APS NEWS

JUNE 1999 | THE AMERICAN PHYSICAL SOCIETY | VOLUME 8, NO. 6

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APS 100 years

celebrate a century of physics

Nobel Luncheon, Exhibits Inspire High School Physics Students and Teachers

Photo by Sweter Image

Above: Nobelist, teacher and student luncheon attendees.
At left: Students play with *Physics Works!* plasmasphere.

Dressed in their Sunday high school physics students and teachers from all around the greater Atlanta region and beyond gathered with more than 50 Nobel laureates in physics and chemistry for a special luncheon on Saturday, March 20, just prior to the APS Centennial meeting. The purpose of the event was to promote and highlight the importance of science education, and also to encourage high school physics students to pursue their scientific studies by providing an opportunity to meet and interact with preeminent scientists from around the world.

"The Nobel laureates get A+ on their warmth and cordiality to the students," said Mildred Sharkey, a former high school math teacher and educational consultant with the Center for Education Integrating Science, Mathematics and Computing, housed at the Georgia Institute of Technology. "The students were so nervous and excited, their hands were like ice, but the Nobel laureates did everything they could to make it a special time for the kids." Students attended from a 120-mile radius around Atlanta, some of whose parents drove three hours or more to ensure their children didn't miss the once-in-a-lifetime opportunity. As a memento of the occasion, each student and teacher received a signed certificate from the Nobel laureate assigned to their table, signifying a symbolic "passing of the baton."

No less a luminary than DOE Energy Secretary Bill Richardson specifically cited the luncheon as "a perfect example of how the lessons of science are handed down," in his keynote address on Monday afternoon (see *APS News*, May 1999). Recalling his boyhood passion for baseball, he said, "Something like the APS luncheon would have been like my meeting 50 Hank Aarons or Joe DiMaggios. They now have the experience of a lifetime, one that will fire their ambitions and imaginations for years to come."

Immediately following the luncheon, students attended the public opening of the W.F. Meggers Gallery of Nobel Laureates in the Georgia World Congress Center, containing historic autographed photographs of all physicists who have won Nobel Prizes. The exhibit also featured a brief history of the Nobel Prize and its founder, Alfred Nobel.

For those high school students and teachers who remained for other Centennial activities during the week, Monday, March 22nd, was the official opening of an interactive exhibit entitled, ***Physics Works! Exploring Nature, Saving Lives, Driving Technology.*** Still something of a work in progress, the exhibit is intended to "engage and inspire young people, get them excited about physics, and surprise them with the way it impacts on our daily lives," says exhibit curator Sara Schechner-Genuth. "The various elements were designed to explain crucial experiments and involve young people in the discovery process." Upon completion, the exhibit will travel to science museums and teaching centers across the country.

FACTAL

Nobel Laureates Who Received Funding from DoD Before Winning their Nobel Prize:

Physics (1950-1997): 43% of all US Nobel winners and 28% of all Nobel prize winners worldwide were funded by DoD.

Chemistry (1950-1997): 58% of all US Nobel winners and 27.5% of all Nobel prize winners worldwide were funded by DoD.

ONR alone funded 41 Nobelists.

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POPA Proposes Statement on What is Science?

The APS Panel on Public Affairs (POPA), concerned by the growing influence of pseudoscientific claims, has been exploring ways of responding. As a first step, POPA prepared a succinct statement defining science and describing the rules of scientific exchange that have made science so successful. The definition was adapted from E.O. Wilson's book, *Consilience*.

At its November meeting, the APS Council accepted the statement as a proposal to be shared with other scientific societies. It is hoped that the statement will serve to initiate a dialogue within the scientific community about the best way of dealing with the problem. In a letter to the Presidents of other societies, Past President Andrew Sessler invited comments on the statement. Some societies, including the American Association of Physics Teachers, have already endorsed it.

In his letter, Sessler remarked that: "Those of us fortunate enough to have chosen careers in science have an obligation to help non-scientists distinguish the genuine from the counterfeit...Our intention in this statement is to provide a template against which claims can be compared, not to see if they are right, but to see if they belong in the realm of science."

APS members are invited to comment on the proposed definition printed at right.

PROPOSAL: What is Science?

Science extends and enriches our lives, expands our imagination and liberates us from the bonds of ignorance and superstition. The endorsing societies wish to affirm the precepts of modern science that are responsible for its success.

Science is the systematic enterprise of gathering knowledge about the world and organizing and condensing that knowledge into testable laws and theories.

The success and credibility of science is anchored in the willingness of scientists to:

1) Expose their ideas and results to independent testing and replication by other scientists. This requires the complete and open exchange of data, procedures and materials.

2) Abandon or modify accepted conclusions when confronted with more complete or reliable experimental evidence.

Adherence to these principles provides a mechanism for self-correction that is the foundation of the credibility of science.

Accepted as a proposal by the Council of The American Physical Society 11/15/98

APS CENTENNIAL PHOTOGRAPHS ONLINE

The APS Centennial meeting in Atlanta, Georgia, March 20-26, 1999 was attended by 11,400 physicists, making it the largest physics meeting in history.

Highlights included the presence of more than 40 Nobel laureates, a talk by Stephen Hawking, the unveiling of the Centennial physics wall chart, an international banquet attended by physicists from over 60 nations, a series of public lectures on everyday physics, and numerous symposia and press conferences on some of the most important physics topics of the day.

A gallery of photographs from these events can be viewed at: http://www.aip.org/physnews/graphics/

To Advance & Diffuse the Knowledge of Physics

100 Years of the American Physical Society

Curator	Sara Schechner Genuth *Gnomon Research*	Researchers	George Trigg Ruth Kastner Steven Norton Amy Halsted
Exhibit Director	Barrett Ripin		
APS History	Harry Lustig	Exhibit Design	Puches Design Inc.
Journals History	R. Mark Wilson	Fabrication	Malone Displays

The American Physical Society was established one hundred years ago; the *Physical Review* six years before that. Together they have shaped and promoted physics research in the 20th century.

This is the second in a series of excerpts from this exhibit to be published in *APS News* throughout the Centennial year.

Next month: *Meeting and Journal Firsts*.

Special thanks also to: Barbara Gill, Debbie Brodbar, Alan Friedman, W. W. Havens, Jr., Margaret Malloy, Eugen Merzbacher, Charles Muller, and the staff of the Niels Bohr Library for valuable assistance with the exhibit.

Early Years of the *Physical Review*

The founding of the *Physical Review* predates that of the American Physical Society, although both arose out of the same ferment. In the 1890s, American physicists had no real niche for publishing their research. Editors of the *American Journal of Science* and *Journal of the Franklin Institute* cared little for physics. To rectify the problem, three Cornell University scientists established the *Physical Review* in 1893.

For the first few years, a disproportionate number of papers came from Cornell faculty. Authorship broadened with the journal's takeover by APS in late 1912. Improving standards for research in U.S. laboratories led to a surge in quality. By the 1930s, the *Physical Review* was unarguably the most important physics journal in the world. Citations to its articles exceeded those to *Zeitschrift für Physik*.

Founding Editors:

Edward L. Nichols, Ernest Merritt, and Frederick Bedell

Three Cornell physicists worked as a team to manage the *Physical Review* for two decades. Nichols was chief among them. As first secretary of APS, Merritt was instrumental in merging the activities of *Phys. Rev.* and APS.

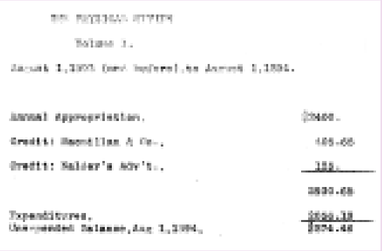
Merritt

Bedell

Photos from AIP Niels Bohr Library

First Funds

Cornell University appropriated $500 to start Phys. Rev. in 1893. The first budget is shown here.


Volume 1.
Expenditures.

Cornell University Archives

1999 Journal Budget $26,491,201

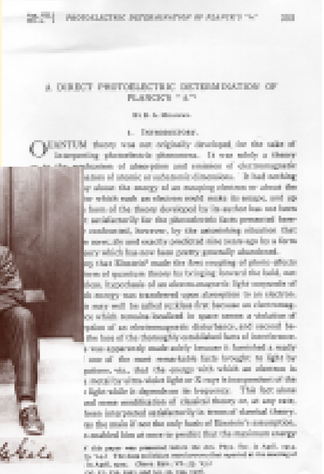
Rockefeller Hall

Home to the *Phys. Rev.* editorial offices on the campus of Cornell until 1926.

From the Early Physical Review*:*

Determination of *h* in 1916

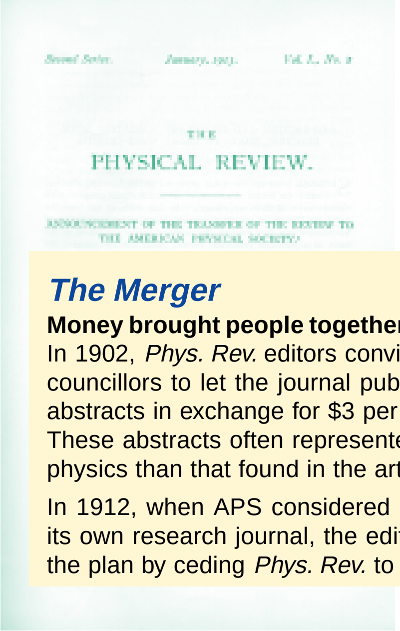
To verify Einstein's photoelectric effect and determine Planck's constant *h*, Robert Millikan required very pure materials. He devised a "machine shop in a vacuum" that enabled him to prepare a fresh, uncontaminated surface for every run.


A DIRECT PHOTOELECTRIC DETERMINATION OF PLANCK'S "h."

Millikan with Michelson, Kinsley, and Gale, circa 1910 (below).

AIP Niels Bohr Library

See http://focus.aps.org/v3/st23.html


Second Series. January, 1913. Vol. I., No. 1

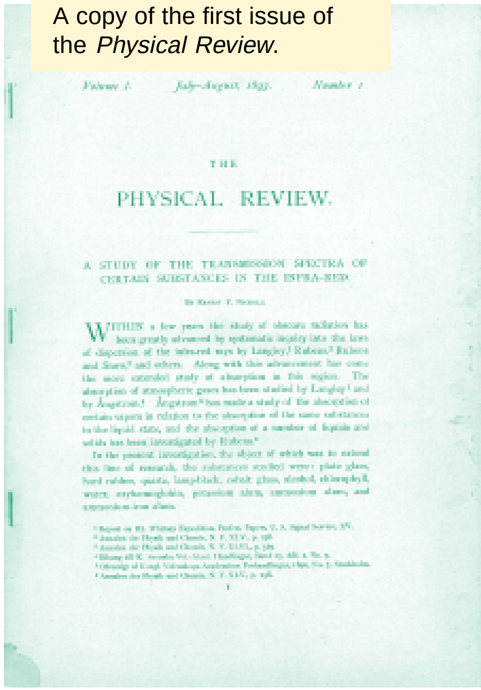
THE

PHYSICAL REVIEW.

ANNOUNCEMENT OF THE TRANSFER OF THE REVIEW TO THE AMERICAN PHYSICAL SOCIETY.

First Issue

A copy of the first issue of the *Physical Review*.


Volume I. July–August, 1893. Number 1

THE

PHYSICAL REVIEW.

A STUDY OF THE TRANSMISSION SPECTRA OF CERTAIN SUBSTANCES IN THE INFRA-RED.

The Merger

Money brought people together:

In 1902, *Phys. Rev.* editors convinced APS councillors to let the journal publish meeting abstracts in exchange for $3 per member. These abstracts often represented better physics than that found in the articles.

In 1912, when APS considered establishing its own research journal, the editors averted the plan by ceding *Phys. Rev.* to APS.

What Did We Publish?

Applied science dominated early issues of *Phys. Rev.*, but theoretical discussions were not shunned.

Letter from a 'typical' contributor:

Harry W. Fisher complained to Merritt of the pounding steam hammers close by his lab in 1895.

Cornell University Archives

APS News

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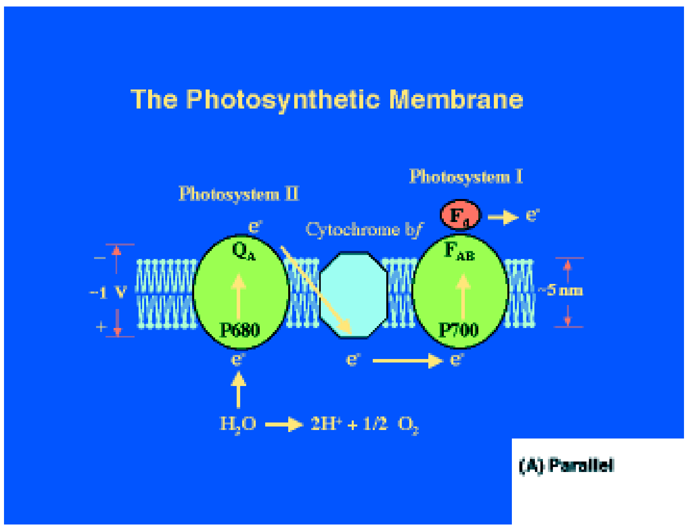
ORNL Breakthroughs Pave Way for Spinach-Based Electronic Devices

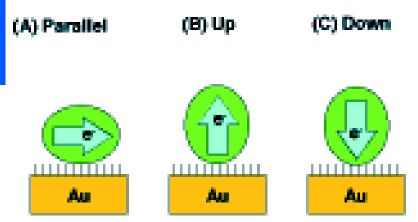
If a team of researchers at Oak Ridge National Laboratory (ORNL) has their way, the next generation of optoelectronic and logic devices may be based on spinach, not silicon. At the APS Centennial meeting in Atlanta, the scientists announced that they have discovered new methods to orient spinach leaf proteins — specifically, the photosynthetic reaction centers that convert electromagnetic (light) energy into stored chemical energy — in such a way as to enable their use for super-high-resolution video imaging, ultrafast switching, logic devices, and solar power generation.

The ORNL work is part of a burgeoning new field known broadly as molecular electronics, in which scientists attempt to use various biomaterials to perform complex functions that are difficult to achieve with other kinds of materials, such as semiconductors. "Natural materials have been optimized for these functions by billions of years of evolution and often perform them better than any human-designed material could," says Paul Kolodner, a researcher with Bell Laboratories/Lucent Technologies, who is seeking to exploit the natural electrochromic properties of the protein bacteriohodopsin for reflective flat panel displays. "Furthermore, organisms manufacture biological materials all by themselves — all we have to do is feed them and harvest the products." In contrast, the production of such devices as integrated circuits requires many time-consuming, high-precision and expensive manufacturing steps. In other work in this area, researchers at the University of Massachusetts, Boston, are investigating the use of chemically stabilized films of bacteriohodopsin in a polymer matrix for all-optical switching and modulation, while at Bell Labs/Lucent Technologies, efforts are geared towards the use of organic materials in smart pixel arrays for use in flat panel displays, and DNA computing (see below).

According to ORNL's Ida Lee, green plant leaves such as spinach contain two pigment protein complexes that perform photosynthetic functions, essentially using the Sun's energy to create plant tissue. The proteins are known as Photosystem I (PSI) and Photosystem II (PSII). The first step was to isolate the proteins from spinach leaves, using a common food processor to chop up the spinach and straining the pulp through a cheesecloth to separate.the juice, after which a high-speed centrifuge process is used to isolate the PSIs. The resulting substance is then tested for purity using a scanning tunneling microscope. Once isolated, the proteins can be rewired to produce fuels such as oxygen or hydrogen by metallocatalysis and photosynthetic water splitting. Isolated PSI reaction centers — naturally occurring photovoltaic and diode structures — can also be used to generate electrical current when provided with an electrical contact, which the researchers achieved by depositing platinum — a good electrical conductor — on one end of the protein, and anchoring it to a gold surface.

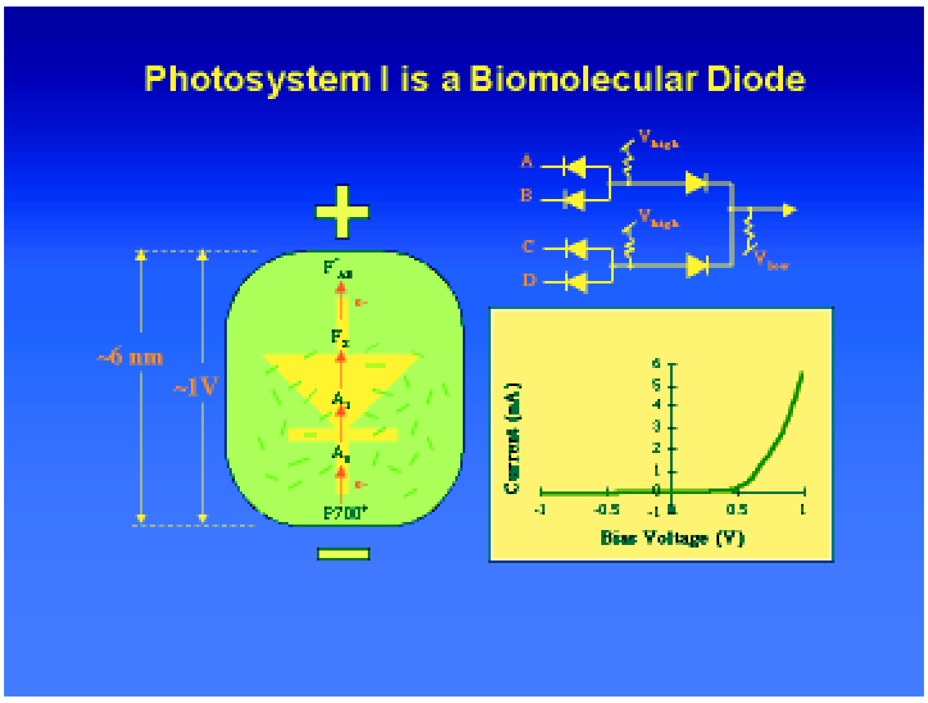
Critical to the potential of PSI for biomolecular electronic applications is the ability to arrange the proteins so that all the same ends point in the same direction, known as preferred orientation. The ORNL team accomplishes this by chemically treating the atomically flat gold surface on a mica substrate, achieving the best results with mercaptoacetic acid and mercaptoethanol. The sulfur atom in each chemical binds strongly to gold, and the negatively charged ends selectively bind to the positively charged ends of the PSIs, causing them to point in the same direction, says Lee, adding, "These experiments are the first demonstration that PSI can be isolated, platinized, and selectively oriented by chemical modification of a surface without denaturation."





Images from http://www.aps.org/meet/CENT99/vpr/laybc31-05.html

The ultimate goal, of course, is the feasibility of a "lean clean green machine" that operates without using fossil fuels, according to Marty Goolsby, manager of ORNL's Communications and Public Affairs division. "Such a machine could meet many DOE mission goals by generating electrical power, producing clean hydrogen fuel, and fixing carbon dioxide on a ruthenium film to produce methane fuel and reduce the atmospheric content of greenhouse gases," he says. "It could be a DOE dream machine."



Images from http://www.aps.org/meet/CENT99/vpr/laybc31-05.html

Computing with DNA

Within the area of organic molecular electronics, DNA computing is an emerging interdisciplinary field that unites computer science and molecular biology. Scientists create fragments of DNA, whose letters represent computer data and instructions, and mix them together in test tubes to solve problems, such as the shortest path through a number of cities. At the APS Centennial meeting in Atlanta, several researchers reported on recent advances that could one day enable the production of a DNA-based electronic device.

Allen Mills of Bell Labs/Lucent Technologies believes it is possible to use DNA to construct a massive neural network — computers modeled after the human nervous system — with a connectivity of 1 trillion synapses, still a mere 1% of the capacity of the human brain. According to Mills, hybridization of pairs of complementary DNA strands makes possible a representation of highly parallel selective operations that he believes could be one key to achieving molecular computation. However, significant undesired pairings of strands frequently result from small departures from the ideal selectivity of DNA hybridization, making it difficult to implement the large-scale Boolean operations necessary for DNA-based computing. Neural networks, which do not require the same high precision as digital computing, offer a promising solution, especially when combined with new rapid techniques for the interconversion of digital and DNA data. Mills' design could also be configured in more general architectures for solving problems of prediction and classification.

Adopting a loftier, theoretical approach to the issue, Simon Berkovich of George Washington University speculates that DNA in a biological organism serves a role comparable to a barcode: it is a pseudo-random number (PRN) that provides classification, so that small differences are enough to distinguish between species. It also provides a unique ID number that is responsible for the biological individuality of an organism. "With this hypothesis, the essence of the phenomenon of Life unfolds as extracorporeal information processing in the infrastructure underlying the physical world," says Berkovich. The corresponding PRN enables biological cells to interact through this infrastructure by sharing its storage and bandwidth resources in a Code Division Multiple Access (CDMA) mode. According to Berkovich, the differences in the behavior of dead and living matter results from differences in the sizes of molecules involved, which affect PRN lengths. A short PRN can pick up only noisy background, while a lengthy PRN can sustain a robust information exchange. Thus, "The macromolecules of the DNA can serve as CDMA transreceivers for interaction with the infrastructure of the physics world, and as microtransducers materializing the control signals into purposeful biological events," he says.

LLNL Researchers Demonstrate Fusion on a Tabletop

A team of researchers from Lawrence Livermore National Laboratory (LLNL) have converted laser energy into ion kinetic energy to produce nuclear fusion reactions between deuterium atoms on a laboratory tabletop. Speaking during a packed symposium at the APS Centennial meeting in Atlanta, group leader Todd Ditmire unveiled the device.

Normally fusion research requires the energy of massive lasers, or complex vaccum chambers using superhot gas confined within magnetic fields. The $1 billion stadium-sized National Ignition Facility being built by LLNL is expected to be the world's largest laser, producing bolts of nearly two million joules of energy on a fuel capsule. Ditmire's laser cost less than $1 million. However the number of fusion neutrons produced by Ditmire's device is quite small compared to most large-scale laser fusion experiments.

The LLNL achievement was made possible by the many studies in recent years of how extremely intense pulses of light interact with matter. By amplifying laser pulses with very short temporal durations, ultrahigh intensity studies have become possible with lasers on a tabletop scale. For example, says Ditmire, "These unique lasers can now produce light pulses that are only 20 femtoseconds in duration and, when focused, can produce light intensity above 10^{17} watts per square centimenter. The last four years in particular have yielded numerous investigations on how such intense pulses of light interact with small balls of atoms ranging in size from 10 to 10,000 atoms per ball, an assemblage known as an atomic cluster. When subjected to very short pulses of high-intensity laser light, these clusters eject very fast ions with energies of many tens of thousands of electron volts, corresponding to ions with temperatures ranging up to 1 billion degress Celsius.

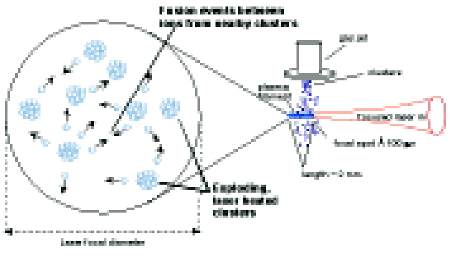


Image courtesy of Ben Stein/AIP

In their experiment, Ditmire and his LLNL colleagues focused an intense 35 femtosecond laser pulse to an intensity of about 10^{17} watts per square centimeter into a jet of ionized gas containing many clusters of deuterium molecules.

Although the fusion reactions achieved by the LLNL team did release energy, the total was only about 10 millionths of that consumed by the laser. Ditmire believes that the experiment could lead to the production of small-scale, high-repetition rate, affordable neutron sources. Neutron sources are used in a variety of applications, including neutron radiography and materials science studies. Future work will attempt to increase the yield of the fusion neutrons to usable levels.

OPINION

Truth, Justice, and the American Way

The Intersection of US Security and the Universality of Science

Irving A. Lerch, APS International Affairs

"Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world. Science is the highest personification of the nation because that nation will remain the first which carries the furthest the works of thought and intelligence."

—Louis Pasteur

In stentorian 19th century tones, Pasteur expressed anew sentiments first promulgated in the 16th century by the philosopher-politician Sir Francis Bacon and given cogency in the 20th century by philosopher-scientists Thomas Kuhn and Michael Polanyi: that science is a collective enterprise which flourishes in an environment of open, unfettered exchange.

But the 20th century has amplified another aspect of science that is equally cogent: science is the raw material of immense national power—economic and military. The battle for the soul of American science is epitomized in a question: How do we protect the national interest while nurturing the very source of our nation's strength? The science that built the first atomic bomb was born in the minds of physicists, chemists and engineers from the US, Germany, Italy, Hungary, the UK and elsewhere. In addition, fully 80% in the growth of our economy is technology driven, much contributed by immigrants and visitors to our nation's research universities and government and industrial laboratories. This was illustrated in our March Centennial meeting in Atlanta: of 48 awards and prizes, 17 were given to naturalized US citizens, 10 to foreign colleagues (many of whom studied and worked in the US) and 21 to US born citizens (many of whose parents and grandparents emigrated to this country in the years between the world wars).

The post-Cold War debate now focuses on the intersection of the globalization of science, our national security and halting the spread of nuclear weapons technologies. The controversy engulfing the Los Alamos weapons lab concerning the alleged loss through espionage of nuclear weapons secrets threatens to throttle the exchanges which have so benefitted the non-defense research of all Energy Department labs. And while Energy Secretary Bill Richardson has promised to fight calls to close the labs against foreign visits [See *APS News*, May 1999, p.1], recent hearings on the Hill along with proposals for extreme security measures have soured the climate. One colleague in a non-weapons lab complained that many visitors—all of whom are invited—were being treated like "criminals."

Equally troubling has been the increasing use of the technology transfer provisions of the Immigration and Naturalization Act to curtail the granting of visas to visiting scientists and students. The "Glenn Amendment"—enacted into law to prevent the spread of weapons technologies—is being used to curtail visits by Indian and Pakistani scientists even though applicants are not known to be involved in weapons programs and their specialties have no discernible applications in weapons design. The enforcement of this law required the publishing of an "entities list" of institutions deemed to have played a role in the development of nuclear weapons. All applicants with ties to these institutions—which encompasses the entirety of the elite scientific establishments of India and Pakistan—must be reviewed by an interagency task group in Washington, DC. The result is that a number of students and scientists have been denied entry. At the same time, the DoE has barred the travel of Department scientists to India to attend purely scientific meetings.

The impact on students can be devastating. Last summer, a young assistant in the Nehru Center for Advanced Scientific Research, was denied a visa to take up graduate studies for a PhD degree at Stanford University. His chosen field is condensed matter theory. He was denied a visa owing to the INA technology transfer provisions because at the time, he was a temporary employee at the Indian Institute of Science (one of the institutes on the "entities list" whose campus includes the Nehru Center). This promising young scientist will probably pursue his studies in Canada or Europe.

In March, a Chinese physicist invited to visit Northwestern University was delayed several weeks in obtaining a visa. Upon inquiry, the local Congresswoman, Janice Schakowsky, was informed by the Consul in our Tokyo embassy: "Applicants who are nationals of the Peoples Republic of China, and who will be involved in an activity related to materials technology, need an advisory opinion from the State Department before we can issue a visa." This includes the largest category of Chinese scholars—one that accounts for thousands of students and researchers. Widely applied, the policy could desolate important areas of US research. The theory of this provision of the INA is that such visits result in a hemorrhage of US technology. The reality is that the talent and industry of such visitors contributes to the advance of the US—and the worldwide—technology base.

Such visa reviews often delay travel beyond the date of the meeting they seek to attend. This was the case in March when a distinguished Chinese physicist sought a visa to participate in the General Assembly of the International Union of Pure and Applied Physics convened in Atlanta the week before the Centennial.

Very disquieting is the growing perception that certain visitors, immigrants and their descendants constitute a danger to the US. The Los Alamos imbroglio which has incriminated a Taiwanese-born American, has led newspapers around the country to impugn the patriotism and loyalty of Chinese-Americans, a deplorable reminder of the war-time hysteria which sent Japanese-Americans into internment camps during World War Two. As we all must acknowledge, Chinese-Americans have made a glorious contribution to our culture, science, technology and security and it is shameful and unjust to claim otherwise.

We have an obligation and a duty to assure our national security and to prevent defense secrets from falling into unfriendly hands. Many of us have served in our armed forces and know the terrible cost to be borne in maintaining our liberties. But we can never achieve our objective of safeguarding our security and increasing the knowledge infrastructure on which that security and our prosperity is founded by shackling and isolating our science. It is too easy to succumb to timidity and opt for the cheap way out—to accept the illusion that it is better to live safely in a prison than to toil diligently in the open air.

"As long as men are free to ask what they must, free to say what they think, free to think what they will, freedom can never be lost and science can never regress."

— J. Robert Oppenheimer

LETTERS

Quoteworthy Science Misquoted

In the April issue of the *APS News*, J.Robert Oppenheimer is given credit for a quote that he himself took from an Indian source, the Bhagavad Gita. Does anyone find it a bit interesting that the "The Bhagavad Gita" originated in India. Oppenheimer quoted the following excerpt upon the first atomic weapon exploding at the Trinity site in Alamagordo, New Mexico, USA: "If the radiance of a thousand suns were to burst at once into the sky that would be like the splendor of the Mighty One... I am become Death, the Shatterer of Worlds."

Wayne Saslow
Texas A&M University

zero gravity

Good News for American Physicists

by Scott Sandford

While reading the latest issue of *APS News*, it struck me that a significant portion of each newsletter was devoted to awards, in the form of articles about those who recently received awards, notifications about fast-approaching nomination deadlines for awards, and announcements of new awards that are just being instituted. Out of curiosity, I connected to the APS Web page and discovered a very well-organized series of pages that provides excellent information about the number and history of the various awards sponsored by the APS.

Figure 1 shows a plot of the number of awards sponsored by the APS as a function of time over the 1950 to 1999 interval. It is apparent that the number of prizes and awards has been increasing monotonically since 1950. In an attempt to predict the trend of increasing awards into the future, I have fit the 1950-1999 award data with both a third-order polynomial function and an exponential function. Both provide reasonable fits to the data, although the third-order polynomial provides a slightly better R value.

Figure 1

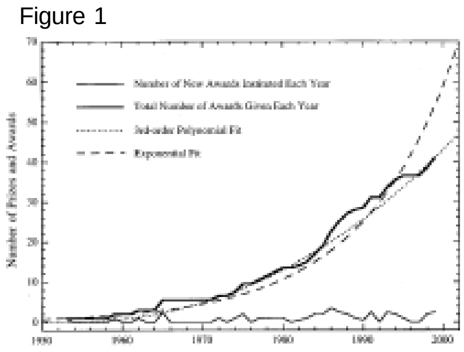
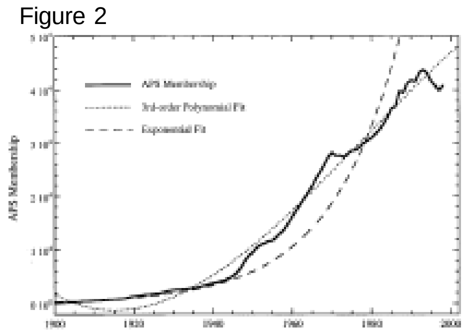


Figure 2 shows a similar plot of the total APS membership as a function of time over the 1900 to 1999 time interval, along with the results of similar curve fits. Again, the third-order polynomial provides a better fit than does the exponential, but both provide better R values than I have seen presented with confidence at scientific conferences.

It should be noted that, other than awards, one of the main topics that fills the pages of *APS News* is the current "glut" of physicists in the world market and the consequent difficulty that new PhDs are having finding jobs doing physics. As a result, it is possible that the APS membership may be leveling off.

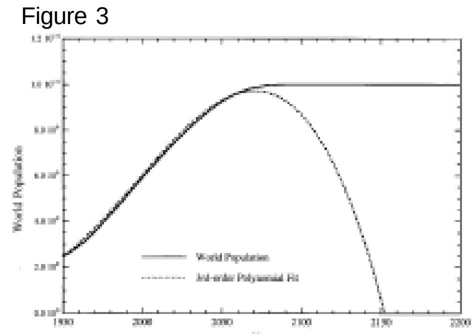
Figure 2



There is some evidence for this in the few years of the APS membership data plotted in Figure 2. Thus, in addition to the extrapolations provided by equations 3 and 4 above, a third possible "extrapolation" of the APS membership into the future would be to assume it maintains a steady value near its current number, i.e., of order 40,000.

Finally, Figure 3 shows a plot of the world population as a function of time over the 1950 to 1998 time interval, along with current estimates of the world's future population. Current UN estimates are that the Earth's population will begin to level off by the year 2050 or so, but estimates of the final value vary from 7.9 to 11.9 billion. In Figure 3, and for the analysis that follows, I will use a value of 10.0 billion. Examination of these three sets of extrapolations, APS awards, APS membership, and world population leads to some startling revelations.

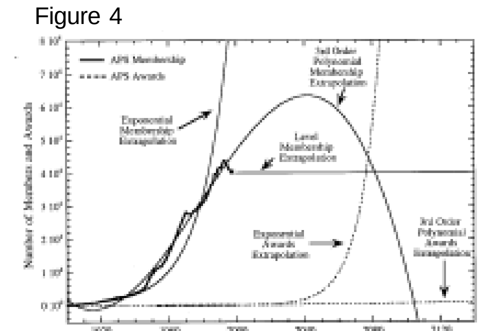
Figure 3



SCENARIOS

Third Order APS Awards and Third Order APS Membership. Since the best fits to the APS membership and award numbers were provided by the third-order polynomial fits, one expects that they provide the most likely future outcomes. As can be seen in Figure 4, the extrapolated numbers of APS members and awards cross around January 1, 2104. At this point, APS members will be receiving, at least on average, one

Figure 4



award per year and the APS will have 611 members. Sadly, in this scenario, the number of APS members drops to zero on April 9th of the same year, so every APS member gets an award in 2104, and then packs up his or her office and goes home. On the bright side, by the year 2040, the number of APS awards will already exceed 1500 per year, a

Continued on page 5

Bell Labs Reports on Progress Towards "Dick Tracy" Watch

Fans of the Dick Tracy watch — a two-way, voice-activated video phone that fits around a wrist, introduced in a Jan. 13, 1946 edition of the famous comic strip — will be thrilled to hear that the device may soon become a technological reality. According to Peter Gammel, a researcher at Bell Labs, such a device contains many of the features one would like to see in portable wireless devices, including voice instruction, video capability, seamless operation and an attractive physical design. At the APS New York State Section meeting held April 20-21 at Bell Labs/ Lucent Technologies in Murray Hill, NJ, Gammel described three research results which are aiding in bringing this vision closer to fruition, estimating that all the necessary components should become technologically available as early as 2005.

The first involves the development of miniature radio frequency filters. In current cell phones, the radio filter, made of a ceramic material, is by far the largest single component. In a second effort, silicon micromachining, a state of the art approach for making silicon materials with microscopic features, is used to incorporate the microphone onto a silicon integrated circuit, another step towards the single chip radio. A third effort also involves the use of silicon micromachining, this time to fabricate high quality inductors. Inductors, which are simple loops of wire, are used in part of a cellular phone which determines the proper frequency for communications. "It turns out the battery life of a cell phone is determined by a measurement in the inductors known as the 'quality factor,'" says Gammel. "High quality factor inductors, such as the ones we are making, can lower the demands on the battery, another step towards a real-life Dick Tracy watch." (For graphics, see www.aip.org/ physnews/graphics.)

Other scientists who gave invited lectures at the meeting covered such topics as optical micro-machines and plastic transistors. [The talks — which were free and open to the public — were designed for non-experts.] Marc Kastner of MIT described recent work on the Single Electron Transistor (SET), a new kind of device that turns on and off every time one electron is added to it, compared with the transistors currently used in cellular phones and laptop computers, which require about 1,000 electrons to turn on and off. "While some researchers are struggling to make these transistors commercially viable, we physicists are using them as laboratories for studying how electrons behave when they are confined to dimensions only about 200 times larger than the size of individual atoms," he said, describing experiments which demonstrate that the electrons in the SET settle into an unusual quantum state at very low temperatures, similar to the behavior of electrons on magnetic impurities in metals.

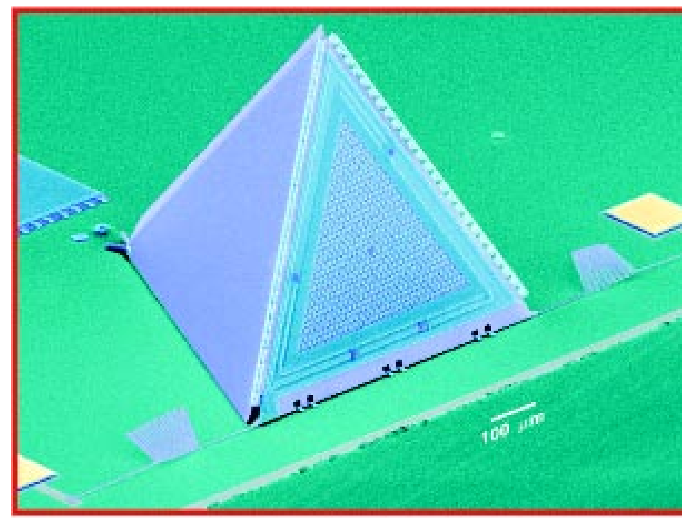


Figure courtesy Bell Labs/Lucent Technologies.

Using silicon micromachining, a state-of-the-art approach for making silicon materials with microscopic features, Peter Gammel and his colleagues at Bell Labs/Lucent Technologies in New Jersey built a microphone on a silicon integrated circuit, shown above. The base has marks with an approximate size of just 100 microns (0.1millimeters).

Another Bell Labs researcher, Zhenan Bao, reported on the developing of electronic devices known as MISFETs—metal-insulator-semiconductor field-effect transistors—made of thin-film and organic components. Organic thin-film MISFETs are potentially useful not only as large area flexible displays (especially for ultrathin TV screens) but also as low-cost memory devices. Some proposed applications for plastic transistors are: driving circuits for electronic papers, luggage tags, price tags, and smart cards. "Plastic transistors are not intended to replace silicon devices, but rather they offer opportunities for low cost flexible large area devices," said Bao.

Zero Gravity, *continued from page 4*

point at which every APS member can reasonably expect to receive at least one award during his or her career. Thus, under this scenario, the years 2040 to 2104 look to be bright for American physicists.

Third Order APS Awards and Exponential APS Membership. This scenario is perhaps the least favorable for physicists of the future. A quick examination is sufficient to determine that, under these unconstrained conditions, the number of APS members and awards never cross, and there is no expectation of every physicist receiving an award every year, as occurred in the earlier case. Indeed, the number of members pulls rapidly away from the number of awards, and the fraction of APS members who receive awards rapidly drops towards zero. This unconstrained case is unlikely, however, since it predicts that the mass of American physicists will exceed the mass of the Earth sometime around the year 2725 AD. In reality, the number of APS members must ultimately top out when it reaches the total world population. According to the extrapolated world population given in Figure 3, this should occur around April 16, 2200. At this point, with the APS membership leveled out at 10 billion, the third-order increase in awards will begin to overtake the membership and the two eventually cross on April 20th of the year 54199 AD. At this point, every APS member, i.e., the entire world's population, can expect an average of at least one APS award per year.

Third Order APS Awards and Level APS Membership. The outcome is significantly happier if one assumes a future APS membership that levels off at its current value of order 40,000. In this case, the number of APS awards crosses the APS membership extrapolation on July 24th, 2711, at which point the APS membership is, of course, 40,000. Under these conditions, the one-member-one-award-in-one-year point takes an additional 607 years to occur compared to the first scenario, but it has the advantage that we don't all have to go home four months later.

Exponential APS Awards and Third-Order APS Membership. This is one of the most favorable scenarios for American physicists. In this case, the number of awards quickly overtakes the number of APS members, and every APS member can expect an average of at least one award per year, starting on August 4th of the year 2077. Also, in this case, at least some of the membership will be able to enjoy their awards for almost 27 years before the Society becomes defunct.

Exponential APS Awards and Exponential APS Membership. This scenario yields a cross-over of membership and awards on October 5th of the year 2264, at which point the APS would be distributing about 4 x 10^{11} awards per year. However, as discussed earlier, this cross-over date ignores the fact that the APS membership will have topped out at — and become equal to — the world population of 10 billion in the year 2200. The exponential extrapolation of APS awards reaches the 10 billion value on July 24th of the year 2221, at which point every APS member will again be receiving an average of one award per year.

Exponential APS Awards and Level APS Membership. This is probably the best scenario for APS physicists as the exponentially increasing number of awards rapidly overtakes the number of APS members and leads to a one-member-one-award-in-one-year point on April 13th, 2076. This is slightly more than a year before the cross-over point predicted by the scenario that uses exponentially increasing awards and a third-order polynomial membership, and it has the added advantage that the APS survives into the next century. The biggest concern may be where to store all the awards, since this case predicts that every APS member will be receiving more than 307,000 awards per year by the year 2100 AD.

Happy Conclusion

Despite the current difficulties associated with new physicists finding employment, the future career prospects of APS physicists looks bright. In all the cases considered, APS physicists can expect their future careers to be very rewarding (or at least very awarding). However, one sole note of caution remains: The APS membership should beware the spectre of the "terminal negative third-order coefficient."

Scott Sandford is a physicist in Santa Clara, California. The above was adapted with permission from an article in the ***Annals of Improbable Research*** *[March/April 1999]. The original article has been reposted online in honor of the APS Centennial at http://www.improbable.com.*

INTERNATIONAL DESK

International Roundtables Address Global Exchange, Collaboration

Taking advantage of the plethora of foreign physicists from around the globe who flocked to the APS Centennial meeting in Atlanta, Georgia, in March, APS Committee on International Scientific Affairs (CISA) and the APS Department of International Scientific Affairs organized four roundtable discussions held on Sunday, March 20th. The panels addressed such topics as the potential of virtual laboratories for research collaborations, promoting international research and educational collaboration, the international role of individual physical societies, and the implications of science and technology for accelerating research capabilities and economic growth in developing countries.

Virtual Laboratories and Collaborations

Facilitated by James Vary (University of Iowa) and Galileo Violini, the roundtable on virtual collaboration included participants from South Africa, El Salvador, Croatia, Sri Lanka, Lithuania, the Ivory Coast, the Czech Republic, Italy and Chile. Vary used the summary of a report on *The Virtual Laboratory: Electronic Support for Cooperative Scientific Research*, as a starting point for the discussion. (A copy of the report is available at http:// www.iitap.iastate.edu/reports/vl.) There was a general consensus that the Virtual Laboratory (VL) approach offered promising opportunities for international collaboration in scientific research and education, especially for bridging the gap between developing and developed countries. However, there was emphatic agreement that a prerequisite for meaningful international cooperation is a strong national science program.

One major advantage of VL is the possibility of video conferencing since facial expressions and body language can contribute significantly to better understanding than conventional email and telephone conversations. VL could also become an important tool inteaching introductory laboratory science, helping junior researchers avoid isolation, and being better able to continue research at a distance. But the participants believe that personal contact is still essential. Many believe that "hands-on" experience is essential to learning introductory laboratory science, and hence feel that junior researchers should have strong exposure to "hands-on" experiences before going into a remote mode of research.

Recommendations arising from the discussion included the suggestion that national facilities, including computational facilities, adopt a policy towards greater international collaborations and thereby increase their effective use for first rate science. Greater promotion of capacity building to enable strong national science programs as the fundamental basis of international cooperation is also needed, along with the promotion of more international exchanges of scientists, not limited to conference participation but including longer term bi-directional exchanges and participation of post-docs.

International Role of the Physical Societies

Another roundtable focused on the international role of physical societies in various countries, organized by Shang-Fen Ren, president of the Chinese Physical Society. While more than 25 scientists participated in the general discussion, the seven featured speakers represented societies from a wide range of geographical areas.

Participants identified current problems of particular concern as: decreasing enrollments in physics courses; decreasing funding to physics; the growing unwillingness of Engineering Departments to have physics courses taught by faculty from the Physics Department; and the responsibility of physicists regarding nuclear weapons

Continued on page 6

FESTIVAL PROFILE

Loving and Leaving in the Subatomic World

Playwright Matthew Wells (inset, left) following the world premiere of his play, *Schrödinger's Girlfriend.* (below) Cast members are all smiles after a successful performance: Whitt Brantley and Georgia Ribeau (top right corner) were joined by (from left) Hope Mills, Jen Apgar, Bill Murphey and (front) Jim Roof.

New York playwright Matthew Wells deliberately kept his expectations low for audience turnout at the world premiere of his play, *Schrödinger's Girlfriend*, presented as a staged reading in the Georgia World Congress Center during the APS Centennial meeting in Atlanta. He knew there would be scheduling conflicts and competing special events, not to mention the lure of Atlanta restaurants and night life, to distract conference goers from the event, and figured if 20-50 people showed up, he could deem the evening a success.

But when the lights went down, Wells was astounded and gratified to find the room filled almost to capacity with roughly 200 in attendance. And it was a decidedly appreciative and responsive audience, laughing and clapping enthusiastically throughout the 90-minute performance. "It was a unique group of people who were listening," says John Cairney, a microbiologist at the Institute of Paper Science and Technology in Atlanta by day and semi-professional actor and director by night, who was tapped to cast and direct the reading. "They were informed and erudite and cultured, but also had the specialized knowledge of physics that enabled them to get the jokes."

Wells first conceived of *Schrödinger's Girlfriend* a few years ago and submitted the idea to the Sloan Foundation, which was looking for original plays with scientific themes at the time. Although he didn't receive funding for the project, the foundation referred him to the APS' Brian Schwartz, who was organizing the Centennial-related Physics Festival and looking for a science-based theatre piece. Once committed, Wells wrote the entire play in about a month and forwarded the draft to Cairney, who essentially pulled the entire production together in three weeks, aided by what he describes as "a very fine group of actors. They were instantly able to recognize what Matthew intended and embellish upon it."

Schrödinger's Girlfriend is best described as "Einstein meets 'The Blue Angel,'" according to Wells, referring to the 1930s German film starring Marlene Dietrich as a husky-voiced cabaret singer — an abstract, burlesque romantic comedy "in which Love obeys the crazy laws of subatomic physics." Physicist Erwin Schrödinger is grappling with the logical absurdities that govern subatomic behavior when he meets the maddeningly unavailable Hansi Haas, a cabaret singer with a knack for theoretical physics who counts Einstein, Niels Bohr and Max Planck among her many admirers. Schrödinger soon succumbs to her charms as well, until Hansi leaves him for yet another physicist: Paul Dirac. It is while plotting his revenge that the devastated Schrödinger eventually realizes that the truth of love — as long as you don't ask the question, the answer can always be yes — is also a truth of quantum physics, and creates the famous thought experiment that bears his name: Schrödinger's Cat.

Despite the esoteric content of the play, Wells himself has no formal education in science beyond the standard high school courses, although he does confess to a long-standing interest in the subject, beginning in the 1970s when he read a biography of Einstein. "I could never get into the math, but I found the concepts behind it, the visuals and analogies, fascinating," he says. His interest in the theater also began in high school, with a "very watered down" version of Henry Fielding's *Tom Jones*. Wells and his fellow cast members chose to ad-lib large portions of dialogue, with Wells feeding some of the best witticisms to various performers. "I realized, in my 17-year-old arrogance, that I could probably write my own plays," he says, adding, "It was another 10-15 years before I started writing anything that was actually any good."

Wells has had a few other plays produced Off-Off-Broadway in New York City, and *Schrödinger's Girlfriend* was performed as yet another staged reading in April, at the Ensemble Theatre Studio. While also a success, Wells confesses that the audience response wasn't quite as knowing as the physicists in Atlanta. However, "The main reason the APS performance was such a success was because of John Cairney and his expert choice of actors," he says. "They walked into it with very little rehearsal and made me look like a genius."

Rush Holt Presented with APS Fellowship at Congressional Reception

Freshman Congressman Rush Holt (D-NJ), former assistant director of the Princeton Plasma Physics Laboratory, was honored as a new APS Fellow at a special Congressional reception in Washington, DC, in April, in which Centennial timeline wall chart was displayed in the Rayburn Building. He was cited "For advancing the health of science in the U.S. through important contributions to plasma physics research, public science education reform, and public service."

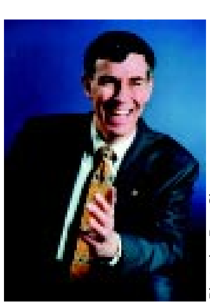


Photo by Ron Sherman

On hand to witness the occasion and offer brief comments were such luminaries as Holt's fellow Congressman and APS fellow, Vernon Ehlers (R-MI), Martha Krebs, director of the DOE Office of Science, and Joe Dehmer, head of the NSF Physics Division, as well as APS President Jerome Friedman (MIT). Both the DOE and the NSF reprised their Centennial exhibits at the reception, and NSF had several graduate students and young investigators on hand to explain their research projects.

Entitled *A Century of Physics*, the timeline consists of a series of posters narrating and illustrating the history of physics in the 20^{th} century, presenting an historical and cultural context for may key discoveries and inventions that define the modern era and provide a glimpse of the scientific and technological achievements of the future. Officially unveiled at the APS Centennial meeting in March (see *APS News*, May 1999), the wall chart was produced with support from the DOE, NSF, IBM, the Richard Lounsbery Foundation, Lucent Technologies, and United Parcel Service. It is being sent with an accompanying teacher's guide to every high school and college in the US, and is also available on the Web: [www.timeline.aps.org/APS/home_HighRes.html]. Reception attendees had the opportunity to preview the online version of the timeline firsthand at a special terminal set up for the occasion.

Holt, who has long been active as a volunteer in APS outreach activities, decided to run for Congress because of his growing distaste for what he viewed as political infighting and a growing mean-spiritedness in the 104^{th} and 105^{th} Congress. The result was a surprise upset over the incumbent, Republican Michael Pappas. But he is no neophyte when it comes to Capitol Hill, having worked in the early 1980s in the office of Congressman Bob Edgar as a science, defense and education advisor, as well as advising on arms control issues during the Bush administration. A strong supporter of substantially increased research into alternative energy sources and increased R&D funding, Holt believes it is critical that there be more scientists in Congress. "A scientific background is important for understanding the limitations of some policies," he told the APS Forum on Physics and Society newsletter in January. "Scientists are in a position to define what is possible. There are examples where policy makers promote programs that essentially are prohibited by the laws of science."

Roundtable, *continued from page 5*

issues. One potential source of these difficulties was deemed to be the longstanding arrogance of physicists. There is also a great need to modify the existing physics teaching curriculum, finding ways to make physics courses more accessible to stem the emigration of potential physicists into engineering disciplines — perhaps by including more emphasis on practical problem solving.

Finally, it was noted that economists have shown the positive connection between basic R&D and the economy; investment in the former usually leads to a phenomenal return to the latter. The participants affirmed the ongoing need to keep working on this connection repeatedly with politicians responsible for establishing national science policy.

Promoting International Research and Educational Collaboration

Coordinated by Ivan Schuller of the University of California, San Diego, this roundtable on promoting international research and educational collaboration had approximately 40 international participants with a cross section from national labs, universities and industrial labs. After considerable discussion, the participants first and foremost reaffirmed the importance of motivation behind scientific and educational operations, namely, that these should be driven by real scientific and educational needs, and not by high-level bureaucratic decisions. Furthermore, the primary role of such programs should be to facilitate interactions between individual scientists, not to create new programs and bureaucracies which may or may not be needed.

Nevertheless, the discussants recognized the inherent difficulty in seeking to apply general rules to guide cooperations, since these depend strongly on the particular countries, areas of research, and individuals. They identified many existing programs with funding already in place for improving international collaborations. It was suggested that the APS attempt to centralize the current information of available funding sources via its website to aid foreign scientists seeking collaborations in locating such sources. In addition, the participants felt that the APS should make an effort to publicize the availability of this information through advertisements in journals and magazines such as *Physics Today* and *APS News*.

Science and Technology: Implications for Accelerating Research Capabilities and Economic Growth in Developing Countries

Kennedy Reed of Lawrence Livermore National Laboratory led a roundtable discussion on science and technology, focusing on its implications for accelerating research capabilities and economic growth in developing countries. Participants included American scientists who had some experience with science and technology in developing countries and scientists from developing countries of Senegal, Algeria, Taiwan and Brazil. "Each of these had an interesting perspective on how science and technology can impact economic growth in developing countries, and each had interesting perspectives on how interaction with the European and American scientific communities can accelerate the growth of science and technology in developing countries," says Reed.

Physicists Honored with DAMOP, Shock Compression Awards

Three physicists were honored recently with awards from the APS. Brett Esry and Jens Nöckel, both recent PhDs, were selected as co-recipients of the Award for Outstanding Doctoral Thesis Research in Atomic, Molecular or Optical Physics during the APS Centennial Meeting in Atlanta. And Lynn M. Barker of Valyn International has been selected as the recipient of the 1999 Shock Compression Science Award, to be presented during the Shock Compression of Condensed Matter meeting in Snowbird, Utah, later this month.

1999 SHOCK COMPRESSION SCIENCE AWARD

Lynn M. Barker
Valyn International

Citation: "In recognition of his outstanding contributions to the temporal measurement and interpretation of nonlinear physical processes in shock-compressed matter."

A former U.S. Navy carrier pilot in the Korean War, Barker earned his MS in physics from the University of Arizona in 1955 and subsequently completed a year of post-graduate studies at Columbia University in 1962. He spent 27 years at Sandia National Laboratories, making important innovations in time-resolved shock-wave instrumentation, and applying new techniques for measuring the dynamic properties of condensed materials. From 1974 to 1981 he was a senior staff consultant with Terra Tek in Salt Lake City, Utah, developing a new fracture toughness test method. Since 1990, he has been president of his own company, Valyn International, where he continues to contribute innovations to the VISAR shock wave instrumentation techniques he pioneered in the 1970s.

1999 DAMOP THESIS AWARD

Brett Esry
Harvard-Smithsonian Center for Astrophysics

Citation: "For his thesis entitled, Many-body effects in Bose-Einstein condensates of dilute atomic gases."

Esry began studying atomic physics as an undergraduate at Kansas State University and graduated with a BS in 1993. He continued his studies in atomic physics as a graduate student at the University of Colorado, working with Chris H. Greene at JILA.

While at JILA, Esry collaborated on a number of problems outside the scope of his primary thesis work, the many-body theory of Bose-Einstein condensation. These additional problems included a study of Efimov states in the helium trimer, double photoionization in helium, ultracold atomic collisions, and aspects of the decay of metastable ionic molecules.

Upon receiving his PhD in 1997, Esry became a postdoctoral fellow at the Institute for Theoretical Atomic and Molecular Physics. His current research interests include few-body problems and time-dependent phenomena as well as Bose-Einstein condensates. This fall he will return to Kansas State University as an assistant professor.

Jens U. Nöckel
Max-Planck Institut für Physik komplexer Systeme, Dresden, Germany

Citation: "For research in the emission properties of assymmetric dielectric resonators with chaotic ray dynamics."

Born and raised on the German island of Helgoland, Nöckel had his first encounters with science through summer jobs at the island's ornithological and marine biology laboratories. He enrolled in physics at Hamburg University in 1986, and spent a year at Oregon State University in Corvallis as a graduate exchange student.

He completed his German Diploma degree in Hamburg with a thesis on magnetotransport in semiconductor microscstructures before beginning PhD studies at Yale University in 1992. He initially worked on electronic transport theory before switching the focus of his thesis research to micro-optics in deformed dielectrics, graduating from Yale in 1997. Since then he has been a staff member at the Max-Planck Institut in Dresden, continuing to investigate microresonators.

Announcements

APS UNDERGRADUATE PHYSICS STUDENT COMPETITION

1999 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 Ph.D. and one to a student attending an institution not offering a Physics Ph.D.

- Recipients receive a $5,000 award; finalists receive $1,000. They also receive an allowance for travel to the Award presentation.
- Recipients' and finalists' home institutions receive $5,000 and $500, 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 15 June 1999 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 **15 June 1999** 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 **15 June 1999** to:
Dr. Barrie Ripin, Administrator, Apker Award Selection Committee
The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844; Telephone: (301) 209-3268, Fax: (301) 209-0865,
email: ripin@aps.org

Call for Nominations for Y2K APS Prizes and Awards

Members are invited to nominate candidates to the respective committees charged with the privilege of recommending the recipients. A brief description of each prize and award is given in the March 1999 *APS News Honors and Awards* insert, available online at www.aps.org under the APS News button, along with the addresses of the selection committee chairs to whom nominations should be sent. Please refer to the APS Membership Directory, pages A21-A40, for complete information regarding rules and eligibility requirements for individual prizes and awards or visit the Prize and Awards page on the APS web site at www.aps.org under the Prize and Awards button.

PRIZES

WILL ALLIS PRIZE FOR THE STUDY OF IONIZED GASES
HANS A. BETHE PRIZE
BIOLOGICAL PHYSICS PRIZE
TOM W. BONNER PRIZE IN NUCLEAR PHYSICS
OLIVER E. BUCKLEY CONDENSED MATTER PHYSICS PRIZE
DAVISSON-GERMER PRIZE IN ATOMIC OR SURFACE PHYSICS
DANNIE HEINEMAN PRIZE FOR MATHEMATICAL PHYSICS
HIGH POLYMER PHYSICS PRIZE
FRANK ISAKSON PRIZE FOR OPTICAL EFFECTS IN SOLIDS
JULIUS EDGAR LILIENFELD PRIZE
JAMES C. MCGRODDY PRIZE FOR NEW MATERIALS
LARS ONSAGER PRIZE
GEORGE E. PAKE PRIZE
W.K.H. PANOFSKY PRIZE IN EXPERIMENTAL PARTICLE PHYSICS
EARLE K. PLYLER PRIZE FOR MOLECULAR SPECTROSCOPY
I. I. RABI PRIZE IN ATOMIC, MOLECULAR AND OPTICAL PHYSICS
ANEESUR RAHMAN PRIZE FOR COMPUTATIONAL PHYSICS
J. J. SAKURAI PRIZE FOR THEORETICAL PARTICLE PHYSICS
ARTHUR L. SCHAWLOW PRIZE IN LASER SCIENCE
PRIZE TO A FACULTY MEMBER FOR RESEARCH IN AN UNDERGRADUATE INSTITUTION
ROBERT R. WILSON PRIZE

AWARDS

LEROY APKER AWARD *(15 June 1999 Deadline)*
JOSEPH A. BURTON FORUM AWARD
MARIA GOEPPERT-MAYER AWARD
JOSEPH F. KEITHLEY AWARD FOR ADVANCES IN MEASUREMENT SCIENCE

MEDALS AND LECTURESHIPS

DAVID ADLER LECTURESHIP AWARD
EDWARD A. BOUCHET AWARD
JOHN H. DILLON MEDAL
LEO SZILARD LECTURESHIP AWARD

DISSERTATION AWARDS

OUTSTANDING DOCTORAL THESIS RESEARCH IN BEAM PHYSICS AWARD
NICHOLAS METROPOLIS AWARD FOR OUTSTANDING DOCTORAL THESIS WORK IN COMPUTATIONAL PHYSICS
DISSERTATION AWARD IN NUCLEAR PHYSICS

NOMINATION DEADLINE IS JULY 1, 1999, UNLESS OTHERWISE INDICATED.

THE BACK PAGE

Physics and the Information Revolution

by Joel Birnbaum

In the fourth century B.C., Pythias was condemned to death by Dionysius, the tyrant of Syracuse, but obtained leave to go home to arrange his affairs after his friend Damon had agreed to take his place and be executed should Pythias not return. Pythias returned in time to save Damon, and Dionysius was so struck with this honorable friendship that he released both of them.

The decades-old friendship of computer technology and physics has also been an honorable one, and it, too, has produced benevolent results. Modern experimental and theoretical physics depend on computing; a debt repaid many times over by fundamental contributions by physicists to hardware, software and systems technologies.

For many years now, I have dreamed of the day when computers would become a pervasive technology, part of everyday life for most people, and more noticeable by their absence rather than their presence. Electric motors are a good example. The average American home contains about two dozen or more electric motors, buried in consumer appliances like vacuum cleaners, electric toothbrushes, washing machines, and VCRs. In the next generation, the same will be true for computers, most of which will be embedded in information appliances, enormously powerful because their parallel architectures will be tailored to particular tasks and inexpensive because of huge production volumes. Just as most electrical consumer appliances are dependent upon the availability of a ubiquitous electric power utility, most information appliances will derive their computational power from a digital information utility.

However, for any technology to become truly pervasive it must transcend being merely manufacturable and commonplace. It must become intuitively accessible to ordinary people, and it must deliver sufficient value to justify the large investment needed to create the supporting infrastructure.

For many years I despaired of this dream ever coming true for computers, because of the political and economic bickering that precluded the creation of a standard that would result in the ability to interconnect systems easily and freely, and by the needless, shortsighted profusion of proprietary, arbitrarily different, complex user interfaces. Isaac Newton was once asked how he had achieved his great accomplishments. He answered modestly that if he had seen far, it was because he had stood on the shoulders of giants. In the computing industry, we have mostly stood on each other's feet.

Web and Mosaic

And then, just a few years ago, a miracle occurred: Both problems were solved by the physics community, long the most sophisticated users of computer technology. Out of CERN came the World Wide Web, based on the quarter-century-old Internet, but with benefits so profound that a *de facto* connectivity standard seemed to emerge overnight and to spread like wildfire. Soon thereafter, the disarmingly simple Mosaic point-and-click browser technology was invented at NCSA (National Center for Supercomputer Applications), clearing the way for truly intuitive access, and suddenly the basis for a true global information infrastructure was born. Many now believe that taken together these two creations, spawned of the needs of physics users, will rank among the most important developments in the history of civilization, and that all aspects of how we work, learn and live will be forever changed by them.

By the end of the next decade, a new generation of information appliances will have emerged. They will be much more intuitive to use than today's small, mobile, general-purpose computers. Dedicated to a particular task, they will be named by that task just as consumer appliances are: users will think of them in terms of what they do, not how they do it. We expect appliances to evolve to hide their own complexity, just as the one-button, automatically-tuned television set of today has replaced its less complex, but harder-to-adjust ancestor. Because of continued advances in semiconductors and software, the information appliances of tomorrow will be able to do the same. Many of the most interesting appliances will include sensors and communications capabilities and soon whole families of appliances will communicate directly, some wirelessly. As network bandwidth increases and becomes far less expensive, the cost of appliances will drop sharply since much of the computation to support both the multimedia human interface and the application will reside on the information utility.

However, while wonderfully useful, the Internet and Web today are a far cry from an information utility, which must have the characteristics common to all utilities. We should notice a utility only when it fails. It must be secure, reliable, ubiquitous, and the standards for its use must endure. It must be perceived to have a value great enough to justify the huge investments required.

We know that utilities catalyze new industries. They are also invariably lucrative; the information infrastructure has already produced new Internet-based companies which defy all conventional economic logic. They are just early precursors of new entities for electronic commerce, communications, electronic publishing, and internet medicine, to name just a few of the industries which are already being created or transformed. The notion of an information infrastructure built upon the standards already set for the Web, but extending them to improve robustness, performance, manageability, and security as the systems scale to huge numbers of users is at the heart of most industrial efforts today.

The fundamental characteristic of an information utility is that it transforms computing from a capital investment to a competitive service, with costs amortized over many users and paid for by usage. We could provide electricity for our homes by buying a generator, but most of us prefer to subscribe to a service. For many users, the same will be true for computing. I think of the utility as a natural evolution of open computing which will enable a web of electronic services to be built by composition of existing and new services. It will do for computation and services what the Web did for data. An HP Labs prototype of an information utility has been running for some time; it has all of the attributes mentioned, and is now being scaled to a large number of users. The evolution of the information utility will be an industry phenomenon driven initially by the acceptance of the Internet as a surrogate for the enterprise backbone and the economic promise of electronic commerce, telephony and entertainment.

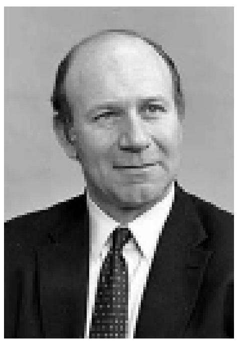
Moore's Law

Gordon Moore of Intel was the first to quantify the improvement in gate density when he noticed that the number of transistors on a chip increased exponentially, and over the past 24 years. That exponential growth rate has corresponded to a factor of four increase in the number of bits that can be stored on a memory chip in every device generation, about every 3.4 years — an increase of 16,000 times! This exponential growth in chip functionality is closely tied to the exponential growth in the chip market, which has been approximately doubling every five years.

At the present time, there are two recognized factors that could bring Moore's Law scaling to an end. The first is economic. The cost of building fabrication facilities to manufacture chips has also been increasing exponentially, about a factor of two every chip generation. Thus, the cost of manufacturing chips is increasing significantly faster than the market is expanding, and at some point a saturation effect should slow the exponential growth to yield a classic s-curve for expanding populations.

The second factor threatening Moore's Law is that the engine that has brought us to this point, the CMOS (Complementary Metal Oxide Semiconductor) field-effect transistor, can only get us part of the way to where we want to go. The Semiconductor Industry Association has established a National Technology Roadmap that sets as a goal the continuation of the current exponential increases in capacity and performance up through the year 2010. That projection calls for chips that are 256 times more capable than current designs with no increase in power dissipation. If this goal is attained, then the silicon-based integrated circuit will have accomplished a more than six order of magnitude performance improvement, using energy as a metric, with a single manufacturing paradigm. Compared to the advances experienced in most human endeavors, that increase is extraordinary.

If we are to have any hope of sustaining the economic benefits to the national economy provided by sustaining Moore's Law, we have no choice but to develop quantum switches and the means to interconnect them. Fundamental limits are now becoming an essential issue. It does not make sense to make the enormous investments in research, development and manufacturing that will be required to replace semiconductor switches by the year 2010, if the new technology can have only marginally better performance. To achieve incredible advances in the future will require a totally different type of computational machinery. The requirement for inventing a new technology paradigm, coupled with the economic rewards that would follow from such a development, has created exciting research opportunities for mathematicians, physicists, physical chemists, and scientists of many disciplines as well as for computer technologists. In fact, much of the current interest in interdisciplinary research areas such as nanofabrication, self-assembly and molecular electronics is being driven by this search for a new archetype computer.


Joel Birnbaum

A common theme that underlies many schemes is the push to fabricate logic devices on the nanometer-length scale, which will therefore be dominated by quantum mechanical effects. An additional huge increase in performance could result from reversible machines executing what has come to be known as quantum logic; in principle, very clever algorithms could exploit the inherent parallelism of the superposition of quantum states. If we could solve knotty problems of decoherence, programming and input/output, to name a few, quantum logic would enable the solution of some classes of computationally intractable problems, such as factorization and search, which are important in cryptography and Fourier analysis. For some applications the reversibility and inherent parallel nature of quantum logic represent a leap far beyond what ideal nonreversible computing can offer, perhaps by still another nine orders of magnitude or more.

Quantum logic is a fascinating prospect, but it does not seem likely to me that this can become a reality in any widespread practical sense before 2025, and many are less optimistic than that. In any case, barring some currently unimagined breakthrough, it is even more unlikely that an entire system would be built this way. However, there are tremendous advances possible for computing, even if quantum logic never becomes a reality. A physicist's workstation of the future may well run Windows 17 on a Decium, with lots of RAM, but with a reconfigurable, application-specific quantum-switch-based, supercomputer attached.

Winston Churchill observed that the further backward you can look, the farther forward you are likely to see. It is possible that history is about to repeat itself, with the introduction of a new disruptive technology for computation in the 21st Century. Today, we have the silicon FET, but we speculate that a quantum-state switch could be better. A large number of laboratories are now engaged in basic research in the fabrication of materials into arbitrary shapes and sizes, and are searching for the device concept that will lead to a disruptive new technology.

Breakthroughs will require significant advances in the understanding of fundamental issues, and will undoubtedly act as the foundation for new mathematical and scientific disciplines; those companies that convert the breakthroughs to a new, manufacturable technology will be the survivors of the quantum age of information processing. It is a noble quest, and we computer technologists are being held hostage by the laws of physics. We can only hope that once again physicists, just like Pythias, will arrive in time to save the day.

Joel Birnbaum is Chief Scientist at Hewlett Packard. The above text was excerpted from his plenary speech at the APS Centennial meeting in Atlanta, GA. The full version can be found online at http://www.hpl.hp.com/speeches/birnbaum_aps.html.