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APS GENERAL ELECTION PREVIEW ON PAGES 6, 7

From Big G to Extra Dimensions

Gravity Measurements Reported at APS Long Beach Meeting

The APS April meeting in Long Beach was an event marked by gravity, judging by the top science stories that emerged from the four-day conference. Two separate teams of scientists from the University of Washington announced both the best measurement of the gravitational constant obtained thus far, and the first measurement of gravity at the submillimeter scale.

UW Scientists Announce Best Measurement of G

By far the most widely covered research result at the APS April Meeting was the announcement of a long-awaited higher precision measurement of the gravitational constant (affectionately known as "Big G" among physicists) by Jens Gundlach of the University of Washington. Although G has been of fundamental importance to physics and astronomy ever since it was introduced by Isaac Newton in the seventeenth century (the gravitational force between two objects equals G times the masses of the two objects and divided by their distance apart squared), it has been relatively hard to measure, owing to the weakness of gravity.

The UW group has reduced the uncertainty in the value of G by almost a factor of ten. Their preliminary value is $G=6.67390 \times 10^{-11}$ $m^3/kg/s^2$ with an uncertainty of 0.0014%. Combining this new value of G with measurements made with the Lageos satellite (which uses laser ranging to keep track of its orbital position to within a millimeter) permits the calculation of a brand new, highest precision mass for the earth: $5.97223 (+/- .00008) \times 10^{24}$ kg. Similarly the new mass of the sun becomes $1.98843 (+/- .00003) \times 10^{30}$ kg.

According to Gundlach, the setup is not unlike Cavendish's venerable torsion balance of two hundred years ago: a hanging pendulum is obliged to twist under the influence of some nearby test weights. But in the Washington experiment measurement uncertainties are greatly reduced by using a feedback mechanism to move the test weights, keeping pendulum twisting to a minimum.

Gravity at the Submillimeter Scale

Another team of scientists at the University of Washington has succeeded in measuring gravity at the submillimeter scale for the first time. The force has long been studied over planetary distances but is more difficult to gauge at the terrestrial scale, where intrusive electric and magnetic fields, many orders of magnitude stronger than gravity fields, can be overwhelming. Nevertheless, Eric Adelberger and his UW colleagues have managed to measure the force of gravity over distances as small as 150 microns using a disk-shaped pendulum carefully suspended above another disk, with a

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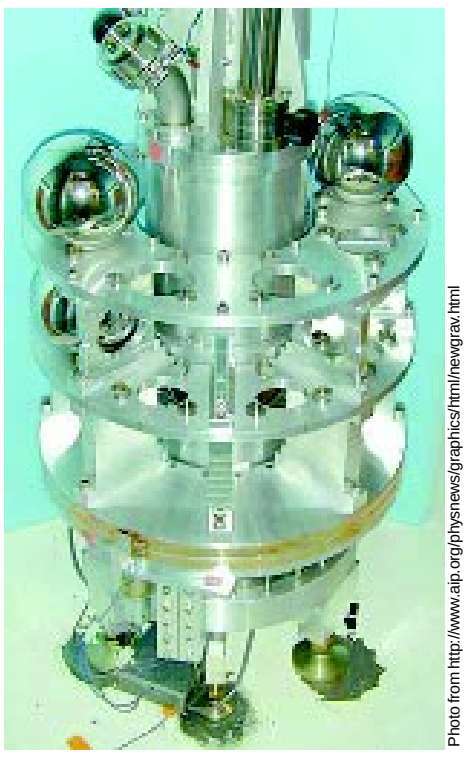

Photo from http://www.aip.org/physnews/graphics/html/newgrav.html

At left: The apparatus used by the research group at the University of Washington, Seattle, to measure G to record high precision. The device, about two feet across, measures the attraction between a hanging plate (hidden inside the cylinder) and several spheres which rotate about the cylinder.

CPU Study to Set Research Priorities at Interface of Physics, Astronomy

In the week just prior to the APS April Meeting in Long Beach, California, the Sloan Digital Sky survey found the most distant object in the universe, believed to be a quasar — an object 27 billion light years away in a universe that is only 14 billion light years old, making it an excellent teaching tool on the expanding universe as well as a significant scientific advance. That same week, the Boomerang Project, operated jointly by the NSF, NASA and the DOE, produced the first time-resolution maps of the cosmic background radiation, providing strong evidence for the prevailing cosmological theory that the universe is flat.

Both recent announcements are excellent examples of the exciting research taking pace at the intersection of physics and astronomy, said Michael Turner (University of Chicago) in a talk given at a special session of the April Meeting. He is the chair of the National Academy of Science's Committee on the Physics of the Universe (CPU). Jointly funded by the NSF, the DOE and NASA, the committee is charged with assessing the area of science between the two fields, providing a broad vision extending beyond traditional categories of space missions, laboratory studies, telescope observations and accelerator experiments. Specifically, it will address opportunities to explore new science through new techniques for observing phenomena in extreme environments and new regimes; new applications of fundamental physics to modeling and simulating the origin, evolution and fate of the universe; and understanding fundamental physics by using space and the cosmos as a laboratory full of experiments that could never be implemented on Earth.

"One of the problems of this field is that many of the research directions are of secondary interest in the context purely of either physics or astronomy," says Turner of the need for such a study. "But in a context that includes the interest of both fields, many of the issues are among the most profound and far reaching questions that science can address."

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Congressional Visits Foster Communication Between Physicists and the Hill

Sixteen APS members descended on the nation's capital during cherry blossom season in April to participate in Congressional visits that were intended to foster communication between the physics community and their Congressional representatives, to educate Congress about the importance of science funding, and to acquaint researchers with the legislative process.

John Clarke (University of California, Berkeley), chair of the Division of Condensed Matter Physics, discussed the role of physics in the economy, medicine, education, and the future prosperity of the U.S. Frances Hellman (University of California, San Diego), past chair of the Division of Materials Physics, also addressed the importance of science funding as an investment in the national economy, and provided staffers with information packets on how physics has impacted our daily lives, and the potential of nanotechnology.

Patricia Mooney (IBM/T.J. Watson Research Center), the current DMP chair, extended the theme to focus on how developments in medical technology often depend upon developments in other fields, such as telecommunications or information technology, or derive from fundamental work in physics and chemistry, as was the case with MRI. She also discussed the importance of having a balanced budget program for research in the various agencies. And while special initiatives, such as the proposed nanotechnology initiative (see *APS News*, May 2000), are also important, "The core programs need to be supported as well, to ensure there is a pool of active scientists to draw from for such initiatives, which are multidisciplinary and also short term," she says.

Some participants focused on more specific regional concerns that they could personally address in detail. For example, Mark Coffey of the University of Colorado, Boulder, discussed the heavy reliance of the aerospace industry on both fundamental science and technological advances with the Colorado congressional delegation, since the state has a sizable presence of several of the nation's largest aerospace contractors. Such aerospace firms, along with many other high technology companies in the area, also have substantial investments and interest in the latest computing technologies and algorithms.

> "We need to communicate that we care about R&D funding."

Most participants surveyed felt the experience was useful and said they would participate again, although Clarke believes there should be more ongoing follow-up after the visits themselves."Such an effort is incremental, and above all entails initiating and establishing a rapport with staffers, congresspersons, and a variety of others," agrees Coffey, who decided to participate to extend his knowledge of how the legislative process works. "The scientific interests of constituents need to be

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Inside...

One Man's Crusade to Exonerate Hydrogen for the Hindenburg Disaster

The perceived dangers of hydrogen are irretrievably linked in the public mind with the tragic fate of the Hindenburg airship, which burst into flames in May 1937, killing 36 of the 97 people on board. Common lore attributes the disaster to the inherent flammability of the gas, a claim repeated in the Back Page article, "Top Twenty Technological Screw-Ups" by Marc Abraham (see *APS News*, May 2000). Alert *APS News* readers Michael Heben (National Renewable Energy Laboratory) and Martin Sage (Syracuse University) both wrote in to object to the continued vilification of hydrogen, and to praise the nearly 30-year crusade of retired NASA scientist Addison Bain, who eventually uncovered important new facts about the blaze.

Image from http://www.geocities.com/Area51/Zone/5942/hindenburg_index.html; inset image from http://www.fsec.ucf.edu/bain.htm

Addison Bain (inset) and the Hindenburg's final moments.

Bain's hunt for the truth about the Hindenburg began in the late 1960s, when he was working on hydrogen systems. The Hindenburg was frequently used as an example in hydrogen safety manuals, but the reported observations of the incident were inconsistent. For example, Bain noticed that the fire burned rapidly in many directions, the zeppelin remained aloft and upright for many seconds after the initial flames were seen, and the flames were bright — none of which are consistent with a hydrogen explosion. He spent large chunks of time researching original documentation of the disaster, which was enough to convince him that the airship's materials had contributed to the ignition of the blaze, but he lacked solid evidence to prove his theory.

Finally, in 1994 Bain obtained samples of the fabric that had covered the Hindenburg and had a volunteer team of scientists analyze them using a variety of physical and chemical techniques, including an infrared spectrograph and a scanning electron microscope, which provided the chemical signatures of the organic compounds and elements present. His conclusion: the source of the fire was the use of lacquers and metal-based paints on the outer hull and bladders, which were ignited by an electrical discharge. "I guess the moral of the story is, don't paint your airship with rocket fuel," Bain said at the time of announcing his discovery.

Ironically, Bain's findings are not well-known, and hence most scientists and members of the public persist in the uncritical belief that hydrogen caused the Hindenburg blaze. Both Heben and Sage believe that this prejudice undermines recent interest in using hydrogen as a fuel and energy storage medium. As Heben wrote, "The distribution of unsubstantiated and incorrect lore regarding this incident greatly harms the world-wide efforts to develop hydrogen technologies for the replacement of fossil fuel."

We stand corrected.

This Month in Physics History

July 5, 1687: Publication of Sir Isaac Newton's Principia

The son of a yeoman farmer in Lincolnshire, England, Isaac Newton was educated in science and mathematics at Cambridge University, earning his BA in 1665. He then returned home on account of the plague until 1666, and while there made several brilliant discoveries that would lay the groundwork for his monumental opus. For example, he thought out the fundamental principles of his theory of gravitation—namely, that every particle of matter attracts every other particle—and worked out the elements of fluxional calculus. He applied fluxions to find the tangent and radius of curvature at any point on a curve in November 1665, and used them to solve several problems in the theory of equations in October 1666. He also devised instruments for grinding lenses into particular forms other than spherical, which would later serve him in his study of optics.

In August 1684, more than a decade after Newton was elected Lucasian professor of mathematics, Edmund Halley came to Cambridge to consult with him about the law of gravitation, specifically seeking to resolve the question of whether the law of attraction was that of the inverse square, and, if so, what the orbit of a planet would be. Newton answered that it was an ellipse and sent a demonstration of his findings that November, also working out the substance of several propositions in the first book of the *Principia*. These, along with notes on the laws of motion, were published by the Royal Society in February 1685 as the paper *De Motu*.

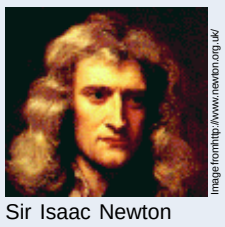

Image from http://www.newton.org.uk/

Sir Isaac Newton

Spurred on by Halley's visit, Newton undertook to attack the whole problem of gravitation and publish his results. Of the three fundamental principles applied in the *Principia*, it is generally agreed by science historians that the notion that every particle attracts every other particle in the universe was formed as early as 1666. The law of equable description of areas, and the fact that if the law of attraction were that of an inverse square the orbit of a particle about the center of force would be conic were proved in 1669. Finally, the discovery that a sphere attracts an external point as if the whole mass were collected in its center was made in 1685.

The draft of the first book was completed before the summer of 1685, although it was not presented to the Royal Society until April 1686, and covers the motion of particles or bodies in free space. The second book was completed by the summer of 1686, and treats the concept of motion in a resisting medium, as well as hydrostatics and hydrodynamics, with special applications to waves, tides, and acoustics. Newton spent the next 10 months writing the third book of the *Principia*, applying the theorems of the first book to the chief phenomena of the solar system to determine the masses and distances of the planets and their satellites.

Financed primarily by Halley, the actual printing of the entire work was not completed until the summer of 1687. While nearly all competent critics admitted the validity of Newton's conclusions, it took some time before the findings in the *Principia* altered prevailing beliefs of educated men; in fact, it was nearly half a century before his work was completely assimilated into the field of mathematics. Within 10 years of its publication, it was generally accepted in Britain as giving a correct account of the laws of the universe, and similarly accepted on the European continent within 20 years, except in France, which clung to the Cartesian hypothesis until 1738, when Newtonian theory was championed by Voltaire.

The man who stood on the shoulders of giants died at Kensington, London, on March 20, 1727, and is buried at Westminster Abbey, but his influence on science and mathematics remained unparalleled until the onset of the 20th century. Lagrange described the *Principia* as the greatest production of the human mind, admitting to feeling dazed at such an illustration of what man's intellect might be capable. Gauss, who used the Latin *magnus* or *clarus* for other great mathematicians or philosophers, reserved the prefix *summus* for Newton alone.

Newton himself was much more modest when estimating his own work. "I do not know what I may appear to the world," he wrote. "But to myself I seem to have been only like a boy, playing on the seashore and diverting myself, in now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

Birthdays for July:

5 Gerard 't Hooft (1946)
17 Georges Lemaitre (1894)
18 Hendrik A. Lorentz (1853)
28 Pavel A. Cerenkov (1904)

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Physicists, Educators Share Experiences at HS Teacher's Day

Isolation can be a serious problem for many high school physics teachers: isolation from their fellow physics teachers, from current research discoveries and physics applications, and from new developments in education-related research and new instructional materials.

According to Ted Schultz of the APS Education and Outreach Department, helping high school physics teachers to break through this isolation was the primary purpose for the High School Teacher's Days held at both the March and April meetings of the APS.

At the March meeting, sixty-one high school physics teachers from the Twin Cities region convened at the Minneapolis Hilton to hear presentations on cutting-edge physics research, attend hands-on workshops on ways of teaching physics, and mingle during a buffet breakfast and lunch with research physicists and science educators to share their experiences.

The presentations on cutting-edge research centered on condensed matter physics, in keeping with the major focus of the APS March Meeting. Moungi Bawendi of MIT's Chemistry Department spoke on fluorescent quantum dots and their potential applications, while Princeton University's Paul Chaikin reported on his studies of the packing of hard spheres, using lasers, cleverly selected polymers, and the Space Shuttle as a venue for some of the experiments. After Chaikin's talk, the visiting high school teachers had the opportunity for hands-on activities and to take samples of these spheres back to their classrooms for further investigations.

Two of the hands-on workshops were based on teaching materials developed by Larry Woolf, a condensed matter experimentalist at General Atomics in San Diego, CA. One on electrical resistivity and resistance used only a graphite pencil, a piezoelectric spark generator, and a piece of paper; and one on color used color strips, wheels, cubes, and diagrams. The third workshop was presented by Ken Heller, professor of physics at the University of Minnesota, together with his wife, Pat Heller, associate professor at UM's College of Education and Human Development, and Laura McCullough, a graduate student in the same department. They brought nine desktop computer systems so participants could try out the Constructing Physics Understanding (CPU) software, produced in a project co-directed by Pat Heller. This software enables students to learn introductory physics by working through detailed simulations of phenomena.

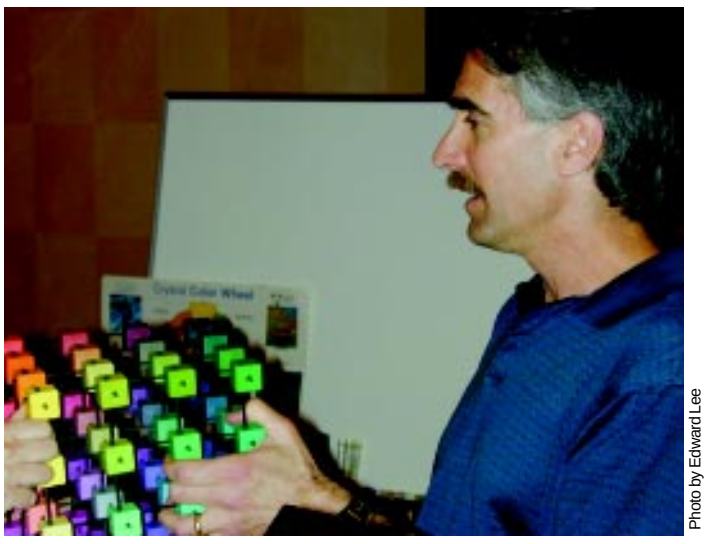

Photo by Edward Lee

Instructor Larry Woolf, from General Atomic, was one of many who presented workshops at Teacher's Day.

A fourth hands-on workshop was presented by Russell Hobbie, professor emeritus in UM's physics department and an expert in medical applications of physics, John Koser, an adjunct lecturer in the physics department at the University of St. Thomas, and Terry Goerke, a local high school physics teacher. They involved participants in several activities from the Medicine unit of *Active Physics*, which all three had developed.

As successful as the event proved to be on its own, Schultz and co-worker Ed Lee in the Education and Outreach Department are dedicated to ensuring that such days have a more lasting effect on high school teachers. To that end, they met with six of the participating teachers who had expressed interest in helping achieve this goal — preferably through the formation of a strong local alliance between high-school and college-level physics teachers in the Twin Cities region. The APS created more than 100 such alliances around the country several years ago through a separate NSF supported program. Schultz said the hope is that the alliance in the Twin Cities region would meet periodically for mini Teacher's Days, including a physics talk by a research physicist in the region and a teaching workshop.

The APS April meeting in Long Beach, CA, featured Michael Turner, chairman of the Department of Astronomy and Astrophysics at the University of Chicago, who gave a presentation on dark matter and dark energy. Chris McCarthy, a graduate student at UCLA and a former member of the Butler-Marcy collaboration, reported on extra-solar planets — two such planets have only recently been discovered, with strong prospects for future discoveries.

In addition, Larry Woolf was on hand in the wake of his success in Minneapolis with his hands-on workshops on resistivity and color, along with Fred Goldberg, a well-known physicist and science educator from San Diego State University, who presented the CPU program, which was also on the agenda at the Teacher's Day in Minneapolis. CPU is the product of a long-term project that Goldberg co-directs with Pat Heller. Ron Stevens of UCLA Medical School's Department of Microbiology and Immunology presented a fourth workshop in which participating teachers had the opportunity to work with novel Web-based computer software for testing and analyzing the way students solve problems. "We expect that many of these teachers will wish to experiment with these programs in their classrooms and that some will develop software specific to problem solving in various areas of physics," said Schultz.

Gravity Measurements Reported, *continued from page 1*

copper membrane stretched between them to help isolate electrical forces.

The subject of short-range gravity has recently attracted much theoretical and experimental interest owing to a relatively new model which supposes the existence of extra spatial dimensions in which gravity, but not other forces, might be operating. According to Nima Arkani-Hamed of LBL, this is why gravity is so weak: it dilutes itself in the extra dimensions. In other words, ordinary particles are tethered to our conventional spacetime, or "brane," while gravitons are free to roam into otherwise unseeable dimensions.

One implication of the model, testable with tabletop experiments such as Adelberger's, is that the gravitational force might depart from Newton's inverse square law (gravity inversely proportional to the square of the distance between two objects) at close range. Adelberger did not observe such a departure at distances down to tenths of a millimeter and will continue to explore even shorter distances. (*For a list of tabletop experiments underway, see http://gravity.phys.psu.edu/mog/mog15/node12.html.*)

Another interesting implication of the model introduced by Arkani-Hamed and collaborators two years ago is that the unification of the four known forces would not necessarily occur at energies as high as 10^{19} GeV but possibly at energies as low as 10^{4} GeV, an energy scale within reach of the Large Hadron Collider under construction at CERN. Extra dimensions could, for example, manifest themselves in proton-proton collisions as an apparent disappearance of energy, implying that some of the collision energy had been converted into gravitons (the particle form of gravity) which then disappear into the extra dimensions. The gravitons produced in this way might come back into our conventional world of 3 spatial dimensions and decay into two photons.

Physicists have already looked for this kind of event. Gregory Landsberg of Brown University reported that at the D0 experiment at Fermilab some energetic two-photon events have been observed (including one in which the energy of the photons added up to 574 GeV, representing the highest composite mass ever seen in the D0 experiment) but not often enough to constitute evidence for extra dimensions. In fact this shortage of events has been translated into a lower limit of 1300 GeV for the energy at which a prospective unification of the forces could take place.

—Philip F. Schewe, AIP Public Information

Parent Seeks Professional Help

Editor's Note: *The following letter was received from Alan Levitt, a pharmacist who was somehow directed to us through his membership in AARP. We wonder whether any of our readers might have the right prescription for him.*

My son is in 10th grade right now. He just took the AP Physics exam and talks about a career as a Chemical Engineer. As his parent what should I tell him?

Thanks.

—Alan Levitt

CPU Study, *continued from page 1*

Among the broad-ranging topics to be covered are strong-field gravitational physics; the origin of high-energy cosmic rays; neutrino observations and their implications for the nature of supernovae and the dynamics of the Sun; black holes; and the condition of the universe moments after the Big Bang. "These phenomena provide unique cosmic experiments probing the laws of physics in regimes that are not accessible on Earth," says Turner. "Conversely, understanding these phenomena challenges our abilities to apply the laws of physics in new regimes."

Entitled "From Quarks to the Cosmos," the CPU study will cover the most fundamental aspects of cosmology, and will consist of two phases. Phase I, to be completed by the end of the year, will identify the scientific priorities of the field, drawing on the combined expertise of the distinguished committee members as well as input from the scientific community. Phase II of the study will focus on the more difficult task of setting priorities for the development of this emerging new interdisciplinary field, and devise mechanisms for evaluating future opportunities and fostering cooperation among the three agencies sponsoring the study. The entire 200-page final report is expected to be completed in January 2002.

"This study will, for the first time, examine and evaluate this fundamentally interdisciplinary science on its own merits and in a broad context encompassing both physics and astronomy," Turner says. "A common picture of how the various aspects of the field fit together will enable a smoother planning process, as well as better communication in the research community, while setting priorities will facilitate action on key requirements to realize the new opportunities outlined in the survey."

Members of the Committee on Physics of the Universe

Michael Turner, *University of Chicago (chair)*
Roger D. Blandford, *Caltech*
Sandra M. Faber, *University of California, Santa Cruz*
Thomas K. Gaisser, *University of Delaware*
Fiona Harrison, *Caltech*
John P. Huchra, *Harvard University*
Helen R. Quinn, *Stanford Linear Accelerator Center*
R.G. Hamish Robertson, *University of Washington*
Bernard Sadoulet, *University of California, Berkeley*
Frank J. Sciulli, *Columbia University*
David N. Spergel, *Princeton University*
J. Anthony Tyson, *Lucent Technologies*
Frank A. Wilczek, *MIT*
Clifford Will, *Washington University*
Bruce D. Winstein, *University of Chicago*

Community input is critical to the success of such a venture. Turner gave a similar presentation at the American Astronomical Society meeting last month to further foster awareness of the CPU study among physicists and astronomers, along with the first draft of the report. A third presentation is scheduled at the APS Division of Particles and Fields meeting at Ohio State University in August to solicit initial community input. Once the Phase I report is complete, formal public input on ideas and mission concepts will be sought through a series of fora, the first of which will be held at the AAS meeting in San Diego in January 2001.

The APS meeting in Washington in April 2001 will have sessions devoted to discussions of these issues as well.

OPINION

LETTERS

Garwin Responds to Charges of Partisanship

A May *APS News* letter, "Garwin's Objectivity Challenged" would have been more appropriate for an April 1 issue. Rather than being a "Democrat partisan," I am a registered Republican — appointed by Richard Nixon to his President's Science Advisory Committee.

My Back Page in February *APS News* presents my own views on the Comprehensive Test Ban Treaty; I am delighted with the extent to which the Administration shares them. On the other hand, the Administration's proposed National Missile Defense Program, which will be defeated by bomblets and balloon decoys, should be replaced by a local system to intercept North Korean ICBMs in boost phase. To paraphrase Bob Park, "These are not necessarily the views of the Administration or its opposition, but they should be."

Richard L. Garwin
Senior Fellow for S&T —Council on Foreign Relations; IBM Fellow Emeritus

More Readers Take Issue with Top 20 Tech Screw-ups

I don't want to second-guess the Ig Nobel Board on their choices for the Top Twenty Technological Screw-ups of the 20th Century (*APS News*, May 2000). However, the mixup between English and metric units that doomed NASA's Mars Climate Orbiter is my solid choice for number 21.

Don Lichtenberg
Indiana University

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I was interested in reading your list of the "Twenty Technological Screw-ups of the 20th Century" in the May *APS News*. Born in 1917, I well recall all but the first three.

But there is one you missed, one in which I was a reluctant participant. You did not include it, probably because the matter was thoroughly "hushed up" by the two major participants: General Electric Co. and the University of Chicago Physics Department, and because my article, "The Short Life of the Mesotron," relating the events, was rejected when I submitted it to *Physics Today* several years ago, on the unusual grounds that most of the other individuals involved were no longer alive to refute it — that, despite the fact that enough was published in APS journals to confirm its major points, that it was accompanied by a letter from my associate at the time, affirming its correctness, and that it had a "moral" for researchers who aspire to be Nobelists.

Briefly, it was a highly publicized "discovery" of accelerator-generated "mesotrons," in such large numbers that its "discoverer" claimed that a new type of energy-releasing chain reaction was possible. When the "discovery" was announced in the *New York Times* and in a symposium at the January 1946 meeting of the American Physical Society at Columbia University, the publicity was so intense that it was necessary to repeat the presentations later in the same day. There was very little notice, however, when a paper refuting those claims was presented later that same year. References to relevant published material occur in Phys. Rev. 71(10), 649-660 (1947).

George C. Baldwin
Santa Fe, New Mexico

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In his column, Top Twenty Technological Screw-ups of the 20th Century, Marc Abraham refers to the Y2K computer bug as one of the "Twenty Screw-ups," but his only comment on its "nature" is that it's "all too well known to turn-of-the-century readers." What does he mean by this? Does he mean the Y2K computer bug was a screw-up because it caused a lot of problems, or it was a screw-up because it didn't cause a lot of problems? It was predicted to be a "screw-up," but I think most "turn-of-the-century readers" would agree that it didn't really have any effect at all. In that case, the only thing we could call a "screw-up" is the people who thought it would cause a problem.

In reality, the Y2K computer bug belongs on the list of the "Top Twenty Predicted Screw-ups that Ended Up Doing Nothing At All." These would include:

1) The Y2K computer bug: No, grandma, your car's computer-controlled engine doesn't care what the date is.

2) El Niño: This and La Niña were designed to make the weather have star appeal, so the local news on one channel could compete with Entertainment Tonight on another channel.

3) Global Warming: So the Earth's temperature has gone up a degree in the last 100 years (maybe), but perhaps this is within the expected century-to-century fluctuation? No, we couldn't say that, because then the government wouldn't spend so much money keeping us scientists employed! So let's use our prestige as scientists to co-sign each other's blather and keep the cash flowing.

4) Space Lab: Remember the helmets people bought in the 70's because Space Lab or Sky Lab, whatever they called it, was going to fall down to Earth at an unknown location?

5) New York City Earthquake: Scientists predict an earthquake is possible in New York. Yeah, a Republican mayor is theoretically possible too, but ...oh, wait!

6) An Apocalyptic Meteor: Remember a couple years ago everyone was looking into the sky for some meteor that could "theoretically" be headed right for Ted Koppel's head? They even made a couple movies about it, and then what? Hollywood lost interest, so now something that's supposed to happen every few million years lost its two-year window of opportunity to be a star.

7) Hurricane Floyd: The one that caused the MANDATORY evacuation of South Carolina this last fall. About three or so leaves blew off a tree on my sister's front yard in Myrtle Beach.

But if I put every bad weather forecast on this list it would be prohibitively long. I'll end it here. The moral of the story is this: science is a job, not a religion. It's very fallible.

Hugh Porter
Springfield, Missouri

Top 20 Screw-ups, *continued*

I enjoy the Ig Nobel Prizes and the shenanigans of the Annals of Improbable Research as much as anyone. However, "The Back Page" of the May 2000 issue of *APS News* was only half true. It is well known that the humor and fact can be quite disjointed. But I believe the list of Top Twenty Technological Screw-ups of the 20th Century should demonstrate the application of intellectual rigor that we physicists use in our scientific work.

A "screw-up" is usually caused by hubris (exaggerated pride or over confidence). I suggest that a top ranked technological screw-up would include actions that push the technology well beyond known limits **and** leaders who force such accomplishments. In my opinion, only 10 screw-ups listed by Marc Abraham were due to such hubris. The remainder included 2 cases of fraud, 4 cases of human error and 4 accidents or incidents resulting from limited knowledge.

My analysis suggests the following distinctions among Abraham's 20 screw-ups:

Hubris
2 – Titanic sinking
3 – World War I deadlock
7 – Antibiotic resistant microbes
10 – China's Great Leap Forward
11 – Mariner I failure
12 – Hancock Tower glass failure
14 – Bhopal chemical plant leak
15 – Challenger explosion
16 – Chernobyl meltdown
20 – Y2k bug

Fraud
1 – N-rays
18 – Cold fusion

Human Error
5 – Wrong Way Corrigan
13 – Korean Air shot down by USSR
17 – Iran Air shot down by Vincennes
19 – Codelco trading fiasco

Accident/Limited Knowledge
4 – Hindenburg explosion
6 – Tacoma Narrows bridge failure
8 – De Havilland Comet crashes
9 – Malpasset Darn failure

Two of Abraham's choices caused me some disquiet. China first decided that a "Great Leap Forward" needed to happen. Only then did technology become the means by which it was to occur. Chairman Mao's Cultural Revolution was a great human tragedy. However, truly great technological screw-ups result by emphasizing the technology and excluding human concerns.

Finally, Chernobyl resulted from a scientific test that put the reactor in a catastrophic operating mode. The design was not particularly sloppy, just not in accord with Western safety standards. This viewpoint would suggest an alternate candidate for a great technological screw-up, namely, the millions of internal combustion engines polluting the Earth's atmosphere.

Larry L. Gadeken
Houston, Texas

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I must confess that it was a severe narcissistic blow to see my technologically underdeveloped country, Chile, contributing with the 19-th top technological screw-up of the 20th Century, in the May issue of *APS News*. Thus, I would like to set the record straight and to prove that this "distinction" is utterly undeserved.

The truth of the matter is that Juan Pablo Dávila was far from pressing the wrong button when placing orders to buy/sell copper for CODELCO, the Chilean government owned company. The investigations that followed the 1994 "blunder" established that Mr. Dávila had conspired to commit fraud with foreign and Chilean agents, including his wife and his brother in law. At this point the judicial process is under appeal, but he has been sentenced to jail for fraud against the Chilean State (3 years), incompatible business with his job as operator for CODELCO (3 years), and introducing false evidence in a criminal trial (2 years). In addition, he has been ordered to refund the non-negligible sum of 186 million dollars to the public treasure.

Thus, I urge you to remove blunder 19 from your list. As Mr. Abraham points out "The people mentioned had reasons -in many cases good reasons- for doing what they did." However, no matter how good the reasons Mr. Dávila could have had, a criminal act cannot be categorized as a technological mishap.

Miguel Kiwi
Univ. Catolica de Chile
San Aiago, Chile

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In "The Back Page" *of APS News* May 2000 issue I found the sentence about Chernobyl. You wrote: "…the Chernobyl nuclear power plant in Russia suffered a partial meltdown due to design deficiencies and sloppy maintenance…" This version was suggested by Russian official news agencies. The question is: is it true?

Some days ago the Russian magazine *Ogonyok* published an interview with Russian physicist Konstantin Checherov (http://www.ropnet.ru/ogonyok/win/200015/15-30-33.html). Checherov started to work in Chernobyl with the special mission of the Atomic Energy Institute (Moscow, Russia) just after the first day of the tragedy. After some years of work with the experimental data, Checherov developed a very realistic model of the Chernobyl catastrophe. His main conclusion was: it was not a "partial meltdown." It was an explosion with the practically full nuclear fuel exhausted into the environment. The Chernobyl reactor was practically empty of nuclear fuel after it happened.

This version was in contradiction with the official version and only now is published in the press for the first time. Possibly, this article I mentioned above can be interesting for scientific community.

Aleksandr Verevkin
Yale University

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I object to your published description of the cold fusion fiasco (Technology Screw-up #18). The work of McKubre et al. at SRI as presented at the Minneapolis APS meeting, and more fully at the American Chemical Society meeting last October, pretty much confirms the conclusion of Fleischmann and Pons that radiationless deuteron fusion sometimes occurs in deuterided palladium with the nuclear product being helium-4. The screw-up was not so much the procedures followed by Fleischmann and Pons as the overly quick rush to judgment by the physics community, despite the stature of the experimenters and despite the supportive theoretical views of Julian Schwinger. After all, Fleischmann was a respected member of the Royal Society, and Schwinger was quite possibly the most eminent US theoretical physicist living at the time.

Talbot A. Chubb
Retired from Naval Research Laboratory

OPINION

Letters, *continued*

My top ten physicists of the millennium are:

1. Albert Einstein: for his creation of the special and general theories of relativity and for his foundational contribution to the creation of quantum mechanics.

2. Isaac Newton: for his mechanics and his theory of gravitation, as well as for having provided physicists with a mathematical tool (calculus) which has proved essential in the development of physics.

3. Galileo Galilei: For having given birth to modern physical (and scientific, in general) analysis and thought.

4. James C. Maxwell: for having given a unified picture of electricity and magnetism (electromagnetism).

5. Werner Heisenberg: for his formulation of quantum mechanics, which has changed how physicists conceive science and has also been seminal for the calculational power of the theory.

6. Ludwig Boltzmann: for his essential contributions to statistical mechanics and to the relation between entropy and disorder.

7. Paul Dirac: for giving birth to modern quantum field theory, by far the highest achievement of theoretical physics to date.

8. Erwin Schrödinger: for his decisive contribution to the development of quantum mechanics.

9. Eugene Wigner: for his deep understanding of the role of symmetry for the formulation of physical theories.

10. Richard Feynman: for his alternative formulation of quantum mechanics, in terms of path integrals, a view which has proved extremely rich not only in its calculational applications but in providing a further unifying concept for theoretical physics.

Rolando Saniz Balderrama
Departamento de Ciencias Exactas, Universidad Catolica Boliviana

Editor's Note: *In the June issue we printed several top ten lists, and thought that was it. The next top ten physicists of the millennium will appear in the year 3000.*

Question of History: Who Was First "Physicist"?

Who was the first physicist in the world to graduate with that title? We know that Galileo was originally a physician, Carnot a military engineer, and so on. What was the division between engineers and physicists when it was done? When was the foundation of a school of Physics in Europe and in the USA?

Jose Lopez Cervantes
Mexico

Spencer Weart Responds:

The term "physics" in English originally applied to all the sciences, and practitioners of the physical sciences in the 18th and early 19th centuries mostly called themselves "natural philosophers." For that matter, many researchers worked as much in chemistry or even medicine as they did in the fields we now call physics. The word "physicist" in its current sense was coined explicitly by the philosopher William Whewell in a book he published in 1840. He said he wanted something comparable to the French term "physicien" — meaning physicist in our sense. I'm not sure of the exact origin of the French word, but I believe it became fairly common among scientists in Paris during the 1820s. Both Whewell's "physicist" and, probably as a consequence, the term "physics" to describe our science, spread in English quite rapidly after 1840. I don't know exactly which school or department first called itself and its graduates by the term "physics" rather than "natural philosophy," and I am afraid it would be quite a lengthy research project to sort that out. I believe it became pretty widespread by the 1890s.

Spencer Weart
Director, Center for History of Physics, American Institute of Physics

Religious Debate Not Appropriate

I think it inappropriate that *APS News* allow itself to be used as a forum for religious debate. Since Barbara S. Helmkamp (Letters, May) is given space to opine that theistic belief is important in obtaining happiness, justice, and peace and to suggest that humanism has been bad for our culture, may we soon look forward to a rejoinder from a non-theist, who will tell us why we should not believe in God? If the views expressed on any such issues can be supported by scientific studies, then the references should be cited. Otherwise they should be omitted from a scientific publication.

John G. Fletcher
Livermore, California

Editorial Cartoon

MRS. SURDOVAL FOUND OUT THE HARD WAY THAT NATURE ABHORS A VACUUM.

zero gravity

Physicists Didn't Touch Ground in Something-apolis

by Joel Achenbach, Washington Post

I just flew in from either Minneapolis or Indianapolis. It was definitely something-apolis. As a reporter I try to nail these things down when I do a story, because even the small details are important. Approximation isn't enough; for the moment I'm leaning hard toward Minneapolis. It was definitely somewhere in the Midwestern portion of the United States. There were some tall buildings.

Most of the time I remained in enclosed spaces, even when moving from my hotel to the convention center. Midwestern cities are deeply into skywalks now, to allow people to move around the downtown without constantly putting on and taking off their big ugly parkas. As I navigated the maze I kept thinking: Des Moines?

Intrepidly, I eventually descended to ground level and entered the outdoor portion of the city. I looked, without success, for the Mississippi River, which my educational background leads me to believe has an association with Minneapolis. I'm sure it was there. You can't hide something like that.

Some advice to the local city planners: In addition to all the little signs telling visitors where the convention center is, you should put up signs pointing to the place where Mary Tyler Moore threw her hat in the air. "Mary's Hat Toss" is all it has to say, with an arrow. Also, find some way to give the city more of "that Hubert H. Humphrey feeling."

The city is full of physicists this week, many thousands of them attending the big meeting of the American Physical Society. Physicists are great company: They spend so much time dealing with excruciatingly abstruse problems and endless squiggly equations that they have an inverse-square delight in jolly good times. Physicists will laugh at your jokes, even if, inside, they are secretly diagraming the humor and breaking it down into overlapping-yet-incompatible frames of reference.

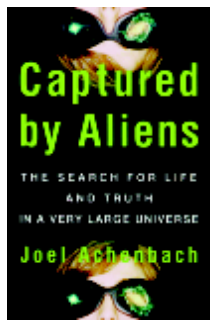
The bad news is that occasionally they give a news conference to announce that they have discovered, for example, "A composite medium with simultaneously negative permeability and permittivity." I had to cover the story and approached it with some trepidation: I'm fine on permeability but my permittivity has always been awful.

Truth be known, I am so dim on electromagnetism that I'm still trying to figure out what's going on with the prongs on electrical plugs. Why are there now usually three prongs, and sometimes one of them is turned sideways? The news conference, as it turned out, could have been worse: The scientists could have been speaking in a language other than English. They did their best to conduct an emergency seminar on the propagation of microwave energy through different media. They drew equations on a chalkboard. They diagramed the resonance curve of "split ring resonators." They labored to demonstrate the elementary fact, predicted by Maxwell's equations, that when you have a material with BOTH negative permeability and negative permittivity — that is, negative Mu and negative Epsilon — you wind up with a medium that *inverts* the Doppler effect, Cerenkov radiation, and Snell's Law.

As they spoke I wanted to raise my hand and say, "Excuse me, is this event real, or am I having an anxiety dream?" It would not have surprised me to look down and discover that I wasn't wearing any clothes.

Nevertheless, journalism marches on. I filed the story. You can read it at http://www.washingtonpost.com/wp-dyn/articles/A56258-2000Mar21.html

A featured speaker at the APS March Meeting session on "Voodoo Science," Joel Achenbach's online column, "Rough Draft," appears three times a week at http://www.washingtonpost.com/wp-dyn/nation/columns/roughdraft/, except when it needs to take an emergency vacation. He is the author of ***Captured by Aliens: The Search for Life and Truth in a Very Large Universe****. This 3/20/00 column is reprinted with permission.*



Editor's Note*: Philip Schewe's take on the new composite material appeared in the June issue of APS News.*

Congressional Visits, *continued from page 1*

confirmed, and we need to communicate that we care about R&D funding." He believes this type of first-hand knowledge and experience of how Congress works is especially critical in a presidential election year. "Next year's new administration will bring manifold changes, to national priorities on economic, technological, educational defense, environmental, health and medical, social and other fronts," he says.

There were some suggestions for improvement. Coffey said he would appreciate more lead time to prepare for the Congressional visits in the future, and also suggested increasing the participation of the APS Forum on Industrial and Applied Physics to help emphasize the theme of how basic science can fuel the national economy. "It would be very helpful to have more information ahead of time to better prepare for these visits," agrees Mooney.

Both Mooney and Clarke believe the APS could to have a better internal organization system to help participants with the logistics, such as hotels and scheduling visits themselves with Senators and members of Congress. "I am sure more people would attend the Congressional visits day if it were easier to figure out what to do," Clarke says. Hellman agrees: "The APS could be of more help, because none of us really knows how to do this."

General Election Preview — Members To Choose New Leadership for 2001

Ballots were mailed to all APS members in June and must be received by September 1, 2000 by SBS, an independent, external organization.

For Vice-President

JERRY GOLLUB
John and Barbara Bush Professor in the Natural Sciences, Haverford College and Adjunct Professor, University of Penn.

Jerry Gollub received his A.B. from Oberlin College in 1966, and his Ph.D. in experimental condensed matter physics from Harvard University in 1971. He was appointed to the faculty at Haverford in 1970, became Professor in 1979, served three terms as Chair of the Physics Department, and was Provost (Chief Academic Officer) of the College in 1988-90. Since 1981 he has also been affiliated with the Physics and Engineering Faculties of University of Pennsylvania, where he has sponsored the Ph.D. research of many graduate students. He is well known for wide ranging experiments on nonlinear and non-equilibrium phenomena in condensed matter, including studies of instabilities, pattern formation and mixing in fluids, chaotic dynamics and turbulence, nonlinear waves, patterns formed at the surface of growing crystals, and the dynamics of granular materials (http://www.haverford.edu/physics-astro/Gollub/). He has co-authored a textbook entitled "Chaotic Dynamics" and teaches a course for a broad audience entitled "Chaos and Quantum Physics: Predictability in Science." Gollub became a Fellow of the American Academy of Arts and Sciences in 1992, was elected to the National Academy of Sciences in 1993, and is an APS Fellow. He was the first recipient of the APS Award for Research in an Undergraduate Institution in 1985, was a Guggenheim Fellow in 1984-85, and earlier held Danforth and Woodrow Wilson Fellowships. He was a Morris Loeb Lecturer in Physics at Harvard University in 1990, a Sigma Xi National Lecturer in 1983-85, and has held Visiting Professorships at Ecole Normale (Paris) and the Weizmann Institute. Gollub is currently an APS Divisional Councilor and has chaired several APS Committees. He has been a member of the Commission on Physical Sciences, Mathematics, and Applications of the National Research Council, the NRC's board overseeing its advisory activities in the physical sciences. He is currently co-chair of a major NRC study on advanced secondary science and mathematics education. He serves on the Physics Section Committee of the AAAS, and has served on the editorial boards of various journals. He co-organized the 1997 Conference of Physics Department Chairs, and has contributed to the organization of several research conferences in nonlinear science.

MYRIAM SARACHIK
Distinguished Professor of Physics, City College of New York–City University of New York

Myriam Sarachik was born in Antwerp, Belgium in 1933, attended primary school in Belgium and Cuba, and the Bronx High School of Science in New York. She earned a B. A. from Barnard College in 1954; after working for a year at the IBM Watson Laboratories, she returned to graduate school, receiving her M.S. in 1957 and Ph.D. in 1960 from Columbia University. Following a year as a research associate at the Watson Laboratories while teaching at City College in the evening, she became a postdoctoral Member of the Technical Staff at Bell Telephone Laboratories in Murray Hill, New Jersey. She was hired by City College as an assistant professor in 1964, was promoted to associate professor in 1967, full professor in 1971, and became a Distinguished Professor of Physics in 1995. She was the Executive Officer of the University-wide CUNY Ph. D. Program in Physics from 1975 to 1978. Sarachik is a condensed matter experimental physicist. Her research has covered a variety of topics, including superconductivity, disordered metallic alloys, metal-insulator transitions in three-dimensional doped semiconductors and in two-dimensional systems, hopping transport in solids, and properties of single molecule magnets. Sarachik is a member of the National Academy of Sciences and the American Academy of Arts and Sciences, and a Fellow of the American Physical Society, the New York Academy of Sciences and the American Association for the Advancement of Science. She was awarded the New York City Mayor's Award for Excellence in Science and Technology in 1995. Sarachik has been a member of many advisory committees and panels. She served the National Science Foundation as a member of its Advisory Committee for Research, the Advisory Council and its Executive Committee, the Advisory Committee of the Division of Materials Research, the Seitz-Richardson Panel, and numerous Boards of Visitors, Presidential Young Investigator Panels and Program Evaluation Panels. She has been a member and Chair of fellowship panels for the National Research Council, and is currently Chair of the Solid State Sciences Committee of the Board of Physics and Astronomy of the NRC. She has been active in APS affairs as a member and/or chair of the Executive Committee of the Forum for International Programs, the Committee on International Scientific Affairs, the Nominating Committee, the Committee for the International Freedom of Scientists, the Committee on the Status of Women in Physics, the Executive Committee of the Division of Condensed Matter Physics, the Executive Committee of GMAG and the APS Council.

For Chair-Elect of the Nominating Committee

SUSAN COPPERSMITH
Professor of Physics, University of Chicago

Susan Coppersmith was born in 1957 in Johnstown, PA. She received an S.B. in Physics from MIT in 1978, spent 1978-1979 at Cambridge University as a Churchill Scholar, and was awarded a Ph.D. in Physics from Cornell University in 1983. She was a research associate at Brookhaven National Laboratory from 1983 to 1985, a postdoc at AT&T Bell Laboratories from 1985 to 1986, and a visiting lecturer at Princeton University from 1986 to 1987. In 1987 she became a member of technical staff at AT&T Bell Laboratories, and in 1995 she joined the faculty of the University of Chicago as a professor of physics. Coppersmith's research focus is on the properties of materials that are far from thermal equilibrium, particularly disordered materials such as glasses, granular materials, and disordered magnets. Coppersmith is a fellow of the American Physical Society and of the American Association for the Advancement of Science. She has served on two National Research Council panels and on the boards of the Institute for Theoretical Physics (UCSB), the Gordon Research Conferences, and the Aspen Center for Physics.

GLENNYS FARRAR
Professor of Physics, New York University

Glennys Farrar joined NYU in 1998 as Chair of the Physics Department. She was previously on the faculties of Rutgers University and Caltech, a Member of the Institute for Advanced Study, and was the first woman to receive a Ph.D. in Physics from Princeton University. Farrar's principlal research has been in theoretical elementary particle physics, cosmology, and astrophysics. Her work provided early evidence for the physical existence of quarks as the fundamental constituents of hadrons. She also pioneered the observational search for supersymmetry, proposing the missing energy and beam dump approaches to detection, which opened the door for laboratory searches world-wide. She has studied baryogenesis, dark matter, ultra high energy cosmic rays and extragalactic magnetic fields. Farrar is the recipient of Alfred P. Sloan Foundation and Solomon R. Guggenheim Foundation fellowships, is a Fellow of the APS, member of the APS DPF Executive Council and of the Steering Committee of the AAAS Section on Physics. She has served on the BNL HEP advisory committee, the DOE/NSF final review panel on CEBAF, and the APS Sakurai Prize Selection committee.

For General Councillor

MARC KAMIONKOWSKI
Professor of Theoretical Physics and Astrophysics, California Institute of Technology

Marc Kamionkowski was born in 1965 in Cleveland, Ohio. He received a B.A. degree in 1987 from Washington University in St. Louis and a Ph.D. in 1991 from the University of Chicago. He was a postdoc at the Institute for Advanced Study in Princeton from 1991 to 1994 and was an Assistant and then Associate Professor in the Department of Physics at Columbia University until 1999 when he became Professor of Theoretical Physics and Astrophysics at the California Institute of Technology. His research has dealt with a variety of topics in theoretical astrophysics, cosmology, and particle astrophysics. He is a member of the American Astronomical Society as well as the American Physical Society. He has been the recipient of an SSC National Fellowship (1991), a Sloan Research Fellowship (1996), an Outstanding Junior Investigator Award from the Department of Energy (1998), and the Helen B. Warner Prize of the American Astronomical Society (1998). Kamionkowski is the Astrophysics Editor for *Physics Reports*, and a receiving editor for the *Journal of High Energy Physics* and has served in recent years on several NASA and NRC committees.

Continued on page 7

NOMINATIONS – 2001 BYLAW COMMITTEES

*To be submitted by members of the American Physical Society **only**.*

The Committee on Committees has the responsibility for nominating elected members of the Publications Oversight Committee and the Lilienfeld Prize Committee and for advising on suitable candidates to serve on the following Bylaw Committees appointed by the President:

Careers and Professional Development • Constitution and Bylaws • Education • Fellowship • International Freedom of Scientists • International Scientific Affairs • Investment • Meetings • Membership • Minorities • Status of Women in Physics • Physics Policy

The APS needs recommendations from the membership. Current personnel and last year's annual reports for many of the committees are on the APS Homepage under the Governance button. Please provide the name and affiliation of nominees and include information on career highlights and suitability for the position. Self-nominations are encouraged. (Please verify that your nominees are APS members prior to submitting your form.)

The form is downloadable: http://www.aps.org/mem-cgi/coc

If you would like a copy of the form faxed to you, please e-mail Danita Boonchaisri at boonchai@aps.org and include your name and fax number.

Deadline for receipt of nominations is August 11, 2000.

General Election Preview, *continued from page 6*

JENNIFER TOUR CHAYES
Manager and Co-Founder, Theory Group, Microsoft Research; Professor of Mathematics, University of California, Los Angeles and Affiliate Professor of Physics and Mathematics, University of Washington

Jennifer Tour Chayes was born in 1956 in New York, NY. She received her B.A. in physics and biology from Wesleyan University in 1979, and her Ph.D. in mathematical physics from Princeton University in 1983. She was a Postdoctoral Fellow in the Physics and Mathematics departments at Harvard University (1983-85), and at the Laboratory of Atomic and Solid State Physics and the Army Mathematics Center at Cornell University (1985-87). In 1987, Chayes became an Associate Professor of Mathematics at UCLA and full Professor in 1990. In 1997, Chayes moved to Microsoft Research. She is the co-founder of the Theory Group at Microsoft Research, a group which brings together researchers in mathematics, physics and theoretical computer science to address problems at the interface of these three fields. Chayes was appointed Affiliate Professor of Physics and Mathematics at the University of Washington in 1997 and 1999, respectively. Chayes was awarded a National Science Foundation Postdoctoral Fellowship in Mathematics (1984) and a Sloan Foundation Fellowship (1989). She has also won several teaching awards including the Distinguished Teaching Award at UCLA (1994). She has twice been a member of the Institute for Advanced Study in Princeton (1994-95 and 1996-97). Chayes' research focuses on statistical physics, particularly on probabilistic and stochastic geometric analyses of phase transitions. During the past few years, she has begun to apply methods from physics and mathematics to problems in theoretical computer science, networking and information technology. She is Vice President of the American Mathematical Society (AMS) and a member of the AMS Council. She is a member of the National Research Council Board of Mathematical Sciences, the Board of Governors of the Institute for Mathematics and its Applications, and the External Advisory Board of the Center for Discrete Mathematics and Computer Science. Chayes also serves on both the Statistical Physics and the Mathematical Physics Commissions of the International Union of Pure and Applied Physics, and she is a member of the Advisory Committee of the National Academy of Sciences for the Public Understanding of Science.

JONATHAN BAGGER
Professor of Physics and Astronomy, Johns Hopkins University

Jonathan Bagger is a Professor of Physics and Astronomy at the Johns Hopkins University. He received his A.B. from Dartmouth College in 1977. After a year at Cambridge as a Churchill Scholar, he continued his graduate study at Princeton University. He received his Ph.D. in 1983 and took a postdoctoral research position at the Stanford Linear Accelerator Center. From 1986-1989 he was an Associate Professor at Harvard University. Bagger has twice been a member of the Institute for Advanced Study in Princeton. He held a Sloan Foundation Fellowship and an NSF Presidential Young Investigator award. He has served on two HEPAP subpanels, several NSF advisory panels, and the SLAC Scientific Policy Committee. Bagger is presently a member of the Fermilab Board of Overseers. He is also on the Editorial Boards of *Physics Reports* and the *Journal of High Energy Physics*. Bagger's APS service includes a term as Secretary-Treasurer of the Division of Particles and Fields. He served two years on the Pricing Subcommittee of the Publications Oversight Committee. He is presently Vice Chair of the Dannie Heineman Prize Committee. Bagger is an Associate Editor of *Physical Review D* and a Fellow of the APS. Bagger's research interests center on high energy physics at the interface of theory and experiment. His present work is focused on supersymmetry and supergravity between the weak and the Planck scales. He has written over 100 scientific papers, and authored or edited four books.

CHERRY A. MURRAY
Senior Vice President, Physical Sciences Research, Bell Laboratories/Lucent Technologies

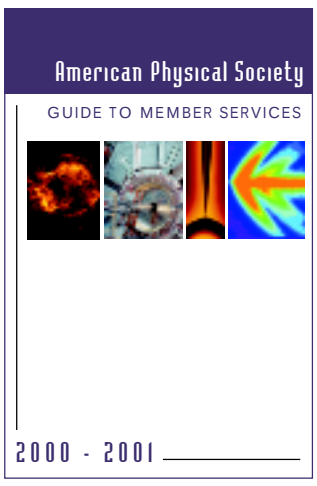
Cherry Murray is currently Physical Sciences Research Sr. Vice President, Bell Laboratories, Lucent Technologies. Before that she served as Director of the Physical Research Laboratory from June 1997–March 2000, and Department Head of three departments in the same Lab, the Low Temperature and Solid State Research Department from 1987–1990, the Condensed Matter Physics Research Department from 1990–1993, and the Semiconductor Physics Research Department from 1993–June 1997. She joined Bell Labs as a member of technical staff in 1978, after receiving a Ph.D in physics from the Massachusetts Institute of Technology, where she also obtained a B.S. in physics in 1973, and became a Distinguished Member of Technical Staff in 1985. She has numerous publications and two patents. Murray has a broad background in experimental research in low temperature, surface, condensed matter and complex fluid physics, with emphasis on light scattering and imaging. Her own research program currently encompasses imaging of order–disorder transitions in colloidal crystals and self–assembly of optical materials. She is a Fellow of the American Physical Society and the American Association for the Advancement of Science and a member of the American Chemical Society, the Optical Society of America, the Materials Research Society, and Sigma Xi. She won the APS Maria Goeppert–Mayer Award in 1989. Her activities in the American Physical Society include service on the executive councils of the Forum on Education and the Forum on Industrial and Applied Physics, on various prize and fellowship committees and as a member of the Panel on Public Affairs. She is the Chair of the International Union of Pure and Applied Physics Commission on the Dynamics of Matter. She is a member of the National Academy of Sciences, and serves on the Board of Physics and Astronomy, the Solid State Sciences Committee and the Physics Survey Overview Committee of the Board of Physics and Astronomy of the National Research Council.

Announcements

Membership News...

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

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



American Physical Society marketplace

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

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

The article in the June issue of *APS News* on the "Creating Copenhagen" symposium in New York neglected to mention the invaluable contributions of two individuals. **Brian Schwartz**, former APS associate executive officer and now dean of CUNY's Graduate Center in New York, spearheaded the entire event, while former APS Treasurer **Harry Lustig** spent countless hours organizing the session on history of physics. *APS News* regrets the error.

Now Appearing in RMP...

The articles in the July 2000 issue of *Reviews of Modern Physics* are listed below. For brief descriptions of each article, consult the *RMP* website at <http://www.phys.washington.edu/~rmp/current.html>. *George Bertsch, Editor.*

Theoretical approaches to x-ray absorption fine structure — *John Rehr and Robert Albers*

Molecular dynamics for fermions — *Hans Feldmeier and Jürgen Schnack*

Observations and implications of the ultrahigh-energy cosmic rays — *M. Nagano and A. A. Watson*

The discovery of the heaviest elements — *Sigurd Hofmann and Gottfried Münzenberg*

μSR studies of the vortex state in type-II superconductors — *Jeff E. Sonier, Jess H. Brewer, and Robert F. Kiefl*

Electrophoresis of DNA and other polyelectrolytes: physical mechanisms — *Jean-Louis Viovy*

Universality of ac conduction in disordered solids (colloquium) — *Jeppe C. Dyre and Thomas B. Schrøder*

Reviews of Modern Physics
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CALL FOR NOMINATIONS

The National Academy of Sciences is accepting nominations for the Henry Draper Medal, a prize of $15,000 given every four years for an original investigation in astronomical physics. The investigation or its completed publication should have occurred since the last award, which was presented in 1997. Nominations will be accepted through September 1, 2000. For more information contact:

National Academy of Sciences
Awards Program, Room NAS 185 • 2101 Constitution Avenue, NW
Washington, D.C. 20418
Phone: (202) 334-1602 • Fax: (202) 334-1682
e-mail: awards@nas.edu • http://national-academies.org/nas/awards

THE BACK PAGE

Copernicus and the Aesthetic Impulse

By Owen Gingerich

In the post-Newtonian cosmos, with its universal gravitation, the Copernican system seems so inevitably right that it is hard for most modern scientists to comprehend why it took so long for people to accept the obvious. Were the academics so steeped in tradition that they just refused to use their eyes? Were the clerics and universities part of a conspiracy of thought control?

"What was the matter with those people? Were they dumb or something? Or were they just blinded by superstition or religious orthodoxy?"

Let me remind you of what Galileo said nearly a century later, when the matter was still far from settled: "I cannot admire enough those who accepted the heliocentric doctrine despite the evidence of their senses." I believe that Copernicus relied on aesthetic principles, "ideas pleasing to the mind," and that such concepts are exceedingly powerful but highly treacherous in physical reasoning. Until technology marches on to provide empirical grounding, the aesthetic ideas must be regarded as dangerously seductive, possibly sheer quicksand for the unwary. I'll describe two aesthetic principles that Copernicus endorsed, and I'll show how our modern evaluation essentially turns upside-down the initial reception of Copernicus' *De revolutionibus*, his life work that was finally published in the year of his death, 1543.

A page from De Revolutionibus.

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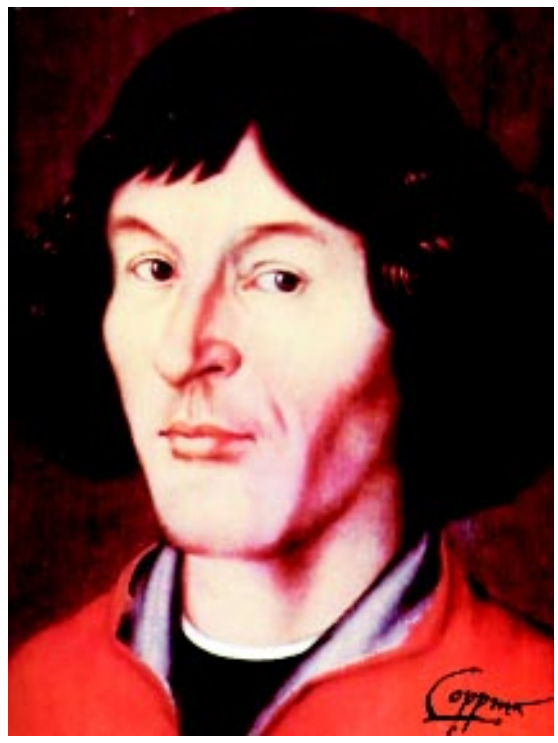
What Copernicus had to offer were two quite independent aesthetic ideas. One was that celestial motions should be described in terms of uniform circular motions, or combinations thereof. The unending, repeating motion in a circle was compellingly suitable for the heavenly movements, where corruption and decay were never found. There was something almost sacred about this proposal, and it appealed strongly to the sensitivities of the sixteenth century. Unfortunately this beautiful idea was wrong, dead wrong. It was not dumb — it was in fact the most intelligent way to start approximating the motions of the heavens, but in Renaissance celestial mechanics it was destined to be a dead end.

Copernicus' other aesthetic idea is quite independent of the aesthetic requirement of circular and uniform motion. It is the great idea that makes copies of the first edition of *De revolutionibus* nowadays estimated at auction at over half a million dollars. This was, of course, the heliocentric arrangement of the planets. But to the sixteenth-century mind, this idea was highly suspect. To begin with, it required new physics. Building a new scaffolding to replace the neatly dove-tailed Aristotelian physics would require more than a generation of inspired work. As Tycho Brahe said, "The Copernican doctrine nowhere offends the principles of mathematics" — that is, aesthetic idea number one is just fine — "but it throws the earth, a lazy, sluggish body unfit for motion into action as swift as the aethereal torches."

But it wasn't just new physics that made the new cosmology seem radical and dangerous. Tycho said that Copernicus offended both physics and the Holy Scriptures, always in that order. Biblical passages such as Psalm 103, "The Lord God laid the foundation of the earth, that it not be moved forever," seemed to call for a firmly fixed earth. Copernicus' heliocentric vision was seen as a challenge to the traditional sacred geography, and hence generated the pervasive unease touching even those who would never worry about mere physics. Because today Copernicus' heliocentrism, his second aesthetic idea, endures, while the first — "celestial motion is uniform and circular or composed of uniform and circular parts" — has faded away into obscurity, it is easy to overlook the appeal of uniform circular motion in the 16th century.

Aesthetic ideas can be seductively wrong, and in the absence of empirical support it is perhaps best to take a wait-and-see attitude. That's the course the overwhelming majority of 16th-century astronomers adopted. What is unusual about the Copernican revolution is that it took so very long. This leaves the writers of modern secondary sources very uneasy. What was the matter with those people? Were they dumb or something? Or were they just blinded by superstition or religious orthodoxy?



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Copernicus

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What was lacking was observational evidence to confirm or refute these ideas. Toward the end of the 16th century the idea of an empirical test of the heliocentric idea gradually occurred to a few leading astronomers, including Tycho. He attempted to distinguish between the Ptolemaic and Copernican systems by determining the distance to Mars and he expended a major observational effort on it. He even built a new subterranean observatory to get better stability, and he redesigned the instruments originally built for the windy balconies of his Uraniborg castle to provide greater rigidity and accuracy. Yet in the end he fails to mention his Mars campaign, something that caused his biographers to long overlook this centrally motivating research.

Why did Tycho give this major effort the silent treatment? Because, unknown to him, the solar system was 20 times larger than he or anyone else imagined, and his carefully organized research agenda was doomed to failure. Had he been successful, his new technology would have provided the empirical evidence for Copernican astronomy almost three decades earlier than actually happened, and Tycho's reputation as an observer/cosmologer would shine brilliantly in the astronomical firmament. Yet from the ashes of his failed campaign there arose, like a phoenix, the evidence that Copernicus' aesthetic principle number one had to be abandoned. The magnificently precise observations of Mars were the grist for Kepler's mill, who showed that an ellipse worked better and more simply than the circles and epicyclets of Copernicus. Furthermore, it offered the prospect of serious new physics, which to Kepler made all the difference. And that physics was a heliocentric physics.

But meanwhile, the acceptance of Copernicus' second aesthetic principle, the heliocentric doctrine, was greatly hastened by an unexpected discovery, one that was critically dependent on a fresh advance of technology. In Galileo's hands, what had been a novel toy was converted into a scientific instrument. When he used the new telescope to examine Venus, he found that the planet exhibited the entire set of phases shown by the moon, guaranteeing that Venus orbited the sun, contrary to the Ptolemaic arrangement. This evidence, in the rhetorical setting of Galileo's Dialogo, essentially turned the tide in the favor of the Copernican heliocentric arrangement.

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Why had it taken so long? There were comparatively few astronomers in those days, and the pace of invention was not as swift as it is now. Nevertheless, in early modern science we can see in slow motion what can happen in a decade or less today. But it distorts the story to demand that Copernicus's contemporaries should have been able to choose and endorse the great aesthetic idea that we know is right only by 20-20 hindsight. Instead, we should give some sympathy to those who withheld judgement until the evidence was in hand.

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