APS NEWS

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APS 100 years celebrate a century of physics

Chodos is New Associate Executive Officer

Alan Chodos, a senior research physicist at Yale University, will succeed Barrett Ripin as Associate Executive Officer of the APS. Ripin stepped down in January after serving five years in that position. Chodos will assume the office full-time in July, and will divide his time between Yale and the APS in the intervening months.

Among the chief responsibilities of the Associate Executive Officer are the editorship of *APS News* and the administration of prizes and awards. The AEO also works with the Executive Officer in the general management of Society affairs. In addition, Chodos will coordinate a new effort to enhance the APS presence on the Web, providing services not only to the APS membership and the physics community, but also to the public at large.

"Alan brings a great enthusiasm and a wealth of experience to the position of Associate Executive Officer. We are very pleased to have him join the APS staff," said Judy Franz, Executive Officer of the APS.

Chodos received his PhD from Cornell University in 1970, and held postdoctoral positions at the University of Pennsylvania and MIT before joining Yale in 1976. His research has concentrated in particle theory, and he is perhaps best known for his work on the MIT bag model and on Kaluza-Klein theories. He is also known to believe that the neutrino is a tachyon. Chodos was elected a Fellow of the APS in 1994.

Outgoing *APS News* editor Barrie Ripin (left) passing the 'baton' to new editor, Alan Chodos under the watchful eye of former APS President Henry Rowland.

During the last decade, Chodos has been active in Society affairs, serving on a task force on publications in the early '90s, on the Committee on Member Publications and briefly on the Membership Committee before joining the Publications Oversight Committee in 1997. He served as Chair of that committee in 1999.

"We are in a period of rapid change, both in the society at large and in the physics community," Chodos said. "The APS has been working hard to keep providing the services that its members need, and I want to help make sure that that continues."

Inside...

APS Career Efforts Focus on Physics Departments

The primary thrust of the APS' career activities, which are guided by the now two-year old APS Committee on Careers and Professional Development (CCPD), has been directed at assisting physics departments in their efforts to prepare graduates for the full range of careers open to them. Foremost among these efforts has been the Careers and Professional Development Liaison (CPDL) program, initiated by former Associate Executive Officer, Barrett Ripin, in 1998 (see *APS News*, June 1998).

The CPD Liaison is a contact person in each participating physics department responsible for programs to prepare students for their post-graduate careers and employment. The APS attempts to provide the Liaison with up-to-date useful information for students and faculty regarding physics employment in industry, academia, government, and other sectors. More importantly, the Liaison will typically play a strong role in the professional development initiatives for students and faculty within their own physics department. One way the APS helps to do this is through a website for Liaisons that acts as a resource of 'good practices' that have proven useful in other departments. This may involve Liaisons in

Continued on page 6

Mass Media Fellow Learns "Nuts and Bolts" of Journalism

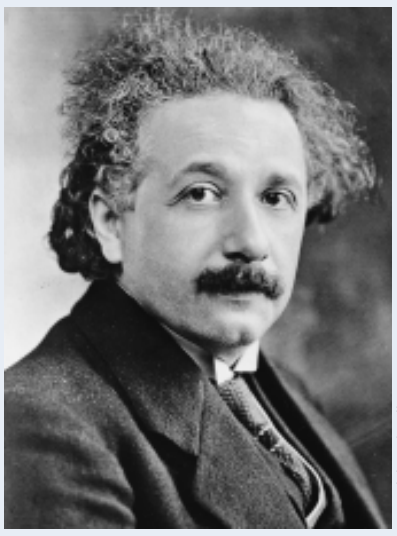
Conducting interviews, writing news articles, and scouting out solid story ideas became part of a typical working day for physicist Ilana Harrus, who spent last summer as a science writer for the *Raleigh News & Observer* in North Carolina as an APS Mass Media Fellow. In the process, she says, "I came back with a better understanding of the problems faced by journalists in their daily coverage of science, and impressed by their fairness in writing and reporting on difficult subjects." She credits the experience with reinforcing her desire to become a full-time science writer.

Ilana Harrus' *Raleigh News & Observer* presscard.

The APS Mass Media Fellowship program was developed by the APS Forum on Education in 1995 as a vehicle for improving public understanding and appreciation of science and technology.

Continued on page 3

Man of the Century



AIP Niels Bohr Library

Albert Einstein

Who says physicists never get respect? *Time* magazine recently named theoretical physicist Albert Einstein its "person of the century" in its year-end issue (December 27, 1999), citing not only his intellectual brilliance but his humanitarian concerns, and describing him as a "paramount icon of our age."

Born in Germany in 1879, Einstein is notorious for having been expelled by a headmaster as a young school boy (see page 4). He went on to win the 1921 Nobel Prize in physics for uncovering the theory of the photoelectric effect. His early work on the fundamentals of quantum theory and, of course, relativity, laid the groundwork for much of modern physics. This in turn paved the way for an unprecedented degree of technological development, including nuclear fission and fusion — the basis for the atomic bomb, nuclear power, and solar energy. Einstein emigrated to the US in 1933 to take a post at the Institute for Advanced Study, Princeton, NJ, narrowly escaping persecution by the Nazi government because of his Jewish heritage. He has since become one of the most recognizable faces in American physics, and has even been immortalized on the Silver Screen by actor Walter Matthau in the popular romantic comedy, *I.Q.*

In announcing their selection, the magazine editors wrote, "In a century that will be remembered foremost for its science and technology — in particular for our ability to understand and then harness the forces of the atom and the universe — one person clearly stands out as both the greatest mind and paramount icon of our age: The kindly, absent-minded professor whose wild halo of hair, piercing eyes, engaging humanity and extraordinary brilliance made his face a symbol and his name a synonym for genius."

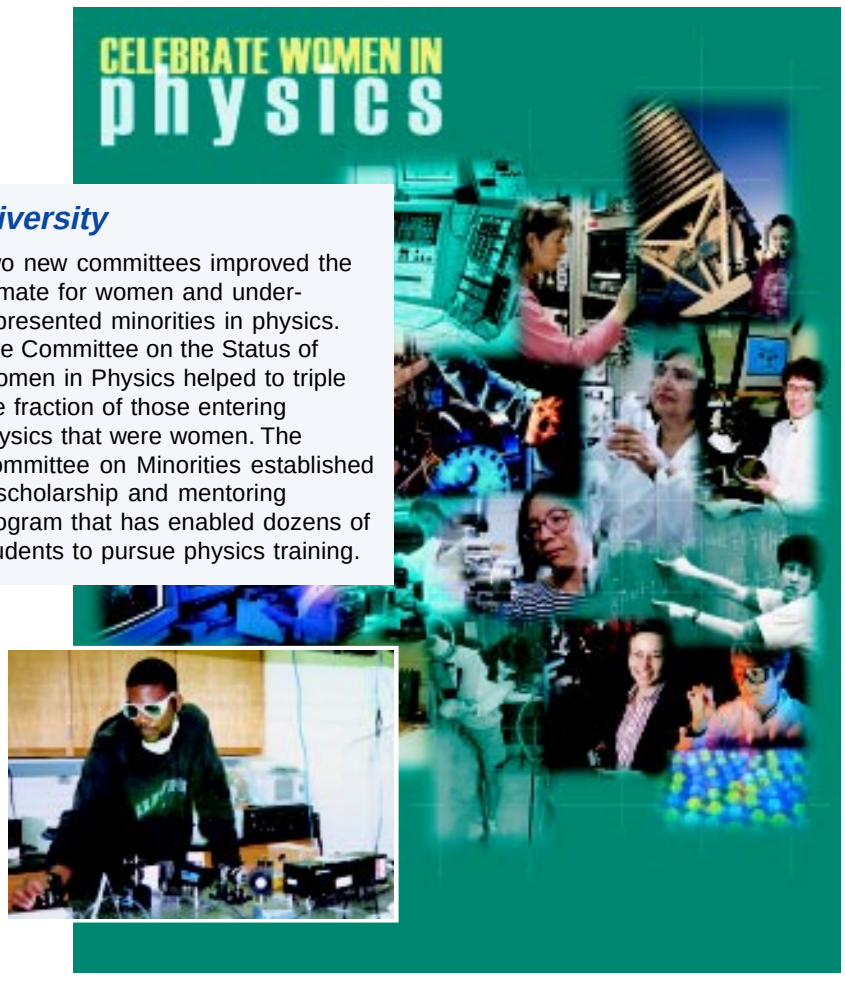
More information about Einstein can be found at websites: **www.aip.org/history** and **www.pbs.org/wgbh/nova/einstein**.

To Advance & Diffuse the Knowledge of Physics

100 Years of the American Physical Society

Excerpts from an exhibit displayed at the APS Centennial Meeting.

Curator: Sara Schechner, *Gnomon Research*
Exhibit Director: Barrett Ripin
With contributions by Harry Lustig, R. Mark Wilson, and others.



Diversity

Two new committees improved the climate for women and under-represented minorities in physics. The Committee on the Status of Women in Physics helped to triple the fraction of those entering physics that were women. The Committee on Minorities established a scholarship and mentoring program that has enabled dozens of students to pursue physics training.

Outreach and Community Service I

The ferment of the Viet Nam era and the concomitant rise in social consciousness propelled APS into community service. New programs reflected contemporary issues:

- **diversity**
- **employment**
- **education**
- **government relations**
- **human rights**

These programs for physicists and the public augmented the Society's ongoing work of advancing the knowledge of physics.

Employment

Rumors of physicists driving taxis or bartending were rampant during the job crisis of the late 1960s and 1970s. This led to a precipitous drop in physics PhDs. In response, the APS offered career counseling and improved placement services.

With the creation of the Forum on Industrial and Applied Physics in 1995, APS recognized the increasing fraction of physicists employed outside of academe.

Human Rights

In the last thirty years, many members of the Society have decried violations of the human rights of dissident scientists in the Soviet Union, China, and elsewhere. Today, the APS Committee on International Freedom of Scientists fights injustice wherever found.

Herman Feshbach with Elena Bonner, Andrei Sakharov, and Alexi Semenov, Moscow, 1987.

Next Month: Outreach and Community Service Part II

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APS and BNL Host XXX e-Print Archive Mirror

The APS is establishing, in cooperation with Brookhaven National Laboratory, the first electronic mirror in the United States for the Los Alamos e-Print Archive. The Archive allows authors of physics articles to post their papers on-line and, in its short life, has become an essential resource for physics research. The mirror, a duplicate web-site updated daily, will provide wider and faster access to the heavily used Archive.

Scientists around the world access the Archive to immediately find out about new developments and directions in research, without having to wait for these to appear in a hard copy journal. Posting on the Archive serves authors as an adjunct or an alternative to publication in a traditional physics journal. Created in 1991 by Los Alamos physicist Paul Ginsparg and known informally as XXX after the original web site at xxx.lanl.gov, the Archive presently contains over

100,000 papers in physics and related fields. It operates with support from the US National Science Foundation, the Los Alamos National Laboratory, and the US Department of Energy. To speed and facilitate access, the Archive is already mirrored at 14 sites around the world.

APS Editor-in-Chief Martin Blume and Deputy Director Peter Paul of Brookhaven National Laboratory led the collaboration. APS initiated and organized the project, obtained the required equipment and will participate in further software development; Brookhaven is providing space and internet access. Eventually, the APS/BNL mirror could move beyond a passive duplication of the XXX Archive to become a second site for submission of articles and vetting for suitability and size.

In the Journals

Science Goes Further Than Fiction

"The universe is not only queerer than we suppose, it's queerer than we can suppose." —***J.B.S. Haldane***

Michael Crichton's current best-seller, *Timeline*, sends science fiction buffs back in time by way of physics' latest theories. While even Crichton admits such time travel dreams require lots of scientific fact stretching, Clarkson University physicist Lawrence S. Schulman is putting a new scientific spin on science fiction. In a paper published in the December 27 issue of *Physical Review Letters*, Schulman suggests — instead of simply skipping to a previous time — the possibility of strange worlds where the timeline itself actually runs backwards.

According to Schulman, in these not-yet-discovered places broken eggs, for example, would re-form. Typically, physics says this isn't allowed. Disorder, which physicists call "entropy," rules in our world. Or, as Schulman states, "the fate of Humpty Dumpty is sealed by the 'Second Law of Thermodynamics.'"

It's been assumed that the entire universe shares the same "thermodynamic arrow of time." But, through statistical computer modeling, Schulman says, "I have found that there could be regions, perhaps within our own galaxy, in which the arrow goes the other way." Furthermore, all physical processes (including entropy) would appear to be going in a normal direction relative to a person living in that system. A person in either system would view a person in one with an opposite arrow as getting younger, from his or her own perspective.

Could we actually see this theoretical reverse arrow system? Well — Schulman uses reasoning, first proposed by physicists John Wheeler and Robert Feynman, to show that the system would have normal transmission and reception of light, which would help. Wheeler's book *Geons, Black Holes, & Quantum Foam* — winner of the American Institute of Physics' 1999 Science Writing Award — also helped Crichton imagine a physics technology to get his characters into the past.

Currently, though, Schulman says we have to settle for less direct — but just as speculative — viewing. While scientists tell us the visible universe is continuing its expansion away from the "Big Bang," Schulman suggests reverse arrow regions are full of burned out stars from the future (the other region's past) that haven't re-lit on their way to a rejuvenating "Big Crunch." But we may be seeing those regions' effects, according to Schulman, as the mysterious "dark matter" that seems to be exerting unseen gravitational effects on visible stars.

Viewing possibilities are definitely greater for a big budget movie version of Crichton's *Timeline*, but a celluloid depiction of Schulman's timeline should be less expensive to make—just run an already made film backwards.

— Randy Atkins, Inside Science News Service

Everyone's a Critic....

Well before the movie version of Crichton's *Timeline* is released, critics are already chiming in with their take on the conclusions of Schulman's *PRL* paper:

"I love this story—a 'believable' explanation for Cold Dark Matter would be a FABULOUS way to leave the 20th Century behind us."

—Walter Lewin, PhD, astrophysics professor, MIT

"He's probably wrong. He's piled speculation upon speculation. However, it will be a wild ride for us physicists to prove him wrong. Physics thrives on teasing apart outrageous and delicious paradoxes. That's how real science is done."

—Michio Kaku, PhD, physics professor, City University of New York

"Although this is a novel conceptual view of time in a macroscopic system, a localized region in the universe would have to be observed for new physical laws to prevail. Our assumptions are that the laws do not change depending upon your location in the universe."

—Herman White, PhD, research physicist, Fermilab

"Thanks for asking but, I'd rather not go there. If that's a pun, all the better."

—Anonymous physicist

IN BRIEF

Kudos for Centennial Projects

Two of the Society's special Centennial-related products have received critical raves in the general media. *Scientific American's* Website featured the APS *A Century of Physics* online wall chart as its "Bookmark of the Week" in December [http://timeline.aps.org/]. "This is not highbrow physics but a clear, readable and easily accessible tour of the century," the site description reads. "The result is a huge, multilayered timeline that puts the myriad important discoveries and inventions in physics in context with their time and their impact on society." In addition, *Publisher's Weekly* (November 1, 1999) selected the APS-sponsored coffee table book, *Physics in the 20th Century*, by Curt Suplee, as coffee table book of the year, citing the "informed clear text" and vivid photographs which "reveal in breathtaking fashion the development of physics in this century." The book has also been featured as a notable pick by the Quality Paperback Book Club and cited in *USA Today*.

Mazur Honored by CSSP

In November 1999, the Council of Scientific Society Presidents (CSSP) honored Eric Mazur, a professor of physics at Harvard University and fellow of APS, with its 1999 Educational Research Award. This is only the third time the award is given, and the first time it has been awarded to a physicist. The CSSP, which has past APS President Jerry Friedman as chair-elect, is a powerful voice in fostering wise science policy, and one of the premier forums for open substantive exchanges on emerging scientific issues. Mazur was honored for the exceptional quality of his work over many years in educational research and outreach.

In Memoriam

At its November meeting, the APS Council adopted two memorial resolutions, in honor of the late Rep. George Brown, Jr. and laser science pioneer Arthur L. Schawlow. The resolutions were incorporated into letters of condolence sent to the families of the deceased by APS Past President Jerome Friedman.

George E. Brown, Jr.

"The Council of The American Physical Society notes with great sadness the death of Rep. George E. Brown, Jr. of California, former chair and ranking member of the House Science Committee and one of the staunchest advocates of science. Congressman Brown leaves a rich legacy: his bipartisan and thoroughly professional approach to science policy; his unswerving devotion to the future good of the nation; and his constant reminder to the science community that it, too, has social and political obligations. George Brown was a statesman and a gentleman who served his country with extraordinary devotion and distinction. The Council conveys its sincere sympathy to his wife and family."

Arthur L. Schawlow

"The Council of The American Physical Society notes with sadness the death of Arthur Leonard Schawlow of Stanford University, a co-inventor of the laser, winner of the Nobel Prize in Physics in 1981 for his work in laser spectroscopy, and recipient of the National Medal of Science in 1991. A talented researcher, outstanding educator and indefatigable lecturer, Dr. Schawlow trained a generation of graduate and post-doctoral students who played a fundamental role in shaping the field of coherent optics and quantum electronics. He was an outstanding physics citizen, serving as president of the APS in 1981. He lectured widely to the public and was active in support of efforts to help autistic individuals. The Council conveys its sincere sympathy to his two daughters and his son."

Mass Media Fellow, *continued from page 1*

It provides an opportunity for physics students or physicists who are early in their careers to work over the summer as science reporters at radio stations, television stations, newspapers and magazines throughout the country. The American Association for the Advancement of Science Mass Media Science and Engineering Fellows program acts as matchmaker to place the APS fellows with host media organizations.

Harrus earned her PhD in physics and astrophysics from Columbia University in 1997 and had just completed a postdoctoral fellowship at the Harvard Smithsonian Center for Astrophysics when she applied for the APS fellowship. As a media intern, she found herself employing the more general analytical tools of her science training rather than any specific knowledge of physics, although she found her statistical background useful for an article on statewide school test results, for example. And, she discovered, "Journalists can be just as passionate as scientists about their work, and I found that enthusiasm is contagious."

Despite her regular contributions to several publications, Harrus had never written for a daily newspaper, and lacked formal training in journalism. As an intern, her education was swift, and very much a trial by fire. She credits *News and Observer* science writer Jon Franklin with taking the time to work with her one-on-one on an early story and helping her develop some of the "nuts and bolts" journalistic skills required.

Harrus is currently debating whether she would prefer to write about science for a general audience or for a more targeted scientific readership. She is drawing a clear distinction between science writing and what she terms, "journalism which happens to be about science." Initially, she plans to focus on freelancing for science publications, but clings to the hope of one day writing again for the general public. "There is so much joy in understanding complicated concepts," she says. "There must be a way to transmit this joy, and not just the illusion of it, to a large number of people."

Initially approved for a trial three-year period, the APS Council unanimously approved the Mass Media Fellowship program as an ongoing APS activity last May. "At the end of their fellowship tenure, whether they become full-time journalists or return to traditional science careers, the APS mass media fellows will serve as a resource for the physics community to facilitate and enhance our communications with the media and, ultimately, the public," says Jim Wynne, program manager for local education outreach at the IBM T. J. Watson Research Center, who also serves as forum councilor for the FED.

OPINION

VIEWPOINT...

Who Taught Physics to Thomas Pynchon?

By Robert A. Levy

Last spring, *APS News* published an article on the genealogy of physicists (The Back Page, March 1999), in terms of the lineage of their principal thesis advisors, which in numerous cases were interesting and sometimes surprising. But what about the physics genealogy of Thomas Pynchon?

Who, you might well ask, is Thomas Pynchon, and why would anyone want to know his physics genealogy? You wouldn't be alone. During a weekly colloquium talk at the University of California, Davis, in 1980, attended by 50 graduate students and faculty, only one knew the name of Pynchon: the department chair. And at the APS Centennial meeting last March, I asked a well-known emeritus member of the physics teaching faculty at Cornell University if Pynchon had been a student during his tenure. [Pynchon graduated from Cornell with a degree in English, although he was originally an engineering major.] He looked at me blankly. And last summer, I asked a well-traveled condensed matter physicist whether he knew of Thomas Pynchon. He had never heard of him.

I found this widespread ignorance difficult to believe. Thomas Pynchon is one of the world's most famous living writers. He is to American literature what Oppenheimer and Fermi were to physics. His first novel is said to have "radically changed the shape of literature in our century." But more importantly, he is a writer who obviously knows something about physics — not the kind you hear from TV anchors or physics historians, but enough to make the kind of jokes and metaphors that we would find amusing. "Entropy" is the title of one of his short stories.

We physicists pride ourselves on our knowledge of, and familiarity with, fields outside our own. We know all about politics, music, sports, cuisine, cars, biology, etc. So why don't we know about Pynchon? I will go out on a limb and conclude that physicists as a group are fairly ignorant of his existence, much less familiar with his work.

Just as the discovery of high-temperature superconductivity has led to the growth of an industry, with academic laboratories, industrial and governmental organizations all working feverishly to expand and develop the phenomenon, so an entire industry has grown up around Pynchon's work, with criticisms, essays, books, and discussions taking place at literature departments everywhere. There are many more books about Pynchon than by Pynchon, such as *Pynchon's Poetics*, by Hanjo Berressem (University of Illinois Press, 1993) The E*ncyclopedia Britannica* describes Pynchon's greatest novel, *Gravity's Rainbow*, as "a *tour de force* in 20th century literature... filled with descriptions of obsessive and paranoid fantasies, ridiculous and grotesque imagery, and esoteric mathematical and scientific language."

I would like to recommend that physicists finally acquaint themselves with this long-overlooked author. If we want to be able to communicate with the general public, we would be well advised to be familiar with the works of Thomas Pynchon and maybe even take a few writing lessons from them at the same time. We might discover new insights into topics currently of interest to physicists, such as creationism, computers, and the environment.

Start with *Slow Learner*, a collection of his early short stories which includes "Entropy." Then tackle *Gravity's Rainbow*, where you'll find plenty more physics, and if you make it to the end, you'll understand why an industry has built up around the author. If you're by chance a philatelist (the American Philatelic Society has the same acronym as the APS), take a shot at *The Crying of Lot 49*. For insight into Pynchon personally, read what little nonfiction he's written, such as "Is It OK To Be a Luddite?" in The New York Times Book Review, and the introduction to *Slow Learner*, both written in 1984. Compare how Pynchon talks about the future with how physicists do so, for example, Freeman Dyson in *The Sun, the Genome and the Internet*. You might also check out one of the many books about Pynchon somewhere along the line.

And what about Pynchon's physics genealogy? Who were his physics professors at Cornell? Will we ever know? Were they azimuthal or radial physicists? Can we tell from how Pynchon writes about physics? I offer these questions as a challenge to you all.

Robert A. Levy lives in El Paso, Texas and is a long-time enthusiast of the works of Thomas Pynchon.

Cosmic CD Available at Last!

Diehard fans of the "Physics Chanteuse" — a.k.a., cosmological physicist turned entertainer Lynda Williams — will be thrilled to hear that the dynamic diva has finally released her first CD compilation. The CD contains both music and data, including lyrics, film clips of her live show, *Cosmic Cabaret*, and links to her colorful website [see www.scientainment.com]. It also contains some of her most popular tunes, many of which were performed during the APS Centennial meeting in Atlanta, GA, last March: "Hi-Tek Girl," "Carbon is a Girl's Best Friend," "Super-symmetry" and just in time for Valentine's Day, "Love Boson," whose lyrics appeared in the February 1999 issue of *APS News*.

Photo by Ron Sherman

Lynda Williams

LETTERS

Sinking Test Ban Politics

There is more to the story, "Sinking the Test Ban Treaty," than the simple political posturing described in Michael Lubell's analysis of the failure of the Senate to ratify this treaty. I was surprised that nothing in the article addressed the merits and demerits of the proposed treaty. As one who would like to see the ratification, eventually, of an enforceable pact banning these tests, I am also aware of the arguments treaty opponents made to the effect that the recent proposal was defective-especially as to its enforceability. I would like to see the *APS News* provide more information on this subject to help APS members understand the two sides of this issue. Simply leaving the impression that the treaty's failure was the result of squabbling political brats does a disservice to the very serious issues that are involved.

David V. Anderson
Orinda, CA

Editor's note: Richard Garwin gives a perspective on attributes of the test ban treaty in this month's Back Page. Readers are encouraged to express opposing views or comments in letters to the editor: letters@aps.org.

Festive Formula Flaw

The claim made on The Back Page of the December *APS News* that the "Festive Formula" yields the day of the week Christmas falls on for "any year after 1600" requires qualification, as the formula is based on the Gregorian calendar. While some European countries did adopt this calendar prior to 1600, many did not. Britain (and its colonies) did not do so until the 18th century, which UNIX users can verify with the command "cal 9 1752". Further details can be found at http://www.magnet.ch/serendipity/hermetic/cal_stud/cal_art.htm#Adoption

Tevian Dray <tevian@math.orst.edu>
Department of Mathematics, Oregon State University
Corvallis, Oregon

Poll Reveals All-Star Physicists

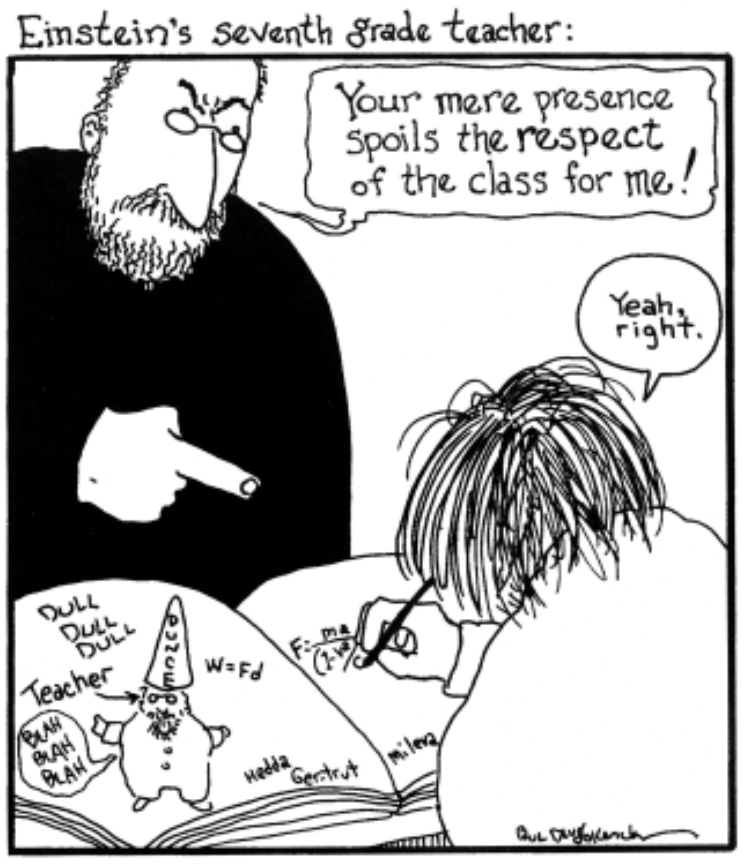
According to a poll of scientists conducted by *Physics World* magazine (December 1999),the top ten physicists in history are as follows:

1. **Albert Einstein**
2. **Isaac Newton**
3. **James Clerk Maxwell**
4. **Niels Bohr**
5. **Werner Heisenberg**
6. **Galileo Galilei**
7. **Richard Feynman**
8. **Paul Dirac**
9. **Erwin Schrodinger**
10. **Ernest Rutherford**

Other highlights of *Physics World's* millennium canvas: the most important physics discoveries are Einstein's relativity theories, Newton's mechanics, and quantum mechanics. Most physicists polled (70%) said that if they had to do it all over again, they would choose to study physics once more. Most do not believe that progress in constructing unified field theories spells the end of physics. Ten great unsolved problems in physics: quantum gravity, understanding the nucleus, fusion energy, climate change, turbulence, glassy materials, high-temperature superconductivity, solar magnetism, complexity, and consciousness. *Physics World* is published by the Institute of Physics, the British professional organization of physicists celebrating its 125th anniversary this year.

—Philip F. Schewe, AIP Public Information

Disagree with any of the above? Let us know! Because we love a good debate, *APS News* invites its readers to submit their own thoughts on the top ten physicists and/or physics discoveries of all time. Lists should be submitted to Editor, *APS News*, One Physics Ellipse, College Park, MD, 20740, letters@aps.org. Be sure to include concise reasons for your selections.



INSIDE THE BELTWAY

A Washington Analysis

Y2K Forecasting Takes Guts

By Michael S. Lubell, APS Director of Public Affairs

Futurism is millennium chic. Far-off auguries are pretty safe bets for soothsayers. They'll either be dead or long-forgotten by the time any of their prophesies are put to the test.

Forecasting Y2K events inside the Beltway bears a much higher risk. Barring an apocalypse, diviners will be around to suffer the truth and will be held accountable for their rash predictions. Still, I can't resist the challenge.

The first year of the new millennium — or, for the purists, the last year of the current one — will be a souped-up version of 1999. The lame-duck presidency will seem even lamer. And the slim Republican majority in the House of Representatives will seem even more anorexic.

At the crack of the starter's gun, all competitors will be off for the November 7 finish line. The race will be a 100-day sprint with partisan elbows flying.

Don't look for any big-issues like health care reform, Social Security, gun control, or campaign financing to get on track. About the only lane open will be the FY 2001 budget. And even there, one hurdle looms large. Appropriators will start off $11.4 billion in the hole.

The IOU comes from clever accounting in the FY 2000 spending plan that allowed both parties to assert that they had not broken the budget caps, even though the Congressional Budget Office and the Office of Management and Budget said they had. Here are some of the big-ticket items that saw their fiscal year reassigned: civilian and military pay date shift ($4.1 billion), Federal Reserve System accelerated payments ($3.8 billion), defense contractors delayed payments ($1.3 billion) and NIH deferred payments ($0.8 billion).

The odds are that Congress will repeat the same kind of creative budgeting this year and that the President will go along with the charade. Both parties will dash to the tape as fast as they can to get out of town before the public picks up a whiff of the chicanery. They'll leave the budget mess for the next President and Congress to clean up.

How will science budgets fare in this scenario? Probably for most agencies the numbers will show consistent increases — so long as members of Congress hear from their constituents.

The one exception could be the Department of Energy, which will come under heavy fire from Capitol Hill critics on both sides of the aisle, who claim that Secretary Richardson thwarted the will of Congress when he took on the added role of the interim Undersecretary of the new National Nuclear Security Agency. Whether the DOE research budget comes up short as a result, will depend on how well the APS and others lobby Congress on the Department's gem — the Office of Science.

Here are two more DOE predictions: House Science Committee Chairman James Sensenbrenner (R-WI) will still have the Spallation Neutron Source in his gun sight, and Stockpile Stewardship Program skeptics will take aim at the National Ignition Facility over allegations of mismanagement, technical shortcomings and cost overruns.

As for Congress after the November die is cast, the odds favor Democrats recovering the House. Republicans who are stepping down from their seats in competitive districts outnumber Democrats by better than a 2 to 1 margin. And generic party-preference polls show Republicans lagging their counterparts by more than 8 points.

Regardless of the outcome, committee chairmanships are going to change. NIH advocate John Porter (R-IL) and DOE promoter Ron Packard (R-CA), are retiring. And should the GOP win,

Republican leaders have said that all committee chairs will step down for new blood. Of course, new blood, could still mean old members, if committees simply swap chairs. Still, the impending shake-up will produce more pork in FY 2001 appropriations, as departing leaders exercise their prerogatives for the last time.

By contrast, the Senate will remain relatively stable. Each party has a few vulnerable seats, but neither one will make inroads large enough to change the Senate dynamics. That means the Democrats will remain in the minority, but the Republicans will fall short of a filibuster-proof majority of 60. For the Senate in Y2K, it means business as usual.

As for the White House, 1999 was a near-record setting year. On issues on which he had staked out a clear position, President Clinton succeeded in a mere 37.8 percent of the votes, the second lowest rate racked up since the political analysis journal Congressional Quarterly began its tabulation 47 years ago. It was just 1.6 percent higher than the record low this President had set in 1995, in the immediate aftermath of the Republican revolution.

Don't look for Y2K to be very different. For all his charisma and intellect, President Clinton has displayed little interest in building bridges to Congress. Much of that stems from the triangulation strategy developed by former presidential advisor Dick Morris after the 1994 Democratic debacle. Morris had argued that to win a second term in 1996, the President had to portray himself as the third alternative to the two-party ideologies that govern congressional debate.

The strategy paid off in the election, but it did little for the President's reputation on the Hill. Still, watch for Congress and the White House to rally around science with calls for a balanced portfolio and increased investment in research as the underpinning of the American economy.

If I'm wrong, remember that it takes more guts to do this than to be a futurist.

zero gravity

Physics Product Warnings

WARNING: This product warps space and time in its vicinity.

WARNING: This product attracts every other piece of matter in the universe, including the products of other manufacturers, with a force proportional to the product of the masses and inversely proportional to the distance between them.

CAUTION: The mass of this product contains the energy equivalent of 85 million tons of TNT per net ounce of weight.

HANDLE WITH EXTREME CARE: This product contains minute electrically charged particles moving at velocities in excess of 500 million MPH.

CONSUMER NOTICE: Because of the "Uncertainty Principle," it is impossible for the consumer to find out at the same time both precisely where this product is and how fast it is moving.

ADVISORY: There is an extremely small but non-zero chance that, through a process known as "tunneling," this product may spontaneously disappear from its present location and reappear at any random place in the universe, including your neighbor's domicile. The manufacturer will not be responsible for any damages or inconvenience that may result.

READ THIS BEFORE OPENING PACKAGE: According to certain suggested versions of the Grand Unified Theory, the primary particles constituting this product may decay to nothingness within the next 400 million years.

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PUBLIC NOTICE AS REQUIRED BY LAW: Any use of this product, in any manner whatsoever, will increase the amount of disorder in the universe. Although no liability is implied herein, the consumer is warned that this process will lead to the heat death of the universe.

NOTE: The most fundamental particles in this product are held together by a "gluing" force about which little is currently known, and whose adhesive power can therefore not be permanently guaranteed.

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US R&D Spending Trends

Last fall the National Science Foundation's Division of Science Resource Studies issued a Data Brief with some interesting numbers on R&D spending in the US. Note that these numbers combine all R&D disciplines and that the physical sciences have fared less well than the biological and medical areas for many years. A few selections are featured below. The full report, *R&D as a Percentage of GDP Continues Upward Climb*, by Steven Payson, can be found online at http://www.nsf.gov/sbe/srs.

WHAT ALL SECTORS IN US ARE SPENDING ON R&D:

- $247 billion, projected total 1999 R&D expenditures

INCREASE IN TOTAL R&D SPENDING:

- 6.8%: average rate of annual increase in total R&D expenditures from 1980 to 1985
- 2.1%: average rate of annual increases in total R&D expenditures from 1985 to 1990
- 1.0%: average rate of annual increases in total R&D expenditures from 1990 to 1995
- 6.1%: average rate of annual increases in total R&D expenditures from 1995 to 1999
- 7.2%: average rate of annual increases in total R&D expenditures from 1998 to 1999

HOW R&D SPENDING COMPARES TO GDP:

- 2.79%: R&D as a share of the 1999 GDP, the highest percentage since 1967
- 2.67%: R&D as a share of the 1998 GDP
- 2.61%: R&D as a share of the 1997 GDP
- 2.87%: Highest R&D/GDP ratio in US history, in 1953

HOW R&D FUNDING IS SPENT:

- 16.3%: share of projected 1999 R&D for basic research
- 22.9%: share of projected 1999 R&D for applied research
- 60.9%: share of projected 1999 R&D for development

WHO SUPPORTED R&D in 1999:

- 68.5%: share supported by industry
- 26.7%: share supported by the federal government, lowest since 1953, when data was collected

—Item courtesy of Richard Jones, AIP Public Information

Exploring "Who Did It?" with Forensic Science

Since the introduction of fictional detective Sherlock Holmes in the 19th Century, scientific methods have become increasingly important, not only to criminal investigations, but also for such purposes as establishing identity for child support and inheritance issues. A special session at the recent fall meeting of the APS Texas Section, held last October in Austin, TX, highlighted the latest developments in such critical areas of forensic science as DNA testing, fingerprint analysis, and drug and alcohol toxicology.

The session was the brainchild of Manfred Fink, a professor of physics at the University of Texas who teaches a highly popular undergraduate course in forensic science, often to standing-room-only crowds of more than 200 students. "I am limited every time by the size of the classroom," he says, and tries to tie the subject matter into what students have seen on TV, from drug and alcohol toxicology, to DNA testing, to forgery, or how Napoleon died. "O.J. Simpson has done [forensics] a fantastic favor, because it really highlighted the sensitivity of these technologies, so this is a fashionable topic."

DNA testing has been an area of intense public interest ever since its pivotal role in the Simpson murder trial several years ago, and the field continues to advance at a rapid pace. According to Lisa White, a research scientist with the Houston-based Identigene, it is now possible to obtain sufficient DNA samples from the handle of a suitcase, cigarette butts, used Kleenex, bubble gum and soda cans — in fact, from almost anything that comes into close contact with blood, saliva, skin cells or other bodily fluids. "There's just no way to escape DNA analysis anymore," says White, pointing out that the human body sheds 10,000 cells day.

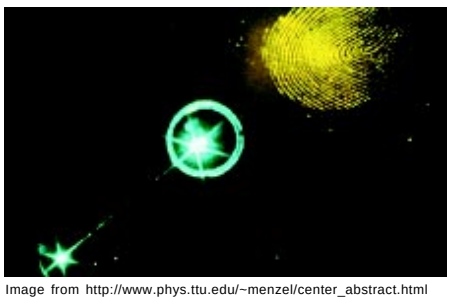

Image from http://www.phys.ttu.edu/~menzel/center_abstract.html

Identigene specializes in laser-based technology for all kinds of DNA analysis, including paternity testing, criminal testing, forensic testing, and family reconstructions. DNA analysis has been used to identify body parts retrieved in the aftermath of the recent Egyptian Air disaster, or body parts scattered from graves in cemeteries during the recent floods in North Carolina, and reassemble them. The company's latest innovation is a DNA microarray called APEX, capable of identifying 70 different genes with nearly absolute certainty. As for the Simpson acquittal and the subsequent controversy surrounding DNA evidence introduced in court, "The science itself is hardly ever questioned," says White. "When defense attorneys object to DNA evidence, it's not the actual results they're fighting, it's how someone gathered the evidence."

Roland Menzel, a professor at Texas Tech University and director of its Forensics Science Center, discussed techniques for fingerprint analysis, opening with a sample obtained from the days of the Civil War, using one of the most primitive methods: laser detection of the inherent fluorescence of fingerprint residue. In addition to occasional casework consulting in forensics, Menzel is developing a new technique that involves tagging fingerprints with photoluminescent semiconductor nanocrystals, which, because they have long luminescent lifetimes, can enable time-resolved imaging to get rid of unwanted backgrounds for a clearer image of the print.

Also featured at the session was W. Ginn, Jr. of the Texas Department of Safety Crime Laboratory, who described how drug and alcohol toxicology methods have helped law enforcement personnel locate and confiscate various contraband substances, such as heroin, cocaine and marijuana. Even standard spectrometry techniques have improved to the point where analysts can now test for 160 different drugs in the body simultaneously, from a single drop of blood, and within two minutes, according to Fink.

However, while the physics and technology for better and more accurate forensic analysis is there, Fink emphasizes that forensic methods are useful primarily if one has a target subject to which one can compare the results. Also, as the LAPD discovered in the Simpson trial, there must be immaculate handling of the collection of the sample to be analyzed in order for the results to be useful as evidence in courts of law. Menzel conducts the occasional workshop for law enforcement employees to train them in various aspects of forensic analysis, including the correct procedure for collecting samples. "Even the most modern technology cannot help you if the sample isn't handled correctly," says Fink. "So we must educate the rest of the world."

Cornell "Nanoharp" Studies Vibrating Materials at High Frequencies

Researchers at Cornell University have fabricated the world's smallest stringed instrument — which they call a "nanoharp" — to study the physics of very small vibrating systems at record high frequencies. The device and associated fabrication techniques were presented during the APS Centennial Meeting in Atlanta, Georgia, this past March.

The same group of researchers fabricated a microscopic guitar two years ago as a whimsical demonstration of their fledgling nanofabrication technology. [The original nanoguitar is included on the APS Timeline of Physics wall chart.] Cornell professor Harold Craighead, who supervised the research, says the nanoharp is just another use for their newfound ability to make microscopic mechanical systems. "By making things very small, you bring out properties that aren't evident in larger materials," he says. "We can combine this information with other types of measurements made by researchers in materials science to help understand how materials behave." Although the current device is made of silicon, Craighead says that the same methods can eventually be applied to other materials as well.

The nanoharp is carved out of a single crystal of silicon using advanced versions of the same methods used to build tiny electronic circuits: electron beam lithography and "released silicon" technology, which refers to nanostructures that have been undercut to be freely suspended in space. It consists of two endpieces, one square and one triangular, with several "strings" of varying lengths stretching between them. The strings are actually silicon rods 50 nm (150 atoms) in diameter, ranging from 1000 to 8000 nm in length, and the entire device is about the size of a single red blood cell.

As with a full-size harp, the resonance frequency at which a string vibrates depends on the length and the mass. However, the microscopic strings are not under tension like those in a musical instrument, and hence the resonant frequency of the nanoharp's strings follow a different rule, varying as the square of its length, similar to a metal bar being struck by a hammer. "It's really more like a xylophone than a harp," says Dustin Carr, a research support specialist in Craighead's lab and graduate researcher in Cornell's physics department, who was one of the featured speakers on the topic at the APS meeting.

The nanoharp's purpose goes beyond mere scientific whimsy. Craighead and his fellow researchers are studying resonance effects in these microscopic systems. They cause the silicon rods to vibrate by applying a radio frequency voltage signal through the silicon base. They then measure the resulting vibrations by bouncing laser light off the strings and observing the reflected light with a highly sensitive interferometer. The effect is similar to the way in which plucking a string tuned to middle C, for example, causes a nearby string tuned an octave higher to vibrate in response to energy transmitted through the air. The team has measured vibrations at frequencies from 15 MHz up to 380 MHz, and the system can detect a motion as little as one nanometer. Eventually they hope to examine the behavior of these oscillators at very low temperatures.

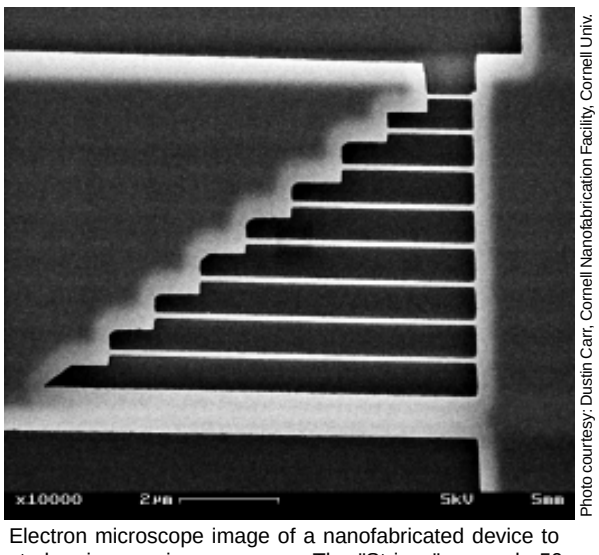

Photo courtesy: Dustin Carr, Cornell Nanofabrication Facility, Cornell Univ.

Electron microscope image of a nanofabricated device to study microscopic resonances. The "Strings" are rods 50 nanometers thick.

For more information about Harold Craighead's nanofabrication research at Cornell University, see http://www.hgc.cornell.edu.

APS Career Efforts Focus on Physics Department,

continued from page 1

departments that have tried successful programs providing suggestions on how to set up student internships, foster closer ties with physics related industry, and developing other ways that physics departments can better prepare students for a diversity of career options. "Despite our good intentions, we sometimes can't provide all of the information our students need," bemoaned one department chair.

The APS is hosting a Career Liaison Workshop in Minneapolis, MN just prior to the Y2K March Meeting to help Liaisons and to stimulate greater interchange between physics departments in the US. In addition, the APS hopes to learn how it can more effectively assist the physics community in the career development area. Currently over 125 physics departments have designated Liaisons, a number that is rapidly growing. The Liaison program is open to all physics departments at all degree levels, BS through PhD granting institutions. Of course, there is a wide spectrum of information to cover these very diverse needs. If your department has not yet designated a Liaison, then consider encouraging the department chair to do so. [Departments may sign up for the Liaison program on the CPDL website at: www.aps.org/jobs/cpdl]

Departments can learn a lot about what works, or doesn't work, by examing existing programs. The Liaison program is designed to foster such cross-examination and make it easy for interested faculty to learn the real scoop from the most experienced persons.

The APS and AIP initiated a prototype "Career Site Visit Program" in which a department invites in a team of experts to evaluate its efforts at providing for the professional needs of its graduates. The first such visit was made to Southwest Texas State University (SWT). The most important finding, according to Barrett Ripin and Bo Hammer, who initiated the program and were, respectively, the APS and AIP representatives, was that "good teaching counts." The report of the visit, which is accessible through the online version of this *APS News* issue and the CPDL website, went on to note that the SWT's enrollment did not decline as many other had over the past few years. Many students cited the small class sizes, attention from faculty, and a program is geared to train graduates with skills in high demand by local semiconductor businesses.

Fall 1999 CCPD meeting attendees. Standing, left to right, are: Arthur Hebard, Tony Nero, James McCambridge (FIAP Rep.), David Elmore, Barrett Ripin (Sr. APS Liaison). Seated are: Arlene Modeste Knowles (APS Staff), Alan Goland (1999 CCPD Chair), Diandra Leslie-Pelecky (2000 CCPD Chair), Jack Hehn (Director, AIP Education Department), Bo Hammer (Director, Society of Physics Students).

Still another way that the Society is actively trying to provide career development is through continuing education for physicists in topics normally not part of the a degree program. For instance, the APS sponsored a short course on *Management Problems of the Technical Person* at the Centennial meeting in Atlanta. FIAP, with sponsorship from CCPD, is running a similar short course at this coming March Meeting. CCPD is studying the pros and cons of establishing an accreditation system for physics departments or for special degree programs.

The current chair of CCPD, Diandra Leslie-Pelecky (diandra2@unl.edu) is very much interested in hearing your reactions to these initiatives as well as other suggestions of ways that the APS might help improve career options for physicists.

Announcements

Y2K APS Fellowship Nomination Deadlines

For submittal information see: http://www.aps.org/fellowships

DIVISIONS	
Astrophysics	05/01/2000
Atomic, Molecular, Optical	02/15/2000
Biological Physics	04/01/2000
Chemical Physics	02/15/2000
Computational Physics	03/15/2000
Condensed Matter	PAST
Fluid Dynamics	02/15/2000
Polymer Physics	04/15/2000
Laser Science	04/01/2000
Materials Physics	02/15/2000
Nuclear Physics	04/01/2000
Particles & Fields	04/01/2000
Physics of Beams	03/15/2000
Plasma Physics	04/01/2000
FORUMS	
Physics & Society	04/01/2000
History of Physics	04/01/2000
International Physics	04/01/2000
Industrial and Applied Physics	02/20/2000
Education	04/15/2000
TOPICAL GROUPS	
Few Body Systems	04/01/2000
Precision Meas. Fund. Const.	04/01/2000
Instruments & Measurement	04/01/2000
Shock Compression	04/01/2000
Gravitation	04/01/2000
Magnetism and Its Applications	04/01/2000
Plasma Astrophysics	04/01/2000
Statistical & Nonlinear Physics	04/01/2000
APS GENERAL	06/01/2000

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*See committee reports at http://www.aps.org/exec/bylaws/apptctes.html

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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.

▶ QUALIFICATIONS

- Students who have been enrolled as undergraduates at colleges and universities in the United States at least one quarter/semester during the year preceding the 16 June 2000 deadline.
- Students who have an excellent academic record and have demonstrated exceptional potential for scientific research through an original contribution to physics.
- Only one candidate may be nominated per department.

▶ APPLICATION PROCEDURE

The complete nomination package is due on or before **16 June 2000** and should include:

1. A letter of nomination from the head of the student's academic department
2. An official copy of the student's academic transcript
3. A description of the original contribution, written by the student such as a manuscript or reprint of a research publication or senior thesis (unbound)
4. A 1000-word summary, written by the student, describing his or her research
5. Two letters of recommendation from physicists who know the candidate's individual contribution to the work submitted
6. The nominee's address and telephone number during the summer.

▶ 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 20740-3844; Telephone: (301) 209-3268, Fax: (301) 209-3652, email: chodos@aps.org

Membership Directory CD-ROM

APS will offer the 2000-2001 Membership Directory in paper or CD-ROM version to each member this year. If you would like to receive the CD-ROM format, please email your request to membership@aps.org, phone 301-209-3280 or fax 301-209-0867 by February 29, 2000. The default will be to receive the paper version.

Visit the APS Online Member Directory (www.aps.org/memb/enter-directory.html).

APS CENTENNIAL SYMPOSIA AND PLENARY SESSIONS NOW AVAILABLE ONLINE!

Nearly all of the APS Centennial symposia and plenary sessions featured at the Centennial meeting in March in Atlanta are now available on a new APS Centennial Website: www.apscenttalks.org. Using RealPlayer G2, users can listen to featured lectures and panel discussions online while viewing the speaker's visual materials (where available). Speaker biographies and photos (again, where available) are included for each talk. Presentations are sorted into three categories: by session, speaker, and date of presentation. The site also provides a Photo Gallery from the Centennial Celebration, along with links to other related physics Web sites, instructions for downloading RealPlayer G2, and contact information for the APS.

CAUGHT IN THE WEB

Notable information on the World Wide Web

Online Centennial Symposia Talks: www.apscenttalks.org
March Meeting: www.aps.org/meet/MAR00
April Meeting: www.aps.org/meet/APR00 (after 14 Feb., 2000)
A Century of Physics timeline: timeline.aps.org
Physics Limericks: www.aps.org/apsnews/limericks.html (Yahoo! cited)
Amazon Books: www.aps.org/memb/amazon
100 Years of the APS - Exhibit & History: www.aps.org/apsnews/history.html

THE BACK PAGE

The Comprehensive Test Ban Treaty and US National Security

by Richard L. Garwin

On October 13, 1999, the US Senate voted against approving the Comprehensive Test Ban Treaty by a vote of 51 to 48. Senate advice to ratify would have required 67 votes. Signed in September 1996, the CTBT had lain before the Senate for two years with no committee action or report, before being scheduled abruptly for a vote within 11 days. The Administration and its Senate supporters, whatever the merit of their case, were outfoxed by the opposition.

Yet the CTBT is greatly in the US security interest. Even opponents of the CTBT generally support the Nonproliferation Treaty, extended indefinitely in 1995, that binds parties with nuclear weapons from transferring them or knowledge to build them, to non-nuclear weapon states (NNWS), while binding Parties who are NNWS not to acquire nuclear weapons. A condition of that extension was the negotiation of a CTBT that would forbid nuclear test explosions by Nuclear Weapon States and by non-members of the NPT such as India, Pakistan, and Israel. As signed, the CTBT bans every nuclear explosion, of whatever yield — it is a "zero threshold" ban on nuclear explosions, and a permanent treaty. It creates an International Monitoring System (IMS), mandating cooperation of the parties in the emplacement of seismic sensors, hydroacoustic sensors, detectors of atmospheric infrasound, and sensors for radioactive particulates and gases from explosions. It provides also for on-site inspections (OSI) of events identified by the IMS, and it permits parties to bring non-IMS evidence, such as that obtained from general intelligence sources. The CTBT cannot enter into force until 44 specified countries sign and ratify. Once a state signs, under conventional international law it should not test unless it declares that it has no intention of pursuing ratification.

The US has conducted more than 1000 nuclear explosions and has about 10,000 nuclear weapons. The Soviet Union, with some 6000 ready strategic weapons and perhaps 18,000 total, could destroy not only the US but much of the civilized world — hence the long-standing US interest in reducing the number of deployed strategic nuclear weapons and ultimately the number of nuclear weapons of all types. The NPT has played a major role in holding the number of states possessing nuclear weapons to eight instead of the dozens foreseen within a decade in the 1960s.

Since 1992, the US has had a moratorium on nuclear testing, signed by President Bush and passed by large majorities in both Houses. Both Bush and Clinton have stated that we have no need for nuclear weapons of new types and no need for nuclear tests. Under these circumstances, there is annual certification by the Secretaries of Energy and Defense that each of the ten types of weapons in the enduring stockpile continues to be safe and reliable. Enabling this certification is a long-standing surveillance program, by which nuclear weapons are drawn from the stockpile at random — 11 of each type, annually — and carefully inspected.

Each US nuclear weapon consists of a primary fission explosive — a metal-sheathed plutonium shell surrounded by high explosive and arranged to be filled with deuterium-tritium (D-T) gas when it is imploded by that explosive. Upon implosion and the provision of neutrons for starting the fission chain reaction, sufficient fission yield is generated to ignite the contained D-T, which "boosts" the primary yield to a level such that thermal x rays carry much of the fission energy to implode the secondary capsule. A radiation case of high-Z material contains the thermal radiation long enough for this to happen. Most of the energy release of the nuclear package comes from the fusion fuel and the neutron-induced fission in the surrounding U-235 or U-238 elements of the secondary.

US nuclear explosions were used for development of new-type weapons, for production verification tests after a stockpile of such weapons had been begun, for weapons effects tests on other systems, for investigation of "Peaceful uses of Nuclear Explosions" (PNEs), and on physics experiments. Among these are the creation of super-heavy nuclei, and the exploration of pellet fusion to guide the laboratory Inertial Confinement Fusion program. There have been rare tests to qualify a nuclear replacement or modification to solve a stockpile problem identified in the surveillance activity. No problem with stockpile aging has even been identified in a nuclear test, although many aging problems are found in surveillance and repaired in weapons of the afflicted type.

Safety of nuclear weapons refers primarily to the prevention of accidental nuclear detonations from lightning or other accidents involving a nuclear weapon. The Sandia National Laboratories provides the Enhanced Nuclear Detonation Safety (ENDS) system, as well as means to prevent unauthorized detonation of a nuclear weapon.

US nuclear weapons have been developed also to be one-point safe, so that detonation of the high-explosive of the primary component of the nuclear weapon at a single point will not produce a significant nuclear yield: either zero or (by design) less than two pounds of high explosive, compared with a typical 100 kilotons of design yield. Nuclear tests were essential in verifying one point safety of the designs in the stockpile, but never need be redone. Nor have nuclear tests ever been used to establish reliability of the nuclear components, which the laboratories have always assumed and stated to be 1.0. Such reliability is established through design and inspection, together with replacement or remanufacturing of parts.

The Pentagon and the directors of the nuclear weapons laboratories support the CTBT as signed, when integrated with a package of six safeguards. One of these is an ongoing $4.5 billion annual Science-Based Stockpile Stewardship Program (SBSSP). Safeguard F, as modified during the negotiations surrounding the Senate vote in October 1999, states that the President will resume testing if a nuclear weapon type in the enduring stockpile, critical to US security, could not be certified safe and reliable without test. Part of the SSP is the creation of new facilities for computation, including the Accelerated Strategic Computing Initiative, the Dual Axis Hydrodynamic Radiographic Test facility, and the National Ignition Facility (NIF).

But the ability to act on the basis of stockpile assessment has not kept pace with the assessment process. For instance, the US has had no ability to manufacture or remanufacture the sealed metal primary "pits" since Rocky Flats, Colorado, was closed in 1989. Los Alamos in its facility at TA-55, has now produced a developmental pit, and will soon be able to manufacture at a rate of 20 or perhaps 50 pits per year. I have long advocated a facility that would produce 300 pits per year, but the need for such a facility has nothing to do with a CTBT.

Opposition to the CTBT in part stemmed from a reluctance to accept any constraints on activities of the US, which is the world's preeminent military power. Specifically, one might want at some time in the future to design nuclear weapons for new purposes or optimize them for a different missile, and that cannot confidently be done and proved without nuclear explosion testing. Beyond that, it was argued that other powers might cheat, so that their explosions could not be detected or identified as nuclear explosions via the IMS, with its goal of detecting one kiloton of underground explosive yield anywhere in the world. Finally, there is the charge that one cannot in fact maintain the stockpile safe and reliable over the decades without nuclear testing either for finding problems or validating fixes.

Even in 1945, the US did not test its gun-assembled U-235 fission weapon before using it on Hiroshima, and a newly nuclear nation in 2000 probably would not need to test either. A conservative military establishment would probably desire a test of a gun-type weapon and certainly of a plutonium implosion weapon. Beyond that, even an advanced power would have difficulty being confident of a new-design two-stage radiation implosion system, such as that demonstrated by the US November 1, 1952.

As for cheating, the existing seismic array in Scandinavia readily detects explosions at the level of a few tons at the Russian test site in Novaya Zemlya, and could detect a fully-decoupled explosion in a large cavity at a level of 0.25 kilotons. A JASON Report to the Department of Energy notes that a yield of about ten kilotons would be required to accommodate the typical full-scale primary output and a telltale secondary yield. On balance, my personal testimony is that explosions that escape the IMS with high probability are not of military significance to the US. Even those who do see military significance in such small tests do not advocate US nuclear testing in return, so that is not properly a CTBT issue.

Weapons with fire-resistant pits and so-called insensitive high explosive (IHE) constitute a portion of the stockpile. Stockpile safety could be further enhanced by redesign. But in fact the armed services in the early 1990s explicitly rejected modifications that would require testing, even though 15 such tests were available under the US moratorium. So the remaining question is that of maintaining the stockpile reliable indefinitely. In addition to the component surveillance, US bombs and missile warheads are subject to Joint Test Flights, in which the plutonium is removed, but almost all of the rest of the warhead or bomb is exercised, right to explosion. These give vital information and will continue to be conducted. Even without a CTBT, they could not be conducted as nuclear explosion in the atmosphere under the Limited Test Ban Treaty of 1973.

The SBSSP will provide increasingly good knowledge of the performance of geriatric weapons, with deeper and deeper wrinkles. I have always recommended a much more conservative approach that would remanufacture weapons when their nuclear components began to exceed the range of parameters in newly manufactured weapons. Of course, all non-nuclear components such as radars, batteries, capacitors, etc., can be upgraded and fully tested as well under a CTBT as in the presence of nuclear testing. The problem comes down to whether the laboratories will have the discipline to reject modifications of processes in the manufacture of the nuclear components likely to impair confidence in stockpile reliability.

Richard L. Garwin

Do I have perfect confidence in the reliability of our stockpile? I have more confidence than I did in 1992 in the days of nuclear testing. A recent (November 8, 1999) Panel report on the reliability of the US nuclear stockpile, mandated by Congress, recommends *inter alia*, "To hedge against future uncertainties, the Stockpile Stewardship Program should include the ability to replicate or design replacement nuclear weapons, for our most critical nuclear systems, that will

- Have a long shelf life
- Be at least as safe as current weapons
- Provide a high degree of confidence that the weapons are acceptably reliable without full-scale nuclear testing
- Be manufacturable

But if such new-design weapons are mandated under a CTBT, that will surely cause a lack of confidence in the nuclear stockpile. One can clearly far more readily remanufacture weapons of existing type than certify weapons of a new design.

In summary, with a continuation of the long-standing stockpile surveillance program and the weapon manufacturing capability that is needed in any case, the enhancements to the program will provide a more reliable weapon stockpile than the United States has ever had in the past. It would be folly to reject the CTBT and thus fail to erect a barrier to the acquisition by others of effective thermonuclear weapons, in order to permit the US to make further improvements in its already highly advanced stockpile.

Richard L. Garwin is an IBM Fellow Emeritus at the Thomas J. Watson Research Center. He contributed to the development of fission fusion weapons beginning in 1950 at Los Alamos, and has been a consultant to the nuclear weapon laboratories to the present day. His testimony of 10/07/99 can be found online at http://www.fas.org/rlg.

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