# APS NEWS

NOVEMBER 1999 THE AMERICAN PHYSICAL SOCIETY VOLUME 8, NO. 10

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APS 100 years celebrate a century of physics

## New Education Officer Joins APS

The APS has hired Fredrick M. Stein, former director of the Center for Science, Mathematics and Technology Education (CSMATE) at Colorado State University, as its new Education Officer. Stein, who officially joined the APS staff September 13, replaces Ramon Lopez, who served in that capacity for five years. Lopez left the APS in July.

Stein recalls always having an interest in both science and education, although he didn't initially plan to make it a career when he enrolled for undergraduate studies at the University of Colorado in Boulder. But he soon decided he wanted to teach high school physics, eventually joining the Peace Corps upon graduation. He trained regional teachers and team-taught physics with them in Spanish in Colombia, South America, before returning to the US to pursue graduate studies. He earned his PhD in chemical physics from Indiana University at Bloomington, and then spent many years as a professor of physical chemistry and dean of natural sciences at Western State College in Gunnison, Colorado. He also had visiting professorships at UC-Boulder, the University of New Mexico, and Amherst College.

His interest in science education reform was awakened when his children came home from school and reported that their science classes were "boring and unengaging." Determined to make a difference, Stein found himself accepting a position as director of the Philadelphia Renaissance in Science and Mathematics program in 1987, intended to raise science and math standards for K-12 grades. "It was the equivalent of going to graduate school to learn about running foundations and dealing with big city politics," he recalls. In that capacity, he served as project director for a comprehensive regional center for minorities, oversaw several teacher enhancement grants for science and mathematics, and helped Philadelphia become one of six sites across the country to participate in Project 2061, a nationwide effort to promote benchmark standards for science education. He moved back to Colorado in 1991 to head CSMATE, where he developed inservice teacher enhancement, preservice training, and numerous student-based programs.

Fredrick M. Stein

Stein joined the APS for the opportunity to work on science education reform at a national level. He intends to initiate APS programs to improve science teacher preparation while revitalizing undergraduate physics education jointly with the AIP and the American Association of Physics Teachers. "We're hoping this will be yet another project in which the three societies can work together," says Stein.

### Learning How PHYSICS WORKS!

Young 'natural scientists' explore the fourth state of matter using a plasma globe, part of the APS PHYSICS WORKS! interactive exhibit at the APS Centennial meeting in Atlanta, Georgia, last March. The exhibit is designed to look broadly at achievements of physicists in the last century while inspiring young people about physics and involving them in the discovery process. *See page 6 for more photos and description.*

## Ripin to Leave the APS

Barrett Ripin announced that he will leave his Associate Executive Officer position after his five-year term ends in January.

In a note to staff, Ripin said "I've enjoyed working with each and all of you immensely and feel great satisfaction with the role I've played in benefiting the health of physics and the Society, it is a good point for me to pursue other interests. When I return to 'volunteer' status, I will look forward to many more years working with you to 'advance and diffuse the knowledge of physics,' as well as maintaining our friendship."

As Associate Executive Officer, Ripin served as the editor of *APS News* and oversaw the APS Membership, Meetings and Honors departments. He led the formation of several new regional Sections, Topical Groups, FIAP, as well as the APS Committee on Careers and Professional Development. During his tenure, Ripin worked to broaden the concept of physics careers and employment opportunities, increase the involvement of industrial physicists in the Society, and improve physics education and communication with members and the public. *APS News* will feature an interview with Ripin in a forthcoming issue.

Physicists interested applying for in the Associate Executive Officer position are encouraged to respond to the announcement on page 7.

## Inside...



## Largest Industrial Employers of PhD Physicists

***The industrial employers in both columns account for 45% of PhD physicist members who are employed in the private sector, reside in the US and are a member of at least one of AIP's Member Societies.***

Every two years, the AIP Education and Employment Statistics Division surveys a group of members belonging to at least one of the 10 AIP Member Societies and residing in the US. In 1998, 30% of the PhD physicist respondents who work in the private sector came from just nineteen companies.

The next largest group of companies each have nearly the same number of respondents. Almost half of the companies in this second group moved into this list since 1996 and are indicated in italics.

Raytheon, since their acquisition of Hughes and Texas Instruments divisions, employs the most PhD physicists that belong to an AIP member society. Since the time these data were collected, several of these corporations (such as Westinghouse) have undergone major restructuring, including mergers and divestitures.

For questions or comments, please contact Raymond Y. Chu or Amanda Benedict at (301) 209-3070 or stats@aip.org. Visit the AIP Stats website at www.aip.org/statistics.

*SOURCE: AIP Membership Sample Survey, 1998*

### Largest 19 Employers*

Raytheon Corporation
IBM
Lockheed Martin Corporation
Lucent Technologies
Boeing Company
Eastman Kodak Company
Science Applications International Corporation
General Atomics
Hewlett-Packard Company
Northrop Grumman Corporation
AT&T
Schlumberger Limited
Motorola Incorporated
Rockwell International Corporation
Seagate Technologies
*Osram Sylvania*
Maxwell Optical Industries
Varian Associates
3M Company

**The above companies employ 30% of industrially-employed PhD physicist members.*

### Next Group of Large Employers

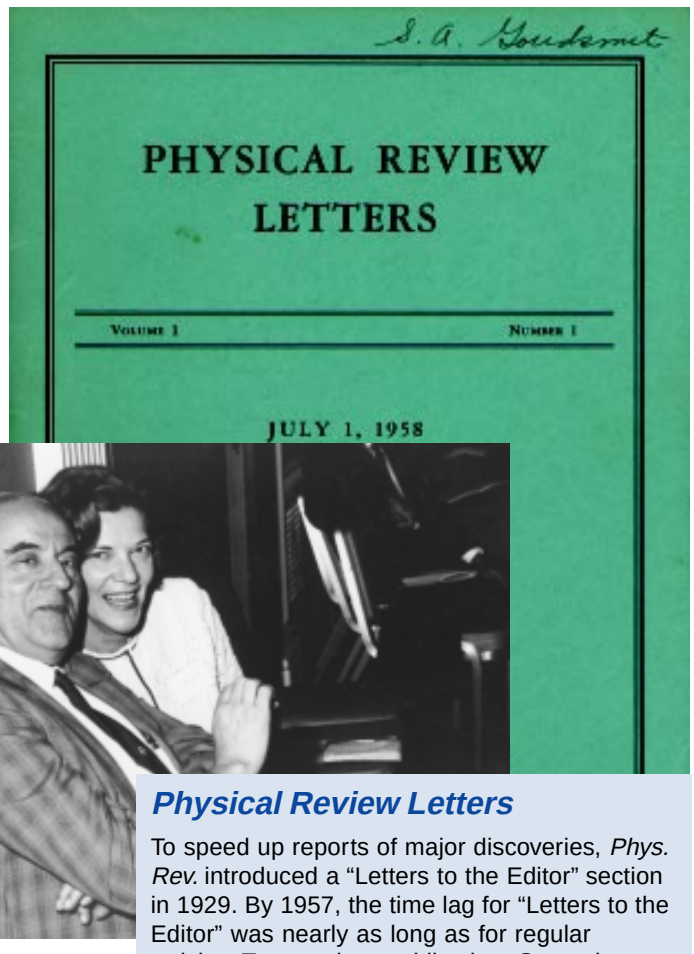
Bechtel
Intel Corporation
Honeywell Incorporated
Exxon Corporation
*ThermoTrex Corporation*
*Arete Associates*
Texas Instruments
NEC Research Institute
*Eaton Corporation*
*Beckman Instruments*
*Picker International*
*Symyx Technologies Incorporated*
General Electric Company
Teledyne
Sverdrup Corporation
*Phillip Morris, Incorporated*
*Silicon Valley Group*
Allied Signal Incorporated
Siemens Medical Systems Incorporated
KLA-Tencor Corporation
ITT
*Westinghouse Electric*
*Fonar Corporation*
General Motors Corporation
Xerox Corporation
TRW Incorporated
*Analogic Corporation*
*Fluor Daniel, Incorporated*
Ford Motor Company
*SDL International*
Sarnoff Corporation
Corning Glass Works
*WebTV Networks Incorporated*
*Veeco Instruments Corporation*

# 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.*




## Expansion of Journals

**Growth in numbers of physicists meant more research to be published. The *Physical Review* grew rapidly in size, quality, and prestige. *Reviews of Modern Physics* was introduced to offer authoritative summaries of specialized areas of research. The need to give others early word of fundamental work led to the establishment of *Physical Review Letters*.**

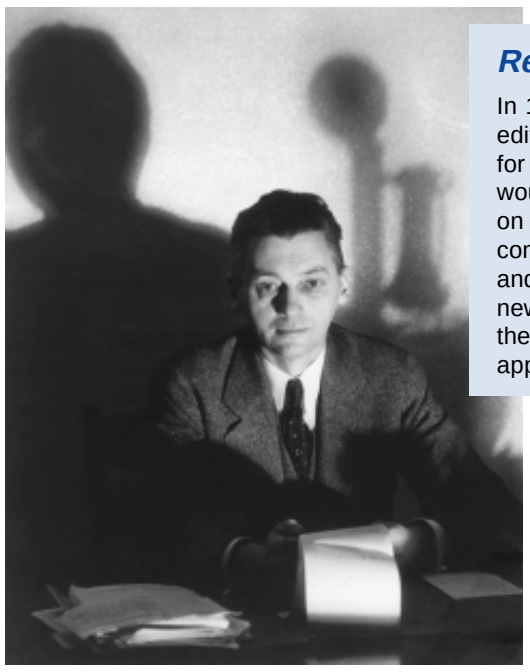


### Physical Review Letters

To speed up reports of major discoveries, *Phys. Rev.* introduced a "Letters to the Editor" section in 1929. By 1957, the time lag for "Letters to the Editor" was nearly as long as for regular articles. To speed up publication, Samuel Goudsmit, the journal's editor, created *Physical Review Letters.*

***PRL Highlights***

| | | |
|---|---|---|
| *1967* | *Electroweak Interactions* | *S. Weinberg* |
| *1982* | *Spooky Q.M. Actions at a Distance* | *A. Aspect, et al.* |
| *1982* | *Scanning Tunneling Microscopy* | *G. Binnig, et al.* |
| *1987* | *High-$T_c$ Superconductors* | *C. W. Chu, et al.* |
| *1998* | *Neutrino Oscillations* | *Y. Fukuda, et al.* |



### Reviews of Modern Physics

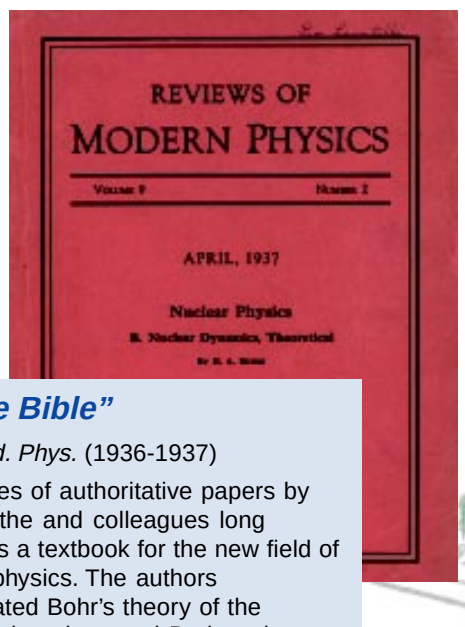
In 1928 John Torrence Tate, managing editor of the *Physical Review*, felt the need for a new type of physics journal—one that would contain definitive, up-to-date reports on branches of physics. He solicited comments from 54 prominent physicists and asked each to consider writing for the new journal. Response was positive, and the first issue of *Reviews of Modern Physics* appeared in 1929.

### PR *'Baby' Grows From an Inch to Over Thirteen Feet*

*Physical Review*, affectionately called 'the creeping green' published all physics topics until it began splitting by subject in 1970. Today, a year of *PR* and *PRL* comprises almost 100,000 pages and has multi-colored covers.

***PR Highlights***

| | | |
|---|---|---|
| *1916* | *Measurement of h* | *R. Millikan* |
| *1923* | *Compton Scattering* | *A. H. Compton* |
| *1927* | *Diffraction of Electrons* | *C. Davisson & L. H. Germer* |
| *1932* | *Cyclotron* | *E. O. Lawrence & M. S. Livingston* |
| *1935* | *EPR Paradox* | *A. Einstein, B. Podolsky & N. Rosen* |
| *1948* | *Transistor* | *J. Bardeen & W.H. Brattain* |
| *1949* | *Feynman Diagrams* | *R. P. Feynman* |
| *1957* | *BCS Superconductivity* | *J. Bardeen, L. Cooper & J. R. Schrieffer* |
| *1958* | *Laser* | *A. L. Schawlow & C. H. Townes* |




### "Bethe Bible"

*Rev. Mod. Phys.* (1936-1937)

This series of authoritative papers by Hans Bethe and colleagues long served as a textbook for the new field of nuclear physics. The authors incorporated Bohr's theory of the compound nucleus and Breit and Wigner's theory of the shape of nuclear resonance, which appeared during the writing of the articles.

***Most Heavily Cited RMP Paper***

| | | |
|---|---|---|
| *1943* | *Stochasticity* | *S. Chandrasekhar* |

To Advance and Diffuse the Knowledge of Physics *will be on exhibit in its entirety at the National Institutes of Standards and Technology (NIST) headquarters in Gaithersburg, MD through the end of 1999. Visitors are welcome.*


**Next Month: Public Affairs and the War Years**


# APS News

Coden: ANWSEN ISSN: 1058-8132
**Series II, Vol. 8, No. 10** **November 1999**


**Editor ..... Barrett H. Ripin**
**Associate Editor ..... Jennifer Ouellette**
**Design and Production ..... Alicia Chang**
**Copy Editing ..... Danita Boonchaisri**

***APS News*** (ISSN: 1058-8132) is published 11X yearly, monthly, except the August/September issue, by the American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, (301) 209-3200. It contains news of the Society and of its Divisions, Topical Groups, Sections and Forums; advance information on meetings of the Society; and reports to the Society by its committees and task forces, as well as opinions.

**Letters** to the editor are welcomed from the membership. Letters must be signed and should include an address and daytime telephone number. The APS reserves the right to select and to edit for length or clarity. All correspondence regarding *APS News* should be directed to: Editor, *APS News*, One Physics Ellipse, College Park, MD 20749-3844, E-mail: letters@aps.org.

**Subscriptions:** *APS News* is an on-membership publication delivered by Periodical Mail. Members residing abroad may receive airfreight delivery for a fee of $20. **Nonmembers:** Subscription rates are: domestic $160; Canada, Mexico, Central and South America, and Caribbean $180; Air Freight Europe, Asia, Africa and Oceania $210.

**Subscription orders, renewals and address changes** should be addressed as follows: **For APS Members**—Membership Department, The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, membership@aps.org. **For Nonmembers**—Circulation and Fulfillment Division, American Institute of Physics, 500 Sunnyside Blvd., Woodbury, NY 11797. Allow at least 6 weeks advance notice. For address changes, please send both the old and new addresses, and, if possible, include a mailing label from a recent issue. Requests from subscribers for missing issues will be honored without charge only if received within 6 months of the issue's actual date of publication.

Periodical Postage Paid at College Park, MD and at additional mailing offices. Postmaster: Send address changes to *APS News*, Membership Department, The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844.

# APS Creates Physicist Networking Database

The APS is creating an exciting new service, which will be of interest to APS members needing technical advice. This APS Technical Network for APS members is a web-based database of information with the primary purpose of establishing a large professional network of physicists (defined broadly) across academia, national labs, industry, and other places where physicists work. The new service, which is intended to be a benefit to APS members and does not generate any income whatsoever for the APS, will be developed in two phases. In the first phase, members who are willing to share their knowledge informally with other APS members, will be asked to list information on their areas of technical expertise. In the second phase, members will be able to search the database by area of expertise, state, or keyword.

The idea for the database came from discussions with industrial physicists, particularly those in small companies, who expressed need for such a database of APS members whom they could contact informally when they had a technical problem. Since those discussions however, the scope of this Network has broadened. Many physicists and other professionals decide to change the direction of their research, enter new disciplines, or transition from academia to industry (or vice versa). The APS Technical Network can not only foster the technical development of these physicists, but can help them establish professional contacts in those new areas of research and help them find mentors to facilitate those transitions.

Arlene Modeste Knowles and Norval Johnson have been leading the efforts to plan and construct this new service. It is now being beta-tested. The completion of the search engine will be the next phase of the Network's development, and will be launched once 100 physicists are enrolled in the database. We invite all of you to be a part of this Network, to fill out the enrollment form, and send feedback on the service process to Arlene Modeste Knowles (knowles@aps.org). Check out the Network at http://www.aps.org/TN/.

# High School Physics Enrollments Hit Post-War High:

## *Undergrad and Grad Enrollments at a Low*

Students are heading back to school, and a new study shows many will be spending more time in science classrooms. *Maintaining Momentum: High School Physics For A New Millennium*, a new report from the American Institute of Physics, shows that enrollment in physics classes is at its highest point since World War II. The study shows big gains in the types of physics being taught and the number of girls studying physics, but points out that more needs to be done where minorities and students with fewer economic advantages are concerned.

According to AIP, over the past ten years, the number of students enrolled in physics has increased by eight percent, reaching an all time high of 28% since the end of World War II. What's more, the study shows that the type of physics being taught is expanding. While traditional introductory physics classes still constitute the bulk of the physics curriculum, the fastest growing alternative uses a less mathematical approach to teach physics concepts. At the other end of the spectrum, the study shows rapid growth in advanced physics courses. The number of students taking Advanced Placement (AP) physics today is double what it was just a decade ago.

Girls are also making a greater showing in physics classrooms. "I am very encouraged by the news that more women are taking physics courses in high school," says Jack Hehn, the manager of the education division of AIP. According to the research, in 1987 only 39% of physics students were girls. Today, girls represent almost half (47%) of students taking physics. But there are still advances that need to be made. Women are less likely to continue in physics education after high school. Only one-fifth of all bachelor's degrees in physics go to women, and only one-eighth of all doctorates.

There are also concerns about drawing more minorities to physics classes. The report shows that African-American and Hispanic students are still under represented in physics classrooms. The research also points out that far fewer students take physics at schools which teachers rate as socioeconomically worse than average. These schools are also much less likely to offer advanced placement classes. According to Michael Neuschatz, the report's author, "a substantial fraction of the academically most successful students are now getting an introduction to physics. But that is not at all the case for other students, including many who are headed towards two- year colleges and technologically demanding jobs."

The study therefore suggests that while there has been great improvement overall in physics education over the past ten years, the fight is not over. Fred Stein, APS' new Education Officer, laments, "It is difficult to be elated over the recent fact that 28% of students are enrolled in high school physics, even if this is an all time high since the end of World War II. It is even more distressing that African-American and Hispanic students are still greatly underrepresented in physics classrooms."

Ironically, the latest statistics for graduate enrollments in physics has experienced a sharp decline and is currently at its lowest point since the post-War boom of the 1950s. During the 1996-1997 academic year, 11,786 graduate students were enrolled in the 261 US physics graduate departments, representing a 6% drop from the previous year and a cumulative 19% drop from the most recent high in 1992. Because of the declines in first-year enrollments, it is expected that overall enrollments will continue to decline for several more years. The decline has been steeper for US students (27%) than for foreign students (15%), and as a result, foreign students now comprise roughly 45% of the physics graduate student population. [See www.aip.org/statistics]

*For more information, contact Randy Atkins, APS, 301-209-3238; atkins@aps.org*

festival profile

# Physics and Dance in a *Pas de Deux*

In a small lecture room at the Atlanta City Ballet, ballerina Amy Kohler is demonstrating sequences of movements for the benefit of the audience, which includes not only physicists in town for the APS Centennial meeting last March, but local non-science residents as well. The purpose of the performance is not simply artistic appreciation: After each sequence, physicist Kenneth Laws analyzes the movements using physics principles to explain such phenomena as balance and the way torques are applied to produce rotational motion.

"The moving human body provides an intriguing opportunity to apply the laws of classical mechanics to visually accessible and interesting phenomena," says Laws. "Dance is a human movement that is particularly rich in variety and beauty." And he should know. For the last 20 years, he has been combining his life as a physics professor at Dickinson College in Carlisle, PA, with delivering lectures and demonstrations on the physics of dance. He believes such research enhances understanding and appreciation of both disciplines, as well as improving the techniques of dancers.

Physics came first. Laws recalls becoming interested in the subject as a high school student, although he enrolled at the California Institute of Technology intending to major in mechanical engineering. But a sophomore physics course convinced him that the world of physics was far more fascinating and he opted instead to focus on that. Then ("because I didn't have anything better to do," he quips) he went on to complete an MS from the University of Pennsylvania and taught for a year before going back to earn his PhD in solid state physics, this time from Bryn Mawr College. He joined the faculty of Dickinson College shortly afterward, and has been teaching there ever since.

Laws' passion for dance was ignited relatively late in life, after he'd already established himself in the physics profession. He took his first ballet class at the age of 40, initially to be near his children, then 5 and 7, who had just started ballet lessons at the Central Pennsylvania Youth Ballet. He started working backstage pulling the curtain for performances, and while watching a *pas de deux* during one, he was so moved by its simple beauty that "I ended up with tears streaming down my face. It turned my life upside down." His son quit after a year and a half; his daughter retired "at the ripe old age of 13 after a long and illustrious career," he says. But Laws couldn't give it up, and continued taking lessons, eventually serving as president of CPYB's Board of Directors. He even had the opportunity to perform in minor character roles, including one of the suitor princes in *Sleeping Beauty*.

A few years into his ballet studies, Laws noticed that the instructor was asking students to perform movements that seemed to be physically impossible — yet many young students were able to do them. He began investigating the physical principles and developing explanations for why dancers can perform such feats. "So the dance captured me first because of its beauty and the way it works with music, and then I discovered the way physics applies," he says. Since then, he has published over 30 articles on the physics of dance in various scientific and dance publications, and eventually authored *The Physics of Dance* in 1984, published by Schirmer Books — although only after Laws had collected 21 rejection slips from other publishers, a testament to his persistence. His faith in the project paid off: the book ended up selling over 10,000 copies and is currently out of print. [Laws is negotiating with Oxford University Press to publish a new, updated edition next year.]

*The Physics of Dance* was followed in 1994 by *Physics, Dance and the Pas de Deux*, co-authored by Cynthia Harvey, a former principal dancer with the American Ballet Theater in New York City, which included an accompanying video, as well as a chapter devoted to the physics of ice skating. Although neither book sold enough copies to generate a significant source of income, it did establish Laws' credibility in both physics and dance, and launched what has become almost a second career of traveling around the country delivering lectures and residency programs on the physics of dance. He teamed up with Kohler, a freelance dancer based in Chicago, last year, and hopes to continue the partnership despite her planned relocation to North Carolina to start her own dance company. "She's just the right size, shape and ability for me to work with, and she has the interest and personality needed to go with it," he says.

Through such presentations, which seem to appeal to scientists, dancers and the general public in equal measure, "Dance can be seen with a new perspective, physics can be seen in an unusual application, and the links between science and art are expanded," says Laws. Through it all, he has continued to teach at Dickinson. "Physics is my vocation and I enjoy it very much, but dance is my passion."

### Mr. Smith Goes to College

This year's crop of college freshmen at Randolph-Macon College in Ashland, VA, includes one particularly unusual student: 10-year-old "boy genius" Gregory Smith, who will be taking a full course load including calculus I, physics, French and an honors course on warfare in antiquity. He plans on being a physics major. According to his parents, Smith began memorizing and reciting books at 14 months, adding numbers at 18 months, and "tested off the bell curve" in an IQ test taken when he was 5. Since starting the second grade three years ago, he has skipped most elementary grades altogether, and completed the standard high school curriculum in just 22 months, becoming the youngest person to graduate from a public high school in Florida. His unique intellectual ability has already won considerable media attention: Smith has appeared on "60 Minutes," "The Today Show," "NBC Nightly News," and "Late Night with David Letterman."

## VIEWPOINT...

# Viewing Teaching as a Physicist

*by Kenneth Heller*

As physicists, we are concerned about science education. We know that to survive, a modern democratic country must have a population that understands and appreciates not only the fruits of science but also supports the process of science. The key to this understanding is not new technology, or better curriculum, as useful as they may be. The key is effective teaching in universities and colleges, in K-12 schools, in museums and nature centers, on TV and radio, and in personal contact as parents or colleagues.

The first step toward a culture that promotes and supports effective teaching is the recognition, by both teachers and their critics, that teaching is neither easy nor natural. As in other complex human endeavors, effectiveness requires using techniques and ideas that may be counter intuitive. This is as true for teaching as it is for physics. Recognizing that teaching is a complex set of skills and not a personal attribute would move us beyond recrimination by critics and defensiveness by teachers. We need to expunge the notion of a "good" or "bad" teacher and replace it with the notion of using more or less effective techniques of teaching. Changing one's tools does not require a gut-wrenching *mea culpa* that past teaching was "bad," but simply the recognition that more effective techniques are now available.

As physicists, we can view teaching dispassionately as the operation that transforms people from their initial state to a desired final state. Effective teaching is then the operation that maximizes the fraction of students making the transition. To find this operation, it is clear that someone must first carefully characterize the desired final state and also determine the ensemble of initial states that we are given. When the final state involves physics, mathematics, or science in general, we physicists have a great deal of input through such projects as the work on national education science standards by the National Academy of Sciences.

Characterizing the initial state of students is the province of education, cognitive psychology, and the emerging fields of specific subject-matter education, including physics education. If every learner were in a completely unique state, it might be impossible to implement a finite number of operations to substantially populate any desired final state. Luckily, broad categories have been found which categorize the initial state of a large fraction of people. This characterization of the initial state of the learner has improved dramatically over the last 20 years and a more precise characterization will come with the increase of research support and the development of new diagnostics tools.

How can we construct the relevant operation: the teaching? As in physics, random guessing is not an efficient technique, although it sometimes works. Theory is needed as a guide, and it is provided by the fields of education and cognitive psychology. A theory does not have to be correct to prove useful. After all, caloric theory was useful in guiding the early and very fruitful development of thermodynamics, and Newtonian theory is still useful in many venues. A useful theory can encompass basic principles or be purely phenomenological.


Kenneth Heller

A phenomenological theory which has proven useful and seems to appeal to physics faculty — probably because it is reminiscent of graduate school — is called cognitive apprenticeship. It begins with the observation that apprenticeship has been an effective approach to teaching complex skills in a small group setting, and then extends that approach into the realm of more abstract learning for large numbers of people. Effective teaching based on cognitive apprenticeship must incorporate modeling (showing exactly how to do the desired skill), coaching (correcting individual work in real time), and fading (independent work). This provides the necessary framework to teach a course, and the framework, in turn, provides a structure to help teachers incorporate other empirical observations.

Determining whether or not a technique will lead to more effective teaching is difficult because learning is a complex process, and may well be non-linear. This may account for the observations that simple "controlled experiments" varying a single quantity typically show very small learning changes. When large learning changes are reported, they are usually difficult to reproduce unless all parts of the learning environment are reproduced. It may be that human learning, which depends on many parameters, has resonances. Although changing each parameter in turn gives a very small effect, the parameters can be tuned to give a large effect.

As physicists we can apply the same standards to teaching as to our field. Our research is based on theory and past measurements. We don't often repeat work without good reason. When a new technique arises that enables us to attack problems more efficiently, we embrace it. Changing method, technology, or analysis technique does not cast doubt on personal worth. We do not dwell on the past, nor do we demand that every new theory or experiment be a breakthrough. We take pride in our past accomplishments and marvel at all we accomplished using the tools at hand. We look forward, with some trepidation, to using the latest techniques and probing the latest theories. Powered by this attitude, the technology and techniques used in physics continuously improve. Can the same be said for teaching? As we look around, do we see the continuous incorporation of improved teaching techniques, or do we hear a clamor for identifying good and bad teachers?

*Kenneth Heller is the Morse-Alumni Distinguished Teaching Professor in the School of Physics and Astronomy at the University of Minnesota, and vice-chair of the APS Forum on Education.*

# LETTERS

### Kansas Makes a Monkey of Itself

When the journalist H.L. Mencken reported on the infamous Scopes trial of 1925, he remarked that the hysteria surrounding it had made a "universal joke" out of the occupants of Dayton, Tennessee, where the trial took place. Now, 74 years later, but only a few degrees of longitude removed, the Kansas Board of Education has in its turn made a monkey of itself. The board has removed the requirement for school students to have a knowledge of evolution to pass examinations.

This might seem hilarious in today's technically wired society were it not for one sobering fact. Despite overwhelming acceptance of the material benefits that science has brought, Americans in general remain deeply ignorant of its basic principles. If such ignorance persists, it will prove devastating to the future of our democracy, whose citizens will increasingly be called upon to exercise judgement on the complex social issues that advances in science inevitably bring.

Thomas Jefferson, perhaps the prime champion among the founding fathers of the principle of separation of church and state, envisioned an American republic governed by a wise and educated electorate. To place at risk for the children of Kansas the chance to obtain all the vital knowledge that will enable them to keep Jefferson's dream alive in the coming age of biological revolution is both deplorable and terrifying.
**Paul M. Grant,** *EPRI, Palo Alto, California*

## zero gravity

### A Conversation in Kansas



See Kaboom! at janus.astro.umd.edu/astro/impact.html
*Science and Creationism: A view from the National Academy of Sciences* (to order a copy see www.nap.edu)

## APS STATEMENT ON CREATIONISM

*Editor's note: This position, which is still in effect, was adopted by APS Council on 22 November l98l in response to initiatives in several states to require 'equal' time for the instruction of creation and evolution in public schools.*

The Council of the American Physical Society opposes proposals to require "equal time" for presentation in public school science classes of the biblical story of creation and the scientific theory of evolution. The issues raised by such proposals, while mainly focused on evolution, have important implications for the entire spectrum of scientific inquiry, including geology, physics, and astronomy. In contrast to "Creationism", the systematic application of scientific principles has led to a current picture of life, of the nature of our planet, and of the universe which, while incomplete, is constantly being tested and refined by observation and analysis. This ability to construct critical experiments, whose results can require rejection of a theory, is fundamental to the scientific method. While our society must constantly guard against oversimplified or dogmatic descriptions of science in the education process, we must also resist attempts to interfere with the presentation of properly developed scientific principles in established guidelines for classroom instruction or in the development of scientific textbooks. We therefore strongly oppose any requirement for parallel treatment of scientific and non-scientific discussions in science classes. Scientific inquiry and religious beliefs are two distinct elements of the human experience. Attempts to present them in the same context can only lead to misunderstandings of both.

### AT LAST! ANOTHER CONTEST!

It seems like ages since *APS News* held a contest for its readers. With that in mind, we're soliciting submissions for amusing tales, puzzles, or other tools that teach physics concepts while entertaining the student. [As an example, see "How To Catch a Lion in the Desert" in the October 1999 issue of *APS News*.] Those who submit the winning entries will receive our usual fabulously silly prizes and have their entry published in *APS News*. Send submissions to the attention of the Editor, *APS News*, One Physics Ellipse, College Park, MD 20740, letters@aps.org. The deadline is any time when we feel we have enough entries to make a selection.

# Schawlow Honored in Special Memorial Session at ILS-XV

Friends and colleagues of the late Arthur Schawlow attended a special memorial session, reception and dinner in his honor at the 15th annual Interdisciplinary Laser Science conference (ILS-XV), held 26-28 September in Santa Clara, California. The meeting is jointly sponsored by the APS Division of Laser Science and the Optical Society of America, and also featured the latest in ground-breaking laser-related research in its traditional invited and contributed technical sessions. First held in Dallas, Texas, in 1985, the ILS conference series was established to survey the core laser science areas, including lasers and their properties, nonlinear optical properties, laser applications in physics and chemistry, and a selection of laser applications in other areas of science and technology.

Held Sunday evening, the Schawlow memorial session featured such luminaries of laser science as Charles Townes and Steven Chu, who reflected upon Schawlow's early contributions to optical science, his later work, his contributions as a teacher, and his public face and humor exhibited during interviews. A co-recipient of the Nobel Prize in Physics in 1981 for his co-invention of the laser with Townes, he was nicknamed "Laser Man" as a result of his many popular demonstrations of the new tool. [In one of his favorites, he used a "ray gun" laser to shoot through a transparent balloon to pop a dark Mickey Mouse balloon inside — without damaging the outer balloon — to indicate the laser's sensitivity.] Schawlow died earlier this year, after a long and illustrious career laying the foundation for much of modern optical science and its applications.

Another highlight of this year's meeting was Monday afternoon's plenary lecture by H. Jeff Kimble of the California Institute of Technology, whimsically (and alliteratively) entitled, "The Quantum Optics Circus: Flying Photons, Acrobatic Atoms, and Teleported Tuataras." Kimble, who joined CalTech's faculty in 1989 and is currently the William L. Valentine Professor there, believes that the field of quantum optics is moving into a radically new domain, where "quantum dynamical processes can be deterministically controlled in real time quantum by quantum." As an example, he points to the modern field of cavity quantum electrodynamics (CQED), in which single atoms are strongly coupled to the fields of high finesse resonators at the single photon level. "Manifestly quantum or nonclassical fields can now be gainfully employed to accomplish otherwise impossible tasks, such as teleportation of quantum states of light, and eventually of matter," he says. In addition, such advances are helping to lay the foundations for quantum information science, including the creation of quantum networks for diverse quantum communication protocols and for distributed quantum computation.

Photo courtesy of AIP Gallery of Member Society Presidents

Arthur Schawlow

The ILS meeting also featured four critical review lectures, given by recognized experts on exciting new developments in the field of laser science. This year's crop of speakers hailed from such diverse institutions as Sandia National Laboratories, the University of Texas at Austin, and Stanford University. Topics presented included laser plasma extreme ultraviolet sources for lithography below 0.1 micron; nonlinear spectroscopy of semiconductor interfaces, including new directions enabled by the advent of ultrafast lasers; sonoluminescent bubbles; and the study of single molecules under an optical spotlight.

# Tiny "Bow-Tie" Micro-Lasers Make It Big

Scientists at Lucent Technologies' Bell Laboratories have developed a radically new resonator design that can dramatically increase the output power and directionality of micro-disk semiconductor lasers. The results were featured at a Monday afternoon session at the APS Centennial meeting in Atlanta, Georgia, in March.

"Miniaturization is a key word often cited for semiconductor devices, built upon the concept that the smaller the active volume of a device, the less electrical power it will consume and the faster it will operate," says Bell Labs, Claire Gmachl, a member of the research team. "This in turn greatly eases the limitations imposed on power supplies and cooling devices, and allows more and more devices to be packed together even more densely." A similar line of thought is equally valid for semiconductor lasers, widely used in applications such as data transfer, telecommunication, and CD-players.

However, the miniaturization of conventional semiconductor lasers faces two problems: smaller devices in general have higher losses, which degrade their laser properties, and usually provide less light output. One of the best ways to solve these problems is to improve reflectivity of the laser resonator mirrors. This was achieved intrinsically by the development of micro-disk semiconductor lasers by Richart Slusher and coworkers at Bell Labs in 1991 — then the world's smallest lasers. In these devices, "Laser action takes place on so-called 'whispering gallery' modes, named after an effect found in medieval churches, where even whispers can travel long distances along the curved inner surfaces of arches and domes," says Gmachl.

The laser operates by confining the light through total internal reflection. The light rays reflect repeatedly from the boundary with the same angle of incidence, which is greater than the allowed maximum angle for refracting out of the medium. Hence the light circulates along the inner boundary of the laser almost infinitely, making the tiny laser-resonator appear to the light like a big 'infinite' one curled up inside the disk, and enabling one to make very compact lasers. However, the devices proved unsuitable for most technological applications because such lasers produce very low power and require additional components to direct the small amount of emitted light.

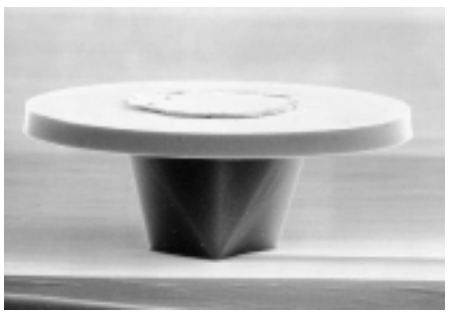


Photo from http://www.aps.org/meet/CENT99/vpr/layfb13-01.html

The new resonator design demonstrated by Gmachl's team increased the output power and directionality of such micro-disk lasers by up to a factor of one thousand. "The design of these new devices was guided by Chaos theory, in a way that is closely related to the description of a ball moving on an oddly shaped billiard table," says Gmachl. The researchers fabricated miniature cylinder lasers — a few hundredths of a millimeter across — which were smoothly deformed from circular symmetry. The lasers have a cross-section that has been elongated in one direction and squeezed in the perpendicular direction. At weak deformations, the devices are dominated by chaotic motion of the light rays in the cavity ("the billiard table"). At higher deformations a different type of laser resonance appears and is responsible for highly directional and high power emission.

These bow tie shaped resonances are stable resonator modes, using only parts of the cylinder-laser's perimeter as resonator mirrors, resulting in strongly directional light output. The reflectivity of the boundary is very high, but not quite unity, as it was in the whispering gallery lasers. This allows the laser to have a low threshold and to reach a high output power. So the lasers emit with high power into very specific directions and even improved some of their general laser characteristics. The effect should be largely independent of the particular laser or semiconductor laser material, but the Bell Labs team achieved their results using a quantum cascade laser emitting in the mid-infrared wavelength region, as it is particularly suited for whispering-gallery type geometries.

*[Adapted from a lay language paper by Claire Gmachl of Lucent Technologies' Bell Laboratories.]*

# IN BRIEF

### New House Science Committee Ranking Minority Member

Rep. Ralph Hall (D-Texas) has been named by the House Democratic Caucus to replace the late George Brown as Ranking Minority Member on the House Science Committee. Brown died in July from complications following heart surgery this past spring. "It is an honor to follow [Brown] as Ranking Democrat on the Science Committee," Hall said of his appointment, "and I look forward to continuing the good work that he has done to promote scientific research and discovery for the benefit of all Americans." Hall has served on the Science Committee for all of his 10 terms in the House, and chaired the Science Committee's Space Subcommittee during the 102nd and 103rd sessions of Congress. He has been a strong supporter of the International Space Station and has commented that "the space station is what has kept me in Congress," according to Congressional Quarterly. [*Item courtesy of Audrey Leath, AIP Public Information.*]

### New Web Service for Science Writers

The American Institute of Physics (AIP) and its member societies have established a Website where the full texts of prominent articles from physics journals can be obtained. The service, entitled *Physics News Select Articles*, is free of charge and intended as a resource for science writers, and will be accessible only with a password. According to Philip Schewe of AIP's Public Information Division, many of the posted articles will be related to items appearing in *Physics News Update*, AIP's weekly summary of interesting physics-based research, and APS *Physical Review Focus*, the new online publication. Articles will be culled from prominent journals such as *Physical Review Letters* and *Applied Physics Letters*.

### Anthony Johnson Elected VP of the Optical Society

Anthony M. Johnson, an APS Fellow and distinguished professor of physics at the New Jersey Institute of Technology, has been elected vice president of the Optical Society of America (OSA), it was announced in September. He will assume office in January 2000 and become OSA president in 2002. A native of Brooklyn, New York, Johnson received his PhD in physics from the City College of New York in 1981, conducting his thesis research at AT&T Bell Laboratories. He spent the next 14 years at Bell Labs, leaving in 1995 to join the faculty of NJIT. Johnson's APS involvement includes service on the APS Council and Executive Board, the Laser Science Topical Group, the Committee on Fellowship, and the Committee on Minorities in Physics. In 1996 he was awarded the APS Edward A. Bouchet Award, intended to recognize outstanding physics contributions by a minority physicist.

### Credit Where Credit is Due

With the advent of the Internet, Web sites, and personal home pages, the concept of intellectual property rights has become more complex. Barbara Andereck of Ohio Wesleyan University was dismayed to see the copyright by Funny Town on "You Might be a Physics Major If..." which appeared in the August/September 1999 *APS News* Zero Gravity section. "I wanted physicists around the country to be aware of the authorship of this clever list of indicators. Jason P. Lisle, while an undergraduate physics and astronomy major at Ohio Wesleyan University, authored the list after an especially frustrating statistical mechanics exam," said Andereck. Jason incorporated it into his home page (http://physics.colorado.edu/~lisle), where it rapidly spread among members of the physics community. Jason is currently a third-year graduate student in astrophysics at the University of Colorado, Boulder.

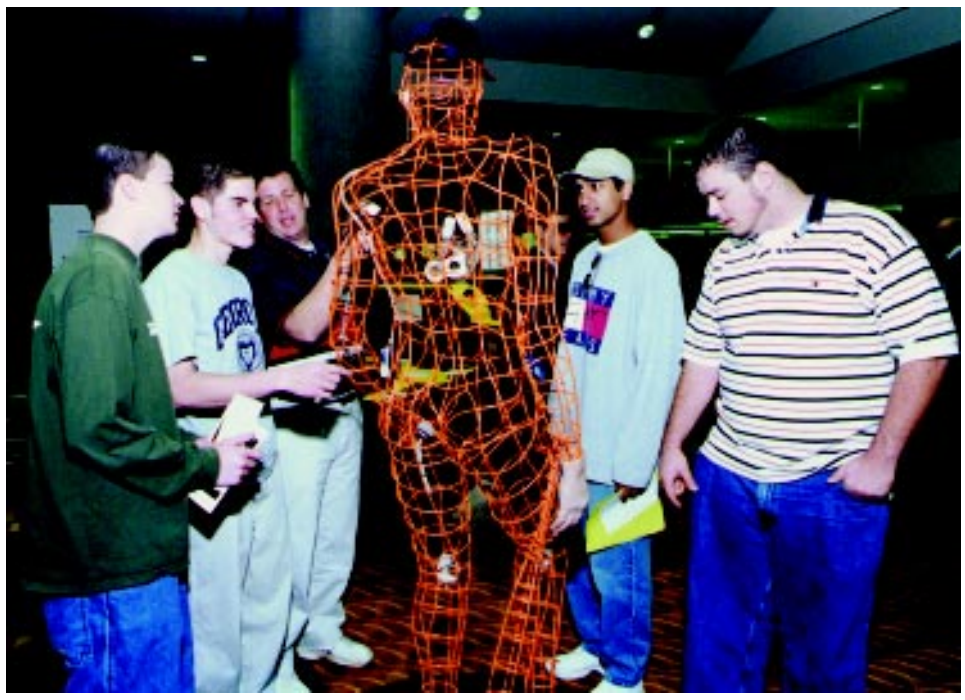
# PHYSICS WORKS! — An Interactive Exhibit for Everyone

Sara Schechner, *Curator*

David Ehrenstein, *Physics Advisor*

Edward Finkel, *Interactives*

Puches Design, *Design*



**At right:** A human form sculpture features artificial joints, skin, and transplant devices that draw on materials physics, electronics, and acoustics.

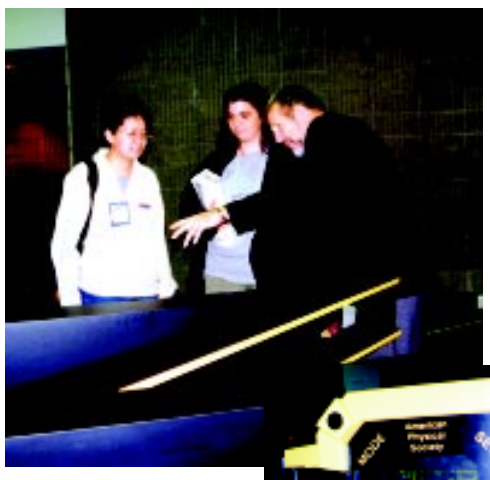
Physics Works! is divided into four parts — Physics Explores the Wonders of Nature, Physics Saves Lives, Physics Drives Technology, and Physics Looks to the Future — each of which illustrates basic discoveries and principles through a large representational component or hands-on interactive element. It emphasizes the importance of physics in our daily lives. A traveling exhibition, Physics Works! will be at the Don Harrington Discovery Center in Amarillo, Texas, through January 2000 and then move to the Fernbank Museum of Natural History in Atlanta (tentative).

**Below:** High school students take a seat in a giant quantum corral as they explore the atomic world.

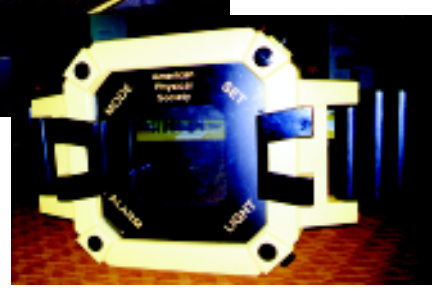
**Above:** Students learn about interactive medical imaging with the thermoscope infrared hand viewer: namely, that all things (even humans!) give off electromagnetic radiation.

**At right:** The 'particle pinball' machine gives a hands-on illustration of how scientists learn about objects that cannot be directly seen by bombarding them with particle beams.

**Above:** The 'crazy' (chaotic) pendulum encourages visitors to pull the pendulum bob and try and predict the unpredictable.



**At left:** A laser speckle device demonstrates unique properties of coherent light.



**At right:** Physics research drives technology, as illustrated by this giant watch with liquid crystal face. Displayed on its reverse are a number of everyday items made possible through physics research.

*For information on booking the exhibit, contact Brian Bonnar: bonnar@aps.org.*

# Physicists To Be Honored at November Unit Meetings

Five physicists will be honored for their work in plasma physics and fluid dynamics in November. The 1999 James Clerk Maxwell Prize, Excellence in Plasma Physics Award, and Outstanding Doctoral Thesis in Plasma Physics Award will be presented during the annual fall meeting of the APS Division of Plasma Physics in Seattle, WA. The 1999 Fluid Dynamics Prize and Otto Laporte Award will be presented during the annual fall meeting of the APS Division of Fluid Dynamics in New Orleans, LA.

## JAMES CLERK MAXWELL PRIZE FOR PLASMA PHYSICS

Established in 1975 and supported by Maxwell Technologies, Inc., the Maxwell Prize recognizes outstanding contributions to the field of plasma physics.

**John Bryan Taylor**

*Culham Laboratory*

**Citation:** *"For ground breaking research, distinguished by its ingenuity and clarity, in such topics as: relaxation theory, transport, finite Larmor radius effects, the minimum-B concept, adiabatic invariance, the standard map, bootstrap currents, the ballooning representation, and confinement scaling laws."*

Taylor received his PhD (1955) from Birmingham University. He joined the Atomic Weapons Research Establishment Aldermaston and in 1962 moved to Culham Laboratory, where he became chief physicist. In 1989 he was appointed Fondren Professor of Plasma Theory at the University of Texas at Austin. Perhaps his most celebrated contribution is the introduction of plasma relaxation theory, which combines plasma turbulence and magnetic helicity to predict, from first principles, many features of plasma behavior. He is a recipient of the 1986 APS Award for Excellence in Plasma Physics.

## EXCELLENCE IN PLASMA PHYSICS RESEARCH AWARD

Established in 1981 by donations from friends of the Division of Plasma Physics, this award recognizes a particular recent outstanding achievement in plasma physics research.

**Raymond A. Fonck**

*University of Wisconsin, Madison*

**Citation:** *"For his implementation, development, and exploitation of Beam Emission Spectroscopy for measuring fluctuations and their relations to anomalous transport in hot, fusion-relevant plasmas."*

Fonck earned his PhD in 1978 from the University of Wisconsin, Madison, where he is currently a professor of engineering physics. He is an experimental physicist with research interests in plasma and fusion science, atomic processes in high-temperature plasmas, and diagnostic instrumentation. He has developed a variety of diagnostic techniques for measuring the particle and energy content and the stability of very-high-temperature plasmas.

## OUTSTANDING DOCTORAL THESIS IN PLASMA PHYSICS AWARD

Established in 1985 and endowed by General Atomics, this award recognizes young scientists whose doctoral thesis work is of outstanding quality and achievement in the area of plasma physics.

**Thomas R. Clarke**

*University of Maryland*

**Citation:** *"For his comprehensive elucidation of the hydrodynamics and the optical mode structure of the plasma waveguide."*

Thomas R. Clark, Jr. received his PhD in physics from the University of Maryland at College Park in 1998. In 1998 he joined the Optical Sciences Division of the Naval Research Laboratory, Washington, DC as a research physicist. His current research interests are in the development of low noise ultrafast fiber laser systems, photonic analog-digital conversion, high-speed photonic devices, and noise characterization of photonic systems. Dr. Clark is a member of Sigma Pi Sigma, the Optical Society of America and the American Physical Society.

## FLUID DYNAMICS PRIZE

Established in 1979 and supported by the AIP journal *Physics of Fluids*, the prize recognizes and encourages outstanding achievements in fluid dynamics research.

**Daniel D. Joseph**

*University of Minnesota*

**Citation:** *"In recognition of the broad range of his contributions to the stability and bifurcation of fluid flows, rheological fluid mechanics, and fluid mechanics of problems involving solid-liquid boundaries."*

Joseph earned his PhD in mechanical engineering from the Illinois Institute of Technology in 1963 and promptly joined the faculty of the University of Minnesota, where he is currently the Russell J. Penrose Professor of aerospace engineering and mechanics. His current research interests include the aerodynamic breakup of Newtonian and non-Newtonian fluids in high-speed flows, foam control using a fluidized bed, and cavitation and the state of stress in a flowing liquid.

## OTTO LAPORTE AWARD

The LaPorte Award was established in 1985 to recognize important advances in fluid dynamics.

**Eli Reshotko**

*Case Western Reserve University*

**Citation:** *"For lasting contributions and leadership to the understanding of transition to turbulence in high-speed flows and non-homogenous flows."*

Following completion of his undergraduate degree in mechanical engineering at Cooper Union in New York City, Reshotko worked at NASA's Lewis Flight Propulsion Laboratory and spent a summer at the Jet Propulsion Laboratory in Pasadena before earning his PhD in aeronautics and physics from CalTech in 1960. He then rejoined the staff of the Lewis Research Center until 1964, when he joined the faculty of Case Western Reserve UniversityHe is presently vice chair of the APS Division of Fluid Dynamics.

# Announcements

## OUTSTANDING DOCTORAL THESIS RESEARCH IN ATOMIC, MOLECULAR, OR OPTICAL PHYSICS

Sponsored by members and friends of the Division of Atomic, Molecular and Optical Physics.

*Deadline:* The deadline for submission of nominations is **DECEMBER 6, 1999.**

Send the name of candidate, biographical information and supporting letters to Eric Cornell, JILA, Campus Box 440, Boulder, CO 80309-0440, Phone: (303) 492-4763, Fax: (303) 492-5235, email: cornell@jila.colorado.edu. Also visit: http://www.aps.org/praw/dissdamo/descrip.html for more detail.

## APS Mass Media Fellowship Program

Applications are now being accepted for the 2000 summer APS Mass Media Fellowships. In affiliation with the popular AAAS program, the APS is sponsoring two ten-week fellowships for physics students to work full-time over the summer as reporters, researchers, and production assistants in mass media organizations nationwide.

**PURPOSE:** The program is intended to improve public understanding and appreciation of science and technology, and to sharpen the ability of the fellows to communicate complex technical issues to non-specialists.

**ELIGIBILITY:** Priority will be given to graduate students in physics, or a closely related field, although applications will also be considered from outstanding undergraduates and post- doctoral researchers. Applicants should possess outstanding written and oral communication skills and a strong interest in learning about the media.

**TERM AND STIPEND:** Following an intensive three-day orientation in early June 1999 at the AAAS in Washington, DC, winning candidates will work full-time through mid-August. Remuneration is **$4500**, plus a travel allowance of up to $1,000.

Mail application materials, which must be received by **January 15, 1999**, to:

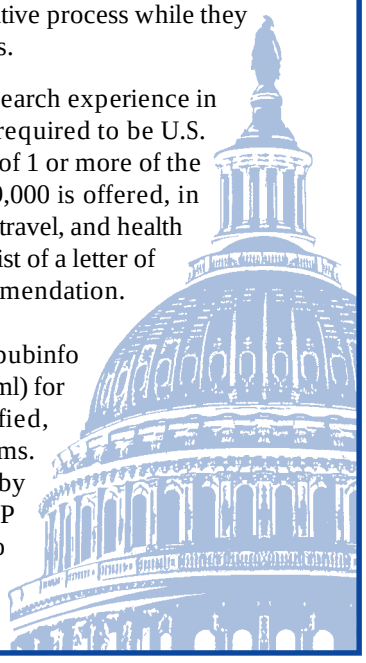
APS Washington Office
ATTN: Mass Media Fellowship Program
529 14th Street NW, Suite 1050
Washington, DC 20045

Information on application requirements can be found at http://www.aps.org/public_affairs/Media.html

## APS/AIP 2000-2001 CONGRESSIONAL SCIENCE FELLOWSHIP PROGRAM

**The American Physical Society and the American Institute of Physics** are accepting applications for their 2000-2001 Congressional Science Fellowship Programs. Fellows serve one year on the staff of a Member of Congress or congressional committee, learning the legislative process while they lend scientific expertise to public policy issues.

**Qualifications** include a PhD or equivalent research experience in physics or a closely related field. Fellows are required to be U.S. citizens and, for the AIP Fellowship, members of 1 or more of the AIP Member Societies. A stipend of up to $49,000 is offered, in addition to allowances for relocation, in-service travel, and health insurance premiums. Applications should consist of a letter of intent, a 2-page resume, and 3 letters of recommendation.



**Please see** our websites (http://www.aip.org/pubinfo or http://www.aps.org/public_affairs/fellow.html) for detailed information on applying. If qualified, applicants will be considered for both programs. All application materials must be postmarked by January 15, 2000, and sent to: APS/AIP Congressional Science Fellowship Programs, c/o Erika Ridgeway/APS Executive Office One Physics Ellipse, College Park, MD 20740-3844.

## CAUGHT IN THE WEB

*Notable information on the APS Web Server.*

**The Microbe Zoo: commtechlab.msu.edu/sites/dlc-me/zoo**
**Acoustics of Mayan Architecture: www.salon.com/books/it/1999/09/15/quetzal/index2.html**
**A Century of Physics timeline: timeline.aps.org**
**Playground Physics: www.aps.org/playground.html**
**Phys. Rev. Focus: focus.aps.org**
**Media Relations: www.aps.org/media**
**Physics Limericks: www.aps.org/apsnews/limericks.html**
**Amazon Books: www.aps.org/memb/amazon**
**100 Years of the APS - Exhibit & History: www.aps.org/apsnews/history.html**

## APS SEEKS ASSOCIATE EXECUTIVE OFFICER

The American Physical Society is seeking applications and nominations for the position of Associate Executive Officer. The primary responsibility of the Associate Executive Officer is to work with the Executive Officer to coordinate and enhance APS programs and activities. It is expected that the person selected will play a leadership role in APS efforts to communicate with the public and with APS members and act as editor of *APS News*, both paper and online versions. Other responsibilities may include the administration of APS awards and fellowship programs, working with APS divisions, sections, forums and topical groups, and initiating new programs to serve APS member needs. Qualifications for the position include a PhD in physics or a related field, extensive familiarity with the physics community, and excellent communication skills. APS offers a competitive salary and an outstanding benefits packet. For consideration, send a cover letter, resume, and professional references to Judy Franz, Executive Officer, APS, One Physics Ellipse, College Park, MD 20740, fax: 301-209-0865, email: **franz@aps.org**. For further information, don't hesitate to send an email message or call: 301-209-3270.

## DOE Offers Grants for Junior Faculty in Plasma Physics

The DOE Office of Fusion Energy Sciences is accepting applications for support under its Plasma Physics Junior Development Program, intended to support the development of the individual research programs of exceptionally talented scientists and engineers early in their careers. The application deadline is January 20, 2000, and submissions are welcome from tenure-track faculty investigators who are currently involved in experimental or theoretical plasma physics research. For further information and application instructions, contact Dr. Ronald McKnight, U.S. Department of Energy, Office of Fusion Energy Sciences, Science Division, SC-55 (GTN), 19901 Germantown Road, Germantown, MD 20874-1290; 301-903-4597; ronald.mcknight@science.doe.gov

## DPP Distinguished Lecturers 1999-2000

The APS Division of Plasma Physics has announced the Second Annual Distinguished Lecturers for Plasma Physics Program for 1999-2000. The Program is intended to share with the larger scientific community exciting recent advances in plasma physics. The following lecturers were selected by the DPP and each one has agreed to present up to half a dozen lectures at no cost to a university.

**Dr. Jill Dahlburg, *Naval Research Laboratory***
The Effect of the Rayleigh-Taylor Instability on Inertial Confinement Fusion Research

**Professor James Drake, *University of Maryland***
Magnetic Reconnection: Explosions in Laboratory and Astrophysical Plasma

**Professor Fred C. Driscoll, *University of California, San Diego***
Pure Electron Plasmas: From Ideal 2D Fluids to Crystallized Molasses

**Professor Walter Gekelman, *University of California, Los Angeles***
Phantom in the Vacuum: Laboratory Experiments on Space Plasmas

**Dr. Dale Meade, *Princeton Plasma Physics Laboratory***
Confining a Fusion Fire - A Grand Challenge for Science and Technology

The DPP travel grant program is funded by the Department of Energy and is designed to reach out beyond those universities that already have a strong plasma physics program. Further information about the Plasma Travel Grant Program can be obtained from the DPP Homepage (http://w3fusion.ph.utexas.edu/aps) or from the Chair of the DPP Science Education Committee: Dr. Thomas Simonen, General Atomics, Phone: 619-455-3522, Email: simonen@gav.gat.com

## Discounted Auto Insurance Added to Member Benefits

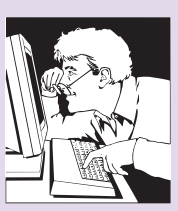
The APS has entered into an agreement with GEICO, a leading auto insurer, to provide members with a preferred rate. With a current or new GEICO Preferred auto insurance policy, mention your APS membership number (listed on the first line of your *APS News* mailing label) and, in most states, GEICO will give you an extra 8% discount.* The savings will cover the cost of annual APS dues in most cases. In addition to savings, GEICO offers convenient 24-hour service from a professional representative for rate quotes, claims, or questions. When you qualify, you'll get coverage tailored to your personal needs and a choice of payment plans.

All it takes is a quick call to GEICO Preferred at: 1-800-368-2734 or a visit to their web site at: www.geico.com.

**Discount is 10% in CA, DC, and IL; 3% in NY; not available in all states. Discount is not available in GEICO Indemnity Company or GEICO Casualty Company. One group discount applicable per policy. Government Employees Insurance Co. GEICO General Insurance Co. GEICO Indemnity Co. GEICO Casualty Co. These shareholder-owned companies are not affiliated with the U.S. Government. GEICO Auto Insurance is not available in MA , NJ or outside the U.S.*

## MAKE SURE WE HAVE IT RIGHT!

The *2000-2001 APS Member Directory* will be compiled in January 2000. Please check your directory listing online (www.aps.org/memb) or on your latest member invoice and forward any necessary changes to coa@aps.org. Updates may also be given to a Membership Representative at 301-209-3280 or faxed to 301-209-0867. All requests should be received no later than December 17, 1999.



# THE BACK PAGE

## Balancing National Security Concerns with Scientific Openness

*by Michael May*

There has been a recent flurry of committee reports and public statements — the Cox Committee Report, the Rudman Report, and the Zachariah report, among others — pointing to alleged security deficiencies at some US defense and space contractors and at the US nuclear weapons laboratories. Specifically, it is alleged that a cleared Los Alamos employee, a US citizen of Chinese origin, has given secrets to China; that China is using or trying to use all US residents of Chinese origin to steal secrets; that US firms such as Loral and Hughes have passed secret or sensitive missile guidance technologies to China in the course of using Chinese missile launch facilities; and that the Department of Energy (DOE) has for many years stonewalled efforts by its own leadership and by others to remedy faulty security procedures.

The accusations against individuals have been contested and are not publicly documented. Several individuals involved in the investigations have testified that racial prejudice played a role in the investigations. Bureaucratic and other politics clearly played a role as well. Many of the technical and historical specifics that have been released are wrong.

Any enquiry into the subject of scientific openness and national security, but any strategy must take the present political environment into account. However, it must also take into account our earlier long-term experience with balancing national security and scientific openness, our goals in carrying out this balancing, and our successes and failures in the attempt. This earlier experience tells us a different story and counsels a different strategy from the story and strategy we might derive from the headlines.

The first thing history tells us is that the US has been extraordinarily successful in applying science and engineering to defense, space and other military systems. The missteps and false starts of course made headlines, but the relentless, open criticism of mistakes and failures is part of the reason for the US success. Today our defense technology is the best in the world.

The second thing history tells us is that the US has run by far the most open defense R&D establishment in the world. The openness is directly connected with our success. Immigrants, refugees, and foreign-born citizens have been welcomed into the most secret circles of classified R&D, and they have made pivotal contributions — specifically in the fields of nuclear weapons and missile technologies, where openness is currently under attack.

The US has repeatedly told the world what it was doing and why. We have debated the most delicate of defense matters in the most public of manner. We have taken the lead in sponsoring international meetings, arms control measures and other initiatives which require international technical interaction. We have sent our cleared scientists and engineers freely all over the world. No one else does quite the same thing.

It might seem to some as if the US were allowing others to catch up. But, if so, why haven't they caught up? The US has done this from the early years following World War II. Not only have the others not caught up, they have fallen further and further behind, not in civilian technologies, but precisely in the defense technologies we are talking about today.

Why has this happened? The very large US investment in science and technology is certainly a principal reason, but it can't be the whole reason. Why have others not taken advantage of our investments to take a shortcut and get ahead? Why did the Soviet Union, with its large spying apparatus, its extensive secrecy, and its very large investments in defense, never come close?

Visiting the Soviet Union in the old days showed what was happening. They had barriers between laboratories and design bureaus, barriers between ministries, between cleared and uncleared scientists. Heaven forbid that Soviet cleared scientists should talk with foreigners. As a result, they wound up not taking advantage of their best ideas. In many cases, we did. Many of these barriers exist to a lesser extent in other countries.

Large investments were essential to the US lead but they were not enough. Some of our large investments were huge mistakes. Open criticism and input from people outside the cleared communities have been essential to put us on the right track. These interactions are even more badly needed today when so much is happening outside the defense science and engineering communities. They are essential in the weapons laboratories, to support the changing science and technology base of the classified projects, to carry out such international tasks as fissile material control and arms control verification, and to retain and hire good scientists and engineers. In the missile business, where American firms must both remain in the lead in their defense tasks, and also field competitive commercial systems such as satellite packages, interaction is even more essential.

What is the right strategy for scientific and engineering organizations to pursue in order to help in the current debate? First, as many people have noted, the alleged breaches of security are not connected with interactions of cleared personnel with the general global science and engineering community. Neither do they involve the spread of unclassified information. The relevant allegations involve cleared US citizens and matters like the design of nuclear weapons, which, by any standard, should be kept secret. Let's put our efforts where the problems have been.

Second, to protect essential secrets and at the same time interact with both foreigners and the American scientific and engineering communities at large, defense personnel must have clear and sensible guidance. That's the way it's been in the past. A clear line used to be drawn around the information that could and should be kept secret, with some margin so that this information would not be partially given away by its boundary.

This clear distinction is being lost. A fog has descended on what used to be a useful workable boundary. New categories are being defined or redefined which blur that boundary and will make it difficult or impossible to carry out technical interactions. Material which has long been in textbooks around the world, such as the fusion cross-section of tritium1, or basic missile guidance principles, may now require a permit for discussion, with heavy penalties to be imposed if unclassified information, generally available but deemed sensitive, is inadvertently released.

This trend must be turned around. It leads to a situation that will not be workable for either technical people or for professional security people. It is the contrary of what the US has done in the past, and much closer to what the Soviet Union and other police states have done. It will hurt not only the scientific and engineering communities, but also the students and the people at large. It won't hurt the spies.

Third, spies are caught through good line leadership and good security work. Security professionals have repeatedly caught spies. The last bunch came to public attention about ten years ago. None of the constraints now being discussed would have helped catch them. But those constraints will hurt the work of security people by diffusing their responsibilities and by damaging their relationship with the technical community, a relationship which up to now has been good, and which is essential if the counter-intelligence people are to do their work.

The other part of good security is a responsible and empowered line leadership, in Washington and in the field. Laboratory directors, company presidents and agency heads should be responsible and empowered to maintain security, just as they should be responsible to maintain operational safety, meet environmental standards, follow the laws and national policies in personnel practices, and do all the other things through which our technical enterprises discharge their responsibilities to the public at large. Of course, there must be effective monitoring and reporting outside line channels. But czars are useless.

I would suggest that a joint group of security professionals and people from the technical communities concerned help draft any needed new security procedures for interactions with the open communities and with foreigners; and that people who have a record of success in keeping the US ahead in the defense technology areas help draft any change in administrative and reporting structure. Clearly the political authorities will have the last word. But any new initiative, such as the new agency now under consideration, can be done in such a way as to help or hinder the basic objective of keeping the US ahead. The devil is in the details. This should not be just the result of a political compromise.

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Regarding export controls, the US no longer has an overall structure and philosophy for such detailed practices, which are often conflicting and self-defeating. It is no longer possible to have an export control policy as clear-cut as our Cold War policy. The US must cooperate, learn from and help countries that are partners in trade, in international initiatives of the first importance, and in many technically oriented matters, but which may also be now and again political, economic and military rivals. Nevertheless, some guiding principles of an exports control policy can be laid down. Detailed laws and regulations can then follow those principles, with frequent scheduled revisions to take care of changes.

Those guiding principles would include protecting what is key to our current military edge, which is first of all the people and teams involved, and also includes specific system design and test information. The people come first, both for technical achievement and for security. Another guiding principle is that the US, because it invests more, usually profits more from common knowledge, so it's to our advantage to increase the pool of common knowledge. Clear lines around what is essential to protect should be drawn, but outside those lines, we must allow for this common knowledge to grow.

Our system is to run wide open. We let all students come and learn, not just science and engineering, but a lot about how the US works and what the world outside their countries is like. We let our cleared scientists and engineers participate abroad, talk, listen, buy and sell. It's a great system for all, but we derive the greatest benefit from it. It's worked both to inform our people and press, and to put our defense technology ahead of everybody else's. Other nations have used the system of suspicion, widespread secrecy, and "gotchas." Look where they are today. Let's not let inevitable rivalries cause us to trade our system for theirs.

*Michael May is a professor of research in the school of Engineering at Stanford University. This article was adapted from a talk delivered to the American Association for the Advancement of Science on August 31, 1999, in Washington, DC.*

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