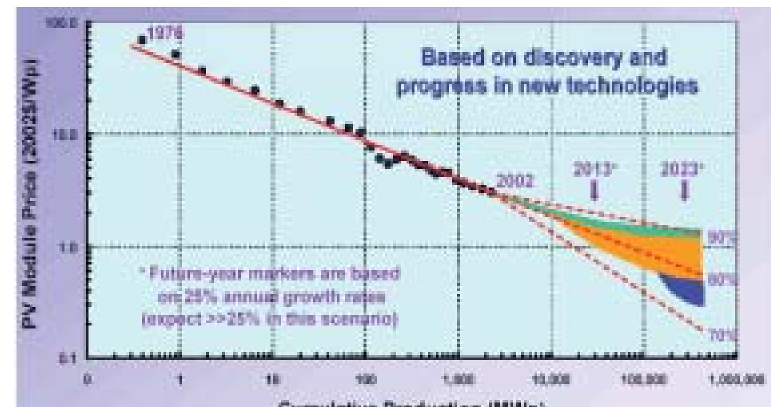

Fig. 3. Experience curve for PV [courtesy of R. Margolis with projections by T. Surek, NREL—c-Si (green), thin-films (orange), possible new technology (blue) http://www.nrel.gov/ncpv/thin_film/docs/margolis2003_experience_curves.ppt]

DHS *from page 1*

Also on hand at the briefing was Kei Koizumi, director of the AAAS R&D Budget and Policy Program, who provided a perspective that included homeland security R&D being funded by other federal agencies. Although homeland security spending remains a top priority, even as the federal budget faces record deficits, "The majority of homeland security R&D investments remain outside of DHS," said Koizumi. The DHS budget is up about 23.8% for FY2006; the total homeland-security-related R&D, including programs in other departments, will jump 10.7% to $4.6 billion.

"There's a lot of low-hanging fruit out there, [technological] capability that already exists, either commercially or in laboratory prototypes," said Albright about the directorate's strategic focus in an economic climate where tough choices must be made. "It's very difficult to do a typical cost-benefit analysis. Our judgments are based on risk and whether we can make a useful technological contribution in that area." He added that the S&T Directorate also looks at what R&D is being done by other agencies to minimize duplicating efforts and encourage cooperation.

The largest portion of the S&T Directorate budget is the $362.3 million for biological countermeasures. Its focus is on surveillance and detection, specifically, the development of the next two generations of environmental monitoring systems. The chemical countermeasures program is budgeted at $102 million for FY2006, with R&D focusing on detection of those chemical agents most likely to pose a realistic threat, both domestically and on the battlefield.

Albright acknowledged that a major issue for the DHS has been its lack of a central focus when it comes to "truly apocalyptic" events, such as a nuclear bomb attack or a widespread biological weapons attack. To address this, the Bush administration has launched the $227.3 million Domestic Nuclear Detection Initiative, focusing on developing new materials for nuclear detection.

The FY2006 budget "puts the brakes" on defense as well as domestic spending; the former will only see modest increases – compared to large increases over the past three years to fund military actions in Iraq and Afghanistan—while the latter is being held flat for the third year in a row, according to Koizumi's preliminary analysis. This means that "There will be ferocious competition for resources if Congress agrees to hold the line on defense spending," he warned, especially since the FY2006 proposed budget does not include funding for the war in Iraq. "There are difficult choices ahead. Will Congress have enough money to add funds for both defense and for homeland security research?"

ANNOUNCEMENTS

American Physical Society Washington Office Senior Science Policy Fellow

Responsibilities: Craft and advocate for key science policy issues. Develop grass roots activities for one of the nation's largest scientific societies. Organize congressional visits programs, "APS Alerts," and letter-writing campaigns. Represent APS Washington Office at selected APS national and divisional meetings, APS committee meetings, and science advocacy coalition meetings.

Requirements: Excellent verbal, writing and interpersonal skills. Hill experience desirable. Science degree strongly preferred.

Salary: Commensurate with experience.

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EDITOR, REVIEWS OF MODERN PHYSICS

The American Physical Society is conducting an international search for a successor to the current Editor of RMP, who is retiring at the end of 2005. The Editor is responsible for editorial standards, policies, and direction of the journal, and leadership of a board of remote Associate Editors, composed of distinguished physicists who solicit review articles in all fields of physics. The Editor reports to the Editor-in-Chief and is supported by an in-house Assistant Editor.

It is expected that the Editor will maintain his/her present appointment and location and devote approximately 20% of his/her time to the position.

A candidate should possess the following qualifications:

- *recognized stature as a research physicist;*
- *broad knowledge and interest in physics and its frontiers;*
- *experience with the editing/refereeing process in physics publication.*

In addition, the Editor needs good interpersonal skills to promote the journal's aim of publishing critical reviews that serve a wide physics readership.

The initial appointment is for three years with renewal possible after review. Salary is negotiable. To ensure a smooth transition, the new Editor is expected to become involved in the fall of 2005, while the current Editor is still active. The APS is an equal opportunity employer.

Inquiries, nominations, and applications (including CV, publications, and letter of intent) are requested by 1 May 2005 and may be directed to: Robert Siemann, Chair, RMP Search Committee, c/o American Physical Society, 1 Research Road, Box 9000, Ridge, NY 11961-9000; or electronically to edsearch@aps.org.

APS April Meeting Job Fair

Come to the Job Fair at the APS April Meeting

Come to the 2005 APS April Meeting Job Fair to meet with employers and job seekers from the fields of Nuclear Physics, Particles and Fields, Astrophysics, Beams, Plasma Physics and Computational physics. The Job fair will provide an excellent opportunity for job seekers to explore new career options, practice one's interviewing skills or conduct research into the job market. For employers, the Job Fair will provide an informal setting to discuss employment opportunities in their organizations.

For More Information

Contact Alix Brice at 301-209-3187 or at abrice@aip.org.

PLAYING SECOND *from page 1*

needs because of pressures from short-term needs. We have been able to get away with it for decades because we were so far ahead of the rest of the world. But the rest of the world is rapidly catching up. Only strong federal investment can ensure the healthy research enterprise that is essential to our innovation future," said Richter.

The Task Force pointed out several other troubling trends:

(1) The number of science and engineering positions in the US has grown at almost five times the rate of the civilian workforce as a whole, but the number of science and engineering degrees earned by US citizens is growing at a much smaller rate. Unless more domestic college students choose to pursue degrees in science, there is likely to be a major shortage in the science and engineering labor market, according to the Task Force.

(2) The US share of science and engineering papers published worldwide declined from 38% in 1988 to 31% in 2001. The US share of worldwide citations is also shrinking. US patent applications from Asian countries grew by 759% from 1989 to 2001, while patent applications from the US during the same period grew only 116%.

(3) The proportion of US citizens in science and engineering graduate studies within the US is declining, and foreign students outnumber American students at US graduate institutions. From 1994 to 2001, graduate science and engineering enrollment in the US declined by 10% for US citizens but increased by 25% for foreign-born students. In 2001, about 57% of all science and engineering postdoctoral positions were held by foreigners.

(4) The US share of worldwide high-tech exports has been in a 20-year decline. And even while the US high tech industry grew during the 1990s, the high-tech industry in many Asian countries grew even faster.

At the press conference Nils Hasselmo, President of the Association of American Universities, said, "The US may be about to experience a significant decline in the number of scientists and engineers it will have available to maintain and further strengthen its innovative capacity. It's bad news for American universities and industry. And it's bad news for our nation's future economic and national security. If the federal government doesn't recommit itself to funding of research in these areas, we will lose students, and our nation will surely suffer."

John Engler, president of the National Association of Manufacturers and former governor of Michigan, added, "We are and remain the world leader in innovation, but we do not enjoy that status by divine right, and we cannot assume that we are safely ahead of the world. The only way the US can continue to create high-wage, high-value-added jobs is to innovate faster than the rest of the world. Federally funded, peer reviewed, and patented scientific advances are essential to innovation. If we shortchange research we do so at our peril."

The Task Force is calling on the federal government to increase the budgets of key research agencies, including the NSF, the DOE, and the DOD, to total one percent of US GDP. The panel declined to specify what other government spending could be cut in order to increase spending on scientific research. "We're not putting the budget together, but this has to be a priority," said Engler.

Asked what has changed since last year, when the Task Force held a similar press conference, Craig Barrett, CEO of Intel Corporation replied, "The challenge we're facing is not a short-term crisis. It happens gradually over a period of time. We have to continue to get the message out."

In addition to the APS, the current members of the Task Force on the Future of American Innovation include the American Chemical Society, the Alliance for Science & Technology Research in America (ASTRA), the Computer Systems Policy Project, the Council on Competitiveness, Intel Corporation, Hewlett Packard, IBM, the National Association of Manufacturers, the Science Coalition, the Semiconductor Industry Association, and Texas Instruments.

The full report can be found at www.futureofinnovation.org .

MEETING BRIEFS

• The APS Texas Section held its annual spring meeting March 3-5, 2005, at Stephen F. Austin State University in Nacogdoches, Texas, in conjunction with the corresponding sections of the American Association of Physics Teachers (AAPT) and the Society of Physics Students (SPS). The meeting featured general sessions on frontier physics, with special consideration given to the World Year of Physics. The three Einstein- related plenary talks focused on Einstein's contributions to quantum mechanics, his contributions to cosmology, and his ethics. Friday evening's banquet speaker was Curtis Bradley, who discussed intriguing connections between Einstein and the painter Pablo Picasso.

• The APS New England Section held its annual spring meeting April 1-2, 2005, at the Massachusetts Institute of Technology in Cambridge, MA. In keeping with the World Year of Physics celebration, the overall theme for the conference was Einstein, including lectures on Brownian motion in E. coli, Bose-Einstein condensates, detecting gravitational waves, testing E=mc^2, GPS measurements, and studying Einstein's manuscripts. Friday evening's banquet speaker was Harvard University's Peter Galison, author of *Einstein's Clocks, Poincare's Maps*.

• Finally, the APS Ohio Section is holding its annual spring meeting April 8-9, 2005, at the University of Dayton in Ohio. The meeting, co-hosted by the Air Force Institute of Dayton and the University of Dayton, is organized around the theme of nanophotonics. Four invited talks focus on photonic crystal fibers; nanofabricated 3D photonic lattices; polymer photonic devices; and quantum control in atom optics. Friday evening features a special public lecture by David Reitze of the University of Florida on the Laser Interferometer Gravitational Wave Observatory (LIGO) in honor of the World Year of Physics. The meeting also features a free optics workshop for high school teachers.

The Back Page

Publication and the Internet: Where Next?

Michael E. Peskin

A part of the vision of the future of science enunciated by Vannevar Bush in1945 was the "memex," a machine that instantly retrieved any paper in the scientific literature[1]. Today, that device is at my disposal. When students come to my office with queries that might be about any topic in high-energy physics, I can put the answers in their hands with a few clicks of the mouse. This is the result of enormous effort in the past decade by many people who shared this vision, from the developers of the World-Wide Web to the authors of Web-accessible archives and search engines. It is time now to consolidate what we have learned and to pose clearly the next set of problems to be addressed.

Electronic dissemination of scientific information can decrease the cost of publication. So it is ironic that, in parallel with these technological developments, we are troubled by spiraling costs for scientific journals. Indeed, this "serials crisis" is the primary concern of university and technical librarians everywhere. Some part of this crisis would be alleviated by authors choosing to publish in cost-effective journals. In my field of physics, the cost/paper to libraries varies among journals by a factor of 10, with the *Physical Review* at the low end of the scale. Over the long run, however, the physics community should move to new modes of publication that are facilitated by the new technologies. In this article, I will explain where I think we should go.

There are, I believe, two important components to a new publishing model. The first is to rely as much as possible on the authors of scientific papers to take over functions now carried out by scientific journals. Good software tools can facilitate this. The second is to recognize tasks that–irreducibly–require professional editors and staff, and to assign the real costs and collect revenues for these tasks.

In the following, I will quote costs for these services as a fraction of the present cost for the *Physical Review* to process a paper ("PR cost"). Please realize that these costs depend on the exact level of service, and that I have assumed a minimal level, as will be explained. The numbers given should be taken only as rough estimates to guide the discussion.

My proposal is given in the belief that the individual scientific article will remain the basic element of scientific communication. Science grows when individual scientists have ideas which they first support with evidence, and then polish and defend. A scientific paper succeeds when it presents an intellectually coherent idea. The formulation of such ideas is not a community process. The judging of ideas cannot be automated. Still, we can present and exchange papers both more cheaply and more effectively.

What are journals for?

In the traditional publishing model, scientists rely on journals to provide four distinct functions. These are: distribution, refereeing, archiving, and indexing. That is, the journal (1) makes the article widely available in a readable form, (2) performs an evaluation and gives its imprimatur to the correctness and importance of the results, (3) preserves the results for future readers, and (4) provides a basis for search and location of the contribution.

I believe that the roles of distribution and archiving can, to a great extent, become the responsibility of the author if appropriate technical means are provided. The roles of refereeing and, to a lesser extent, indexing, require professional services. Following this path, we can save costs and improve communication at the same time.

Distribution

The most elemental function of a journal is to present articles in a form in which they can be distributed and read, and to make these articles widely available. Until very recently, this required authors to interact with a publisher and an editor, laboriously exchanging and correcting proofs. Newton and Bohr famously agonized over their page proofs. I do too, but I have the luxury of desktop software that gives me control over every detail of how my paper appears. Indeed, the greatest success of the current phase of electronic publishing has been the triumph of the author-prepared manuscript. Anyone with a computer can now prepare a paper that is cleanly formatted, with equations beautifully typeset, and can convert it to an electronic file that can be transparently viewed over the Internet.

This has made it possible for physicists to communicate by posting papers on centralized electronic archives such as the Cornell e-print archive.[2] In some subfields of physics (mine is one) the posting on the Cornell archive is the publication of record. It is the place that my colleagues go to read the paper, even after it is accepted by a refereed journal. The posting date determines intellectual priority. Through this medium, our papers are brought immediately to the attention of our community world-wide. The cost/paper of arXiv deposition is less than 2% of the PR cost. These costs are currently paid by the National Science Foundation and the Cornell University Library.

I believe that the advantages of communicating through unrefereed e-prints is so great that eventually this method will be adopted by all communities in physics. Refereeing is not incompatible with this means of distribution; rather, it is a credential applied at a later stage of the publication process. It may be that new elec- tronic archives will be created to better fit the cultural styles of other communities within physics (for example, solid state experimenters). It is only important that these archives are centralized for each subfield and that they are given permanence, e.g., through hosting by a university library. I will refer to these collectively as "the Archive." Once a community has adopted Archive publication, more advantages follow, as we will see below.

Michael Peskin (center) and colleagues use the miracle of electronic publishing to bring to their desktop a classic 1969 paper by Kenneth Wilson on the operator product expansion.

Archiving

A centralized Archive can improve the presentation of papers by providing guidelines and templates for the creation of electronic manuscripts. In the process, it can collect "metadata"–explicit identification of authors, for example–that would be valuable in cataloguing. Eventually, the Archive might provide tools that allow authors to produce papers in a standard format for permanent archiving.

There is no universally accepted standard today for electronic archiving of papers. The choice should eventually be made by a consortium of institutions interested in preserving scholarly electronic materials, including scientific societies, university libraries, and the Library of Congress. The sooner this consortium is assembled, the better. In principle, pdf could be used as an archival file format, as long as a particular well-defined version of pdf is specified.[3] In this case, a rendering engine producing that version of pdf could be used to present papers at the Archive. Authors would then ensure that their papers posted on the Archive appear correctly and have the correct associated metadata. This would then leave to the Archive and the consortium of which it is a part only the task of preserving the electronic files indefinitely. This is a challenging task, but one that could be automated in a scalable way, without requiring further human intervention for individual papers.

In a system in which preparation for archiving is the responsibility of the author, the cost/paper of archiving could likely be brought down to a few percent of the PR cost. At this level, the costs might be paid by the institutions that support the Archive. If it turns out that, to produce archival-quality files, a central authority must reformat each article, the cost will be higher–more than 20% of the PR cost–and the payment for this service will need to be collected by journals.

Indexing

Once one has a centralized Archive containing papers and associated metadata, it is possible to search and index this database. The result would be a bibliographic record of the field, to the extent that its papers have been stored in the Archive. In high-energy physics and astrophysics, the libraries of the Stanford Linear Accelerator Center and the Harvard Smithsonian Astrophysical Observatory already provide bibliographic search engines that are up-to-date within a few days of posting on the Cornell archive.[4,5] Thus, these services are about three months ahead of refereed journals and six months ahead of commercial services such as ISI. They provide not only author, title, and textual searches but also forward and backward citation linking. As more subfields adopt Archive publication, this capability could be extended to all of physics.

It is important to note that, for this service, it is likely not possible to give the full burden to the author. It is the current experience that the references in author- prepared manuscripts contain many errors and ambiguities. In principle, these can be corrected at a later stage by authors and readers. Still, someone must receive the notices and make the corrections. Both of the services named above have several full-time employees devoted to this task and incur costs/paper of about 4% of the PR cost. It is possible that similar services in other subfields of physics could be donated by other laboratories or universities. The multiple databases could be consolidated either by sharing of data through the consortium described above or by a higher-level service such as the recently announced Google Scholar.

Refereeing

I have now argued that the model of author-prepared papers published in an electronic Archive can fill the roles of presentation and archiving traditionally offered by journals and would enable improved indexing and search of the physics literature. The relatively small institutional costs for these services could be funded outside the system of journals. But the final role, refereeing, cannot be given over to this mode of support. It requires a substantial professional infrastructure.

In some models for electronic publication, the refereeing step is conveniently eliminated or replaced by automated download or citation counting. This, I feel, is a mistake. The essential feature of refereeing is that the original idea presented in the paper should be confronted intellectually by a knowledgeable reader. That ought to remain a necessary criterion for the acceptance of that idea by the scientific community. Such engaged reading should be part of any evaluation of the authors for grant funding or career advancement. The fact that refereeing in the real world often falls short of the ideal does not make this any less true.

Refereeing has costs that must be paid. Referees are typically individual scientists who volunteer their time. But a cadre of professional editors is needed to manage the dialogue between authors and referees and, ultimately, to take responsibility for the decision to accept or reject a paper. For the *Physical Review*, this task accounts for 30% of the PR cost. Adding the costs of overhead, financial services, and an editorial office, the cost per article would be almost 50% of the PR cost, even if the only product of the journal is the decision to accept or reject the paper.

Who would pay these costs? The model in which physicists pay for each paper submitted has been tried, and it was a failure. Authors migrated to journals with no publication charges but with much higher subscription costs to libraries. I favor the "institutional membership" model, in which libraries pay a fee which allows authors from their institutions to submit papers for refereeing. These fees would be tiered for research institutions of different sizes, as is done now for APS journal subscriptions. Such a fee would be easier to collect than page charges paid by individual scientists, but only if the library community understood and supported this model.

I believe that librarians would see the value of this model, even though the journals would not produce a product that libraries can purchase and own. The model fulfills their goals–access to scholarly communication, with evaluation, search, and permanent archiving. It provides some savings even from the current prices of low-cost journals. More importantly, by focusing on payment for essential services, it eliminates the niche held by high-cost journals, and this would bring libraries very significant savings.

Conclusions

I believe, then, that the new technologies have enabled a change in the way physicists publish that is more profound than simply making journals available on-line. If we use these technologies wisely, we can shift to authors many of the responsibilities now managed by journals. We must, at the same time, identify the irreducible part of the journals' task that requires a professional staff, and a means to pay for their service. In this way, we can remake the literature in a way that improves its accessibility and allows it to grow to accommodate the future development of science.

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[2]http://arXiv.org/

[3]See http://www.digitalpreservation.gov/formats/fdd/fdd000125.shtml

[4]http://www.slac.stanford.edu/spires/

[5]http://adswww.harvard.edu/