APS President Urges Members To Take Action on Federal Science Funding

By Calla Cofield

In response to the FY08 budget passed by Congress, which fell nearly a billion dollars short in science funding compared to the levels authorized last summer, APS president Arthur Bienenstock sent two email messages to all APS members, urging them to write to Congress. The Federal Funding Alert email that went out on January 10 called the cuts a "devastating blow to basic research." Bienenstock is asking APS members to tell Congress to pass emergency supplemental appropriations to replace some of the cut funding.

The email provided a link to an on-line form for members to write to their representatives or the President Bush, including suggested templates for the letters. At press time, APS’s Washington DC office reported that more than 3300 members had used the online form to write to Congress and the Administration.

The email, titled “Please help rectify science damage in FY08 budget,” emphasized the impact that the budget cuts will have on science programs nationally and internationally:

“The [FY08] budget, which wipes out $1 billion in increases approved last summer for the National Science Foundation (NSF), the Department of Energy’s Office of Science (DOE Science) and the NIST laboratories, does irreparable damage to science and undermines the U.S. standing in the international community,” the message says.

In a second email, sent January 22, Bienenstock added “The Department of Energy Office of Science-released a document last week listing the impacts to all of its programs. In addition to damage to the Fusion and High Energy Physics programs that I emphasized last week, there are major impacts in Basic Energy Sciences (BES) and Nuclear Physics programs. The Intense Pulsed Neutron Source at Argonne National Laboratory is being closed permanently and various construction projects will be delayed...nearly 700 proposals responding to a BES solicitation for energy research have been declined.”

The online form to write to Congress can be found on the APS website. Go to the Policy and Advocacy page, click on “Advocacy Tools” and then on “Write Congress.”

POPA’s Short Reports Give Congress Timely Scientific Expertise

The APS Panel on Public Affairs (POPA) has produced a series of “short reports” on topics ranging from energy and the environment to national security issues since 2004. The aim: to provide critical technical expertise to Congress in a timely fashion on policy issues with a strong science or technological component.

The APS membership includes eminent physicists with expertise that is highly relevant to several issues being debated in Congress, and part of POPA’s mission is to provide the Society’s input on those issues to Congress for the purpose of enabling Congress to make policy decisions. One way of doing this is through in-depth technical studies, known as full-length reports.

Full-length reports—such as the landmark 1989 Directed Energy Weapons study—are costly and can take as long as three years to complete. By the time a full-length study is completed, Congress may have acted on some of the pending questions without input from key scientific experts. Short reports are designed to fill that gap. They can run about 20 pages, include a summary of the main findings and recommendations, and can be completed in eight months or less.

POPA members propose topics for short reports to the panel, which discusses the merits, time scale, logistical feasibility and “whether or not the physics community has something intelligent to say about the issue,” says Robert A. Eisenstein, who chaired POPA in 2007.

“This is very critical,” he says. “We don’t get involved with issues where we don’t have expertise. Our focus is, what can science tell you? We stay out of the political dimension.” If the proposed topic passes muster, a formal charge is prepared.

“The model has worked well because the issues are still fresh in Congress’s mind when we announce our results,” says Francis Sladey, associate director of public affairs in the APS Washington Office.

The office now receives direct queries from congressional and federal offices on specific issues because stakeholders are aware that APS has expertise and can respond in a shorter time frame. For example, the U.S. Department of Homeland Security recently asked POPA to convene a panel of experts to evaluate the capability of devices to detect nuclear materials and/or radiation shielding.

Most importantly, Congress seems to be open to the physics community’s recommendations. The first short report on the planned $1.2 billion Hydrogen Initiative appeared in 2004, calling for a focus on basic research and away from demonstration projects. It concluded that major scientific breakthroughs are needed to make progress and Congress took the APS members up on the challenge.

“The cuts will result in layoffs of hundreds of workers at both SLAC and Fermilab. At SLAC, the B-factory experiment will end in March, seven months before its planned shutdown. In the final appropriations, Fermi lab’s budget for FY08 was cut from the $372 million requested to $320 million. This is less than the FY07 budget of $342 million. The cuts will result in layoffs of about 200 of the lab’s approximately 2000 staff members, and remaining staff will subject to a “rolling furlough,” requiring them to take two to three days of unpaid leave per month. Work on development for future projects, such as the ILC, has been stopped at Fermilab. Fermilab Director Pier Oddone said that the cuts represent a “devastating” blow to physics. He said it pained him to have to offer layoff notices to hundreds of workers at both SLAC and Fermilab experiment will end in March, seven months before its planned shutdown. The PETES bill authorized significant increases for basic science. But in December, Congress, scrambling to pass an omnibus appropriations bill for fiscal year 2008 that would meet the President’s spending target, cut billions of dollars, including substantial cuts for science.

The impact on science was very broad. At the DOE Office of Science, fusion energy sciences was 33% below the President’s request (including the cancellation of the promised $160 million US contribution to ITER, an international fusion program); basic energy sciences was 15.3% below; and nuclear physics 8.2% below. The budget for high energy physics was slashed 12%, from the $782 million requested to $688 million.

High-Energy Labs Reel Under Budget Cuts

By Ernie Tretkoff

Last year both the Administration and Congress had shown support for increasing spending on physical science; the bipartisan America COMPETES bill authorized significant increases for basic science. But in December, Congress, scrambling to pass an omnibus appropriations bill for fiscal year 2008 that would meet the President’s spending target, cut billions of dollars, including substantial cuts for science.

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Abstract Reasoning

Category: 13 Article: 35

Marco Formani of Central Michigan University and Noam Barnstein of the Naval Research Laboratory were among the 132 APS members who came to College Park, MD in December to sort the almost 7000 abstracts that had been submitted to the March Meeting. The meeting takes place in New Orleans, March 10-14.
In February 1927, the young Werner Heisenberg developed a key piece of quantum theory, the uncertainty principle, with profound implications. Heisenberg, who was born in December 1901 in Germany, into an upper-middle-class academic family. He liked mathematics and technical gadgets as a boy, and his teachers considered him gifted. In 1920 he began studying physics at the University of Munich, and published four physics papers within two years under the guidance of mentor Arnold Sommerfeld. Heisenberg became professional friends with quantum pioneer Max Born, just one year older than Heisenberg and also a student at Munich.

He earned his doctorate in 1923, with a thesis on a problem in hydrodynamics, though he nearly failed due to his poor performance on the required experimental questions on the oral examination. After receiving his doctorate, he worked as an assistant to Max Born at Göttingen, then spent a year working with Niels Bohr at his institute in Copenhagen.

The prevailing quantum theory in the early 1920s modeled the atom as having electrons in fixed quantized orbits. An electron could move to higher energy levels by emitting a photon of the right wavelength. The model worked well for hydrogen, but ran into problems with larger atoms and molecules. Physicists realized a new approach was needed.

Heisenberg objected to the current model because he claimed that one could not actually observe the orbit of electrons around a nucleus, such orbits could not exist. He was, of course, only observing the spectrum of light emitted or absorbed by atoms. Starting in 1925, Heisenberg set to work trying to come up with a quantum mechanics that could describe what properties could be observed.

With help and inspiration from several colleagues, Heisenberg developed a new approach to quantum mechanics. Basically, he took quantities such as position and velocity, and found a way to represent and manipulate them. Max Born identified the strange math in Heisenberg’s method as matrices. The new formulation accounted for many observed properties of atoms.

Shortly after Heisenberg came up with his matrix mechanics, Schrödinger developed his wave formulation. The absolute square of Schrödinger’s wave function was soon interpretable as the probability of finding a particle in a certain state. Schrödinger’s wave formulation, which he soon proved was mathematically equivalent to Heisenberg’s matrix mechanics, became the more popular approach, partly because physicists were more comfortable with it than with the unfamiliar matrix mechanics. The unpopularity of his own method annoyed Heisenberg, especially because a lot was at stake at the time as he and other young scientists were beginning to look for their first jobs as professors at an older generation of scientists was retiring.

Though others may have found the wave approach easier to use, Heisenberg’s matrix mechanics led him naturally to the uncertainty principle, which is well known. In matrix mechanics, it is not always the case that a*b = b*a, and for pairs of variables that don’t commute, such as position and momentum, or energy and time, an uncertainty relation arises.

Heisenberg conducted a thought experiment as well. He considered trying to measure the position and momentum of a gamma ray microscope. The high-energy photon used to illuminate the electron would give it a kick, changing its momentum in an uncertain way. A higher resolution microscope would require higher energy light, giving an even bigger kick to the electron. The more precisely one tried to measure the position, the more uncertain the momentum would become, and vice versa, Heisenberg reasoned. This uncertainty is a fundamental feature of quantum mechanics, not a limitation of any particular experimental apparatus.

Heisenberg outlined his new principle in 14-page letter to Wolfgang Pauli, sent February 23, 1927. In March he submitted his paper on the uncertainty principle for publication.

Niels Bohr pointed out some errors in Heisenberg’s thought experiment, but agreed the uncertainty principle itself was correct, and the paper was published. The new principle had deep implications. Before, it had been thought that if you knew the exact position and momentum of a particle at any given time, and all the forces acting on it, you could, at least in theory, predict its position and momentum at any time in the future. Heisenberg had found that not to be the case. He would never actually know a particle’s exact position and momentum at the same time.

The uncertainty principle soon became part of the basis for the widely accepted Copenhagen interpretation of quantum mechanics, and at the Solvay conference in Brussels that fall, Heisenberg and Max Born declared the quantum revolution complete.

In the fall of 1927, Heisenberg took on a position as a professor at the University of Leipzig, making him the youngest full professor in Germany. In 1932 he won the Nobel Prize for his work on quantum mechanics. He continued his scientific research and became a key figure in the German fusion program, which failed in its effort to build at atomic bomb. Heisenberg’s actions and motivations have been the subject of controversy ever since. He died in 1976.

There is professional lore that claims a person changes careers on average seven times in their lives. Movita Johnson-Harrell now holds an element of truth to this. By age 31, she had already held positions in physics, comedy, mathematical modeling, and a software company where she did customer support. She wasn’t sure what she wanted to do next, but she didn’t want to stop learning.
Oil Addiction Distorts Senator’s Thinking


Most glaring was Senator Dorgan’s statement of “…so they don’t dismantle the lab until the country’s energy is at risk! The Senator states unequivocally that America needs an energy policy and that the US should withdraw its promised contribution to Fermilab’s two main detector collaborations (1) increased energy conservation/alternative energy development, and (2) production of oil at home and strengthened alliances so import intensity is reduced. These two points are like arguing for both n and 1/n, which are like arguing for both n and 1/n, (Cambridge U Press, 1982).

US Needs a Tax on Oil

The Back Page article by Sen. Dorgan in the December APS News is absolutely correct about the urgent need for renewable and environmentally friendly energy sources, and to conserve our energy so we need less of it. But I am disappointed by the lack of political will in the US to do the most effective thing. A tax on oil provides a meaningful incentive to conserve, and makes alternative energy a better investment. An oil tax can be provided to investors to cover the start-up costs of renewable energy. I favor a floor price for oil, so investors could be assured of making a profit on their investment and could recover. But some are less optimistic about future funding for physics (1). increased energy conservation/alternative energy development, and (2) production of oil at home and strengthened alliances so import intensity is reduced. These two points are like arguing for both n and 1/n, which are like arguing for both n and 1/n, (Cambridge U Press, 1982).
**Introduction**

Physics News in 2007, a summary of physics highlights for the past year, was compiled from items appearing in AIP’s weekly newsletter Physics News Update, written by Phil Schewe, Ben Stein and Jason Bardi. (Ben Stein has since left AIP and is now at NIST. Jason Bardi has replaced Ben Stein at AIP)

The items below are in no particular order. Because of limited space in this supplement, some physics fields and certain contributions to particular research areas might be underrepresented in this compendium. These items mostly appear as they did during the year, and the events reported therein may in some cases have been overtaken by newer results and newer publications which might not be reflected in the reporting. Readers can get a fuller account of the year’s achievements by going to the Physics News Update website at http://www.aip.org/pnu and APS’s Physical Review Focus website at http://focus-aps.org.

**Gravitational Wave Background**

In the standard model of cosmology, the early universe underwent a period of fantastic growth. This inflationary phase, after only a trillionth of a second, concluded with a violent conversion of energy into hot matter and radiation. This “reheating” process also resulted in a flood of gravitational waves.

The gravitational wave background (GWB) dates from the trillionth-of-a-second mark, while the cosmic microwave background (CMB) sets in around 380,000 years later when the first atoms formed. What does the GWB represent? It stems from three different production processes at work in the inflationary era: waves stemming from the inflationary expansion of space itself; waves from the collision of bubble-like clumps of new matter at reheating after inflation; and waves from the turbulent fluid mixing of the early pools of matter and radiation, before equilibrium among them (known as thermalization) had been achieved. The gravity waves would never have been in equilibrium with the matter (since gravity is such a weak force there wouldn’t be time to mingle adequately); consequently the GWB will not appear to a viewer now to be at a single overall temperature.

A new paper by Juan Garcia-Bellido and Daniel Figueroa (Universidad Autonoma de Madrid) explains how these separate processes could be detected and differentiated in modern detectors set up to see gravity waves, such as LIGO, LISA, or BBO (Big Bang Observ-er). First, the GWB would be redshifted, like the CMB. But because of the GWB’s earlier production, the rehisting would be even more dramatic: the energy of the waves would be redshifted by 24 orders of magnitude. Second, the GWB waves would be distinct from gravity waves from point sources (such as the collision of two black holes) since such an encounter would release waves with a sharper spectral signal. By contrast the GWB from reheating after inflation would have much a broader specter, centered around 1 hertz to 1 gigahertz depending on the scale of inflation.

Garcia-Bellido suggests that if a detector like the proposed BBO could disentangle these separate signals of the end-of-inflation GWB, then such a signal could be used as a probe of inflation and could help explore some fundamental issues as matter-antimatter asymmetry, the production of topological defects like cosmic strings, primordial magnetic fields, and possibly superheavy dark matter.


**The Casimir Effect Heats Up**

For the first time, a group led by Nobel laureate Eric Cornell at the National Institute of Standards and Technology and the University of Colorado in Boulder has confirmed a 1955 prediction, by physicist Evgeny Lifschitz, that temperature affects the Casimir force, the attractive force threefold, confirming theoretical predictions recently made by the group’s co-authors in Trento, Italy.

The Casimir force arises from the effects of the vacuum. According to quantum mechanics, the vacuum contains fleeting electromagnetic waves, in turn consisting of electric and magnet-ic fields. The electric fields can slightly rearrange the charge in atoms. Such “polarized” atoms can then feel a force from an electric field. The vacuum’s electric fields are altered by the presence of the glass, creating a region of maximum electric field that attracts the atoms. In addition, heat inside the glass also drives the fleeting electromagnetic waves, some of which leak onto the surface as “evanescent waves.” These evanescent waves have a maximum electric field on the surface and further attract the atoms.

Electromagnetic waves from heat in the rest of the environment would usually cancel out the thermal attraction from the glass surface. However, dialing up the temperature on the glass tilts the playing field in favor of glass’s thermal force and heightens the attraction between the wall and the atoms. (Obrecht et al., Phys. Rev. Lett. 98, 063201 (2007) Also see the NIST press release: http://www.nist.gov/public_affairs/newsfromnist_casimir.html)

**Radium Atoms Trapped**

Physicists at Argonne National Laboratory, near Chicago, have laser-cooled and trapped radium atoms for the first time.

Surprisingly, room temperature blackbody photons—thermal radiation over a wide spec-trum emitted by the apparatus itself—were found to play a critical role in the laser-trapping of this rare and unstable element. This represents the heaviest atom ever trapped by laser light.

Using only 20 nanograms of radium-225 (half-life of 15 days) and one microgram of radium-226 (half-life of 1,600 years), the Argonne scientists held tens of radium-225 and hundreds of radium-226 atoms in the laser trap.

Why go through the trouble of trapping radium atoms? Because it might provide a chance to detect a violation of time-reversal symmetry (abbreviated with the letter T), which would manifest itself as an electric dipole moment in the radium atom.

Electric dipole moment searches have been ongoing for over 50 years and continue to yield smaller and smaller limits on the size of these T-violating interactions. These limits place constraints on theories beyond the Standard Model of particle physics and explanations for the matter-antimatter asymmetry in the universe.

Next-generation electric dipole moment searches may take advantage of rare isotopes such as radium-225, which are expected to be extremely sensitive to T-violation owing to their non-spherical “egg”-shaped nucleus. For the rare and unstable radium atoms, a laser trap offers a promising path to such a measurement. (Gesualdi et al., Phys. Rev. Lett. 99, 050801 (2007))

**Slowed Light Hand Off**

Several years ago, physicists gained the ability to slow a beam of light in a gas of atoms; by manipulating the atoms’ spins, the energy and information contained in the light could be transferred to the atoms in a coherent way. By turning on additional laser beams, the original light signal could be reconstituted and sent on its way.

Now, one of the first researchers to slow light, Lene Hau of Harvard, has added an extra layer to this story. She and her colleagues halted and store a light signal in a Bose-Einstein condensate (BEC) of sodium atoms, then transfer the signal, now in the form of a coherent pulse of atom waves rather than light waves, into a second BEC of sodium atoms some 160 microns away, from which, finally, the signal is revived as a conventional light pulse.

This feat, the sharing around of quantum information in light-form and in not just one but two atom-forms, was a great milestone to those who hope to develop quantum computers. (Ginsberg et al., Nature 445, 623-626 (8 February 2007))

**String Theory Explains RHC Jet Suppression**

String theory argues that all matter is composed of string-like shards in a 10-dimensional hyperspace assembled in various forms. The theory has been put into play in the realm of high-energy ion collisions, the kind carried out at Brookhaven’s Relativistic Heavy Ion Collider (RHIC). A few years ago string practitioners attempted to establish a relationship between the 10-dimensional string world and the 4-di-mensional (3 spatial dimensions plus time) world in which we observe interactions among quark-filled particles like protons.

This duality between string theory and the theory of the strong nuclear force, quan-tum chromodynamics (QCD), was recently used to interpret puzzling early results from RHIC, namely the suppression of energetic quark jets that should have emerged from the fireball formed when two heavy nuclei collide head on. The thinking was that perhaps the plasma of quarks and gluons wasn’t a gas of weakly interacting par-ticles (as was originally thought) but a gas of strongly interacting particles, so strong that any energetic quarks that might have escaped the fireball (initiating a secondary avalanche, or jet of quarks) would quickly be slowed and stripped of energy on their way through the tumultuous quark-gluon plasma (QGP) environment.

Two new papers by Hong Liu and Krishna Rajagopal (MIT) and Urs Wiedemann (CERN) address this problem. The first paper calculates a specific quark-suppression parameter (namely, how much the quarks, each attached to a string dangling “downward” into a fifth-dimensional universe were suppressed in the quark-gluon plasma) that agrees closely with the experimentally observed value.

Rajagopal says that in the second paper, the same authors make a specific testable prediction using string theory that bears not just on missing jets of energetic light quarks (up, down, and strange quarks), but on the melting or dissociation tempera-tures of bound states of heavy quarks (charm-anticharm or bottom-antibottom pairs) moving through the quark-gluon plasma with sufficiently high velocity, as will be produced in future experiments at RHIC and the Large Hadron Collider (LHC) under construction at CERN. (Liu, Rajagopal, and Wiedemann, Phys. Rev. Lett. 97, 182301 (2006) and Phys. Rev. Lett. 99, 182301 (2007))
The Woodstock of Physics

The famous session at the 1987 March Meeting of the American Physical Society earned its nickname because of the rock-concert atmosphere inspired by the confluence of dozens of reports all bearing on copper-oxide superconductivity. The 20th anniversary of this singular event was celebrated at the APS March Meeting in Denver. Prior to 1987, the highest temperature at which superconductivity could be observed was around 23 K. And suddenly a whole new set of compounds—not metallic alloys but crystals whose structure put them within a class of minerals known as perovskites—with superconducting transition temperatures above 35 K, and eventually 100K—generated an explosion of interest among physicists. Because of the technological benefits possibly provided by high-temperature superconductivity (HTSC)—things like bulk power storage and magnetically levitated trains—the public was intrigued too.

The commemoration of the Woodstock moment provided an excellent history lesson on the science of copper-oxide superconductors. Georg Bednorz (IBM-Zürich), who with Alex Mueller made the initial HTSC discovery, recounted a story of frustration and exhilaration, including working for years without seeing clear evidence for superconductivity; having to use borrowed equipment after hours; overcoming skepticism from IBM colleagues and others; and having to make a decision very early on to publicly present this unexpected result even before Fred Seitz had observed HTSC with his team at IBM-Almaden. Mueller wrote a paper announcing another exciting finding in their work: this time the telltale expulsion of magneism (the Meissner effect) from the material during the transition to superconductivity. A year later Bednorz and Mueller won the Nobel Prize.

The IBM finding was soon seconded by work in Japan and at the University of Houston, where Paul Chu, testing a Y-Ba-Cu-O compound, was the first to push superconductivity above the temperature of liquid nitrogen, 77 K. Very quickly a gold rush began, with dozens of condensed-matter labs around the world dropping what they were doing in order to to radiate, heat, chill, squeeze, and magnetize the new material.

At the March APS Meeting Chu said that he and his colleagues went for months on three hours’ sleep per night. Several other speakers at the 2007 session spoke of the excitement of their experiments. Paul Chu remembered a meeting in Denver, according to which such researchers as Marin Cohen (UC Berkeley) and Douglas Scalapino (UC Santa Barbara) the achievement of room-temperature superconductivity did not seem inconceivable.

The Woodstock event, featuring 50 speakers delivering their fresh results at a very crowded room at the New York Hilton Hotel until 3:15 am, was a culmination. In following years, HTSC progress continued on a number of fronts, but expectations gradually became more pragmatic. Paul Chu’s Y-Ba-Cu-O compound, under high-pressure conditions, still holds the transition temperature record at 164 K. Making lab samples had been easy—there was a steady supply of usable power-bearing wires in long spools, partly because of the brittle nature of the ceramic compounds and partly because of the tendency for potentially superconductivity-quenching magnetic vortices to form in the material.

A graduate student at IBM-Almaden, pointed out that HTSC applications have largely not materialized. No companies are making a profit from selling HTSC products. Nevertheless, the mood of the 2007 session (Woodstock20) was upbeat. Bednorz said that if the wave of HTSC innovation could occur. Paul Chu ventured to predict that within ten years, HTSC products would have an impact in the power industry.

Paul Grant, in 1987 a scientist at IBM-Almaden, pointed out that HTSC applications allow much greater data storage. (Sokolov et al., Nature 446, 627-632 (5 April 2007))

Quantized Magnetoresistance

The conversion of a tiny magnetic flux into a change in the resistance of an external circuit, called magnetoresistance, is at the heart of the $60$ billion magnetic hard disk-drive industry. Digital data, stored on the disk in the form of miniscule domains only 50 by 200 nm in size, representing a 1 or a 0, are read out by a sensor flying only 10 nm overhead.

The first unambiguous observation of a digital version of the magnetoresistance effect—the change in the resistance recorded by the sensor changes in discrete steps as the magnetic orientation relative to the sensor is changed—was reported by physicists from the University of Nebraska and the Institut de Physique et de Chimie des Materiaux de Nancy.

The quantization of conductance on the sensor side was achieved by having the current flow through a constriction that tapers down to the size of a single atom, a passage which imposes quantum conditions. According to Nebraska scientist Andrei Sokolov, an atom-sized point contact makes the read-write process ever more compact in physical extent, allowing much greater data storage. (Sokolov et al., Nature 437, 171-175 (2005))

The Ever-Shifting Face of Plutonium

A new theory explains some of the unusual properties of plutonium, the radioactive metal best known for its proclivity to undergo nuclear fission chain reactions, making it a potent fuel for nuclear weapons and power plants. Plutonium is one of the most unusual metals—it’s not magnetic and it does not conduct electricity well. The material also changes its properties dramatically because of the tendencies of its different electrons to shuttle about randomly. If its size dramatically with even the slightest changes in its temperature and pressure. The material also changes its properties because of the tendency for potentially superconductivity-quenching magnetic vortices to form in the material.

The IBMer who coined the term “plutonium” was a scientist at IBM-Almaden, pointing out that HTSC applications have largely not materialized. No companies are making a profit from selling HTSC products. Nevertheless, the mood of the 2007 session (Woodstock20) was upbeat. Bednorz said that if the wave of HTSC innovation could occur. Paul Chu ventured to predict that within ten years, HTSC products would have an impact in the power industry.

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Electron Tunneling in Atoms Has Now Been Observed in Real Time

Electron tunneling in atoms has now been observed in real time by a German-Austrian-Dutch team (Ferenc Krausz, Max Planck Institute of Quantum Optics, and Ludwig Maximilians, University of Munich) using light pulses lasting only several attoseconds (billionths of a billionth of a second), providing new glimpses into an important ultrafast process in nature.

The tunneling process is responsible for the operation of certain electronic components, such as scanning tunneling microscopes, Esaki (tunneling) diodes, and quantum-cascade lasers. And in nuclear fission, alpha particles are believed to escape the fracturing material by tunneling instead of scattering. Yet the tunneling process occurs so quickly, on the scale of attoseconds, that it has been possible to observe directly. With the recent ability to create attosecond-scale light pulses—pioneered by Krausz and others—theon is now possible. With the new experiment, a gas of neon atoms is exposed to two light pulses. One is an intense pulse containing low-energy red photons. The second pulse is an attosecond-length pulse of ultraviolet light. This ultraviolet attosecond pulse delivers photons so energetic that they can rip off an electron and promote a second one to the periphery of the atom, into an excited electronic state.

Then, the intense red pulse, consisting of just a few wave cycles, has a chance to liberate the outgoing electron via a light-field-induced tunneling. Indeed, the researchers saw this phenomenon, predicted theoretically forty years ago but only verified now for the first time experimentally—in a direct test of the ultrafast study. As each electron is sent in the freewheeling red pulse course through the atoms, the electrons each time upper their probability of escaping through tunneling until it reached about 100%.

The data indicate that, in this particular system, the electrons escape via tunneling in three discrete steps, synchronized with the three most intense wave crests at the center of the few-cycle laser wave. Each step lasts less than 400 attoseconds. (Uiberacker et al, Nature 446, 627-632 (4 April 2007))

Laser Cooling of Coin-sized Objects

Laser cooling of coin-sized objects down to one-keV temperatures is now possible. In a set of experiments performed last year, a variation on the laser-cooling technique used in chilling vapors of gases down to sub-keV temperatures had been used in macroscopic (but still small) samples of named material. Now, a collaboration of scientists from the LIGO Laboratory at MIT and Caltech and from the Max Planck Institutes in Potsdam and Hanover has used laser beams to cool a coin-sized mirror with a mass of 1 gram down to a temperature of 0.8 K. The goal of chilling such a comparatively large object (with more than 10^7 atoms) is to investigate the...
Quantum properties of large ensembles of matter.

An important caveat here is the fact that in all these experiments the “cooling” takes place in a vacuum. This is a thousandfold improvement over the best previous test, one carried out 21 years ago (Physical Review D, 34, 3240, (1986)). The new test was performed by physicists at the University of Washington using a swiveling torsion pendulum. One implication of Newton’s law is that the pendulum’s frequency should be independent of the amplitude of its swinging (as long as the oscillation is small). Looking for a slight departure from this expected independence, the Washington researchers watched the pendulum at very small amplitudes; in fact, the observed swivel was kept so small that the Brownian excitation of the pendulum was a considerable factor in interpreting the results. Newton’s second law is expected to break down for subatomic size scales, where quantum uncertainty frustrates any precise definition of velocity. But for this experiment, where the pendulum consists of 10^24 atoms, quantum considerations were not important. According to one of the scientists involved, Jens Gundlach, this new affirmation that force is proportional to acceleration (at least for non-relativistic speeds), might influence further discussion of two anomalies:

1. Oddities in the rotation curves for galaxies–characterizing the velocity of stars as a function of their radii from the galactic center–suggest either that extra gravitational pull in the form of the presence of as-yet-undetected dark matter is at work or that some new form of Newton’s second law could be operating (referred to as Modified Newtonian Dynamics, or MOND). (Stanford).

2. The GP-B experiment, a research team led by Rudi Grimm of the University of Innsbruck in Austria finally succeeded in the production of a single top quark via a weak-force interaction, a much rarer event than the one in which a top-antitop pair is made via the strong force. (Chicago).

Tevatron’s Higgs Quest Quickens

Physicists from Fermilab’s Tevatron collider have reported their most comprehensive summary yet of physics at the highest laboratory energies. At the APS April Meeting in Jacksonville, Florida they delivered dozens of papers on a spectrum of topics, many of which are related in some way to the Higgs boson. The Higgs is the cornerstone ingredient in the standard model of high energy physics. It is the particle manifestation of the curious mechanism that kicked in at an early moment in the life of the universe: the W and Z bosons (the carriers of the weak force) became endowed with mass while the photon (the carrier of the electromagnetic force) did not. This asymmetry makes the two forces very different in the way they operate in the universe.

Validating this grand hypothesis by actually making Higgs particles in the lab has always been a supremely difficult goal. This year the LEP and the Tevatron had combined energy of 2 TeV. However, the search for the Higgs is expected to be shadowed by the production of other rare scattering scenarios, some of them nearly as interesting as the Higgs itself.

According to Jacobo Konigsberg (University of Florida), co-spokesperson for the D0 collaboration (one of the two big detector groups operating at the Tevatron), the search for the Higgs is speeding up owing to a number of factors, including the achievement of more intense beams and increasingly sophisticated algorithms for discriminating between meaningful and mundane events.

Here is a catalog of some of the recent results from the Tevatron. Kevin Lannon (Ohio State), a new Category V, has a neutrino detection over the short run from the fixed target to the detector one would expect very few neutrino events. MiniBooNE, after taking into account expected background events, sees none. Thus they see no oscillation and therefore no evidence for a fourth neutrino.

Actually it’s not exactly true that they see no electron neutrinos. At low neutrino energy the background events, of course, overwhelm the signal. At the highest energy, however, they data-taking now underway using a beam of anti-neutrinos. At the APS meeting, MiniBooNE co-spokesperson Janet Conrad (Columbia) said that the low-energy data are robust (meaning that a shortage of statistical evidence or systematic problems with the apparatus should not be major factors) and that some new physical effect cannot be ruled out.
Nuclear Magnetic Resonance Imaging with 90-Nm Resolution

Researchers in Italy have created the shortest light pulse yet—a single isolated burst of extreme-ultraviolet light that lasts for only 130 attoseconds (billionths of a billionth of a second). Shining this ultrashort light pulse on atoms and molecules can reveal new details of their inner workings—providing benefits to fundamental science as well as potential industrial applications such as better controlling quantum reactions.

Working at Italy’s National Laboratory for Ultrastar and Ultraintense Optical Science in Milan (as well as laboratories in Padua and Naples), the researchers believe that their current technique will allow them to create even shorter pulses well below 100 attoseconds. In previous experiments, longer pulses, in the higher hundreds of attoseconds, have been created.

The general process for this experiment is the same. An intense infrared laser strikes a jet of gas (usually argon or neon). The laser’s powerful electric fields rock the electrons back and forth, causing them to release a train of attosecond pulses consisting of high-energy photons (extreme ultraviolet in this experiment). Creating a single isolated attosecond pulse, rather than a train of them, is more complex. To do this, the researchers employ their previously developed technique for delivering intense short (5 femtosecond) laser pulses to an argon gas target. They use additional optical techniques (including the frequency comb that was a subject of the 2005 Nobel Prize in physics) for creating and shaping a single attosecond pulse.

The results were presented (paper JTHA5) at the Conference on Lasers and Electro-Optics and the Quantum Electronics and Laser Science Conference (CLEO/QELS); also seeSansone et al., Science 20 October 2006: Vol. 314, no. 5799, pp. 443–446).

Ripping Fluids

A major difference between a solid and a liquid is that if you move a knife through a solid, the cleft portions stay cleft, whereas in a liquid the two parts flow back together. Almost always, however, nature provides materials and processes that don’t quite fit into such neat categories.

Joseph Gladden (University of Mississippi) and Andrew Belmonte (Penn State) have contrived an experiment in which a cylinder is dragged through a mixture of water, soap, and certain salts. At small drag speeds, the material—viscous gel-like substance which is a fluid at these temperatures does indeed close back on itself, as a liquid normally does. At higher speeds, the cylinder creates more of a cleft and the material is slower to “heal” itself. At still higher velocities, the fluid acts like a solid, at least for a while; it is ripped into several parts, with separate surfaces, which take as long as a few hours to close up, and it exhibits various “cracks” emanating from the cylinder’s wake.

Gladden says that the phase diagram (cylinder speed versus cylinder diameter) for the fluid displays three regions: the modest tearing, and on the right mapping out this phase diagram should help in understanding other phenomena involving viscoelastic materials, Gladden says. (Phys. Rev. Lett. 98, 224501 (2007)).

Nuclear Magnetic Resonance Imaging with 90-Nm Resolution

Nuclear magnetic resonance imaging (with 90-Nm resolution has been achieved by John Mamin and his colleagues at the IBM Almaden lab in San Jose, California. The approach used, magnetic resonance force microscopy (MRFM), maps the location of matter at small scale by observing the resonant vibration of a spindly silver of silicon (bearing the sample in question) when it is both exposed to radio-frequency waves and scanned over a tiny magnetic tip.

Previously this same group of physicists had used a similar setup to detect the magnetic resonance of a single unpaired electron in a sample. But now they are detecting the magnetic resonance of nuclei in the sample, a much more difficult thing since nuclear magnetism is much weaker than electron magnetism (in the case of hydrogen, some 660 times weaker). The main challenge was that the response of various biologically and technologically important atoms such as H, P, C-13 or F can be differentiated.

Another polonium oddity: its elastic anisotropy is greater than for any other solid. That is, it is about 10 times easier to deform a Po crystal along the direction diagonal to the consolidated cubic cells than it is to deform the crystal in a direction perpendicular to any of the cubic faces. According to Dominik Legut, this property results directly from the simple cubic structure of polonium. Polonium is a hazardous element that appears in the air and soil and in such plants as tobacco, tea, and mushrooms. (Legut et al., Phys. Rev. Lett. 98, 254501 (2007)).

Polonium Is the Only Element with Simple Cubic Structural

Polonium is the only element with a simple cubic crystal structure, and new theoretical work explains why that is. In a solid piece of polonium the atoms sit at the corners of a cubic unit cell and nowhere else.

One reason the study of Po is so difficult is that it is highly radioactive and spews forth decay products; indeed, polonium may even be hazardous to other elements. Physicists at the Academy of Sciences in the Czech Republic have now produced the first detailed theoretical explanation for polonium’s unique crystal structure; it is the result of the complicated interplay of relativistic effects which become important in such heavy atoms as polonium (element 84).

Specifically they have identified the so-called mass-velocity term (describing the relativistic increase in mass of electrons traveling with velocities comparable to the velocity of light) as the cause of the simple-cubic structure of polonium.

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First Direct Measurement of DNA Stacking Forces

DNA is one of the most important and studied molecules around, and yet only now has a team of scientists, working at Duke University, succeeded in measuring the force between the nucleotides in a single-stranded DNA (ssDNA) molecule, using an atomic force microscope (AFM).

A double-stranded DNA is characterized by two principal forces—the stacking force between base units along the length of the double helix and the pairing force (Watson-Crick pairing) between the opposing base units forming the runs of the helix. Measurements of DNA elasticity dating back to the 1990s (see http://static.sciencemag.org/content/290/5503/1811.DC1.htm) were done with double-stranded DNA, and it is difficult to separate the effects of the pairing and stacking forces.

That’s why Pietro E. Marszalek and his colleagues (Changhong Ke, Michael Humenik, and Hans-Georg Schmeterl) used ssDNA. They rigged an artificial ssDNA consisting only of adenine base units attached to a gold substrate, and then pulled it with an AFM tip.

With a force resolution of about 1 pico-Newton, the Duke apparatus detected one plateau in elasticity (of the stacking force) at around 23 pN, which was expected, and then a second plateau around 108 pN. (Ke et al., Phys. Rev. Lett. 99, 018302 (2007) a paper measuring forces for a single RNA molecule, finding a single force plateau at 20 pN, appeared in Seol et al., Phys. Rev. Lett. 98, 158103 (2007)).

Time and Time Again

The physics world accepts the idea of spacetime, a combined metrical entity which puts molecules at the single nuclear spin level. Mamin et al., Nature Nanotechnology 2, 301-306 (2007))

Warm the World, Shrink the Day

Global warming is expected to raise ocean levels and thereby effectively shift some ocean water from currently deep areas into shallower continental shelves, including a net transfer of water mass from the southern to the northern hemisphere. This in turn will bring just so much water closer to Earth’s rotational axis, and this—like a figure skater speeding up—will in turn shorten Earth’s day, says she folds her limbs inward—which will shorten the diurnal period.

Not by much, though. According to Felix Landerer, Johann Jungclaus, and Jochem Ma- rotzke, scientists at the Max Planck Institute for Meteorology in Hamburg, the day should shorten by about 0.12 milliseconds over the next two centuries. (Landerer, Jungclaus, and Ma-rotzke, Geophys. Rev. Lett., 34, L03307 (2007)).

Microfluidic Accelerator

Microfluidics is the science of carrying out fluid chemical processing on a chip whose channels are typically millimeters or microns across. In such a confined space, viscosity becomes large, and the fluid flow will slow down way down, thus limiting the kind of mixing or testing that can be done. Physicists at the University of Twente in the Netherlands, however, use tiny exploding bubbles to speed things up.

The bubbles are produced by shooting laser light into the fluid. (See movie at http://still time-and-time-again.nl/people/ohl/controlled-cavitation.html). The light brings a tiny volume of fluid above its boiling temperature, causing a local bubble explosion, which accelerates the surrounding fluid along the channel, now at speeds of up to 20 m/sec, twenty times higher than would be the case without the bubble, and still another factor of 10 within reach. (The same researchers have produced sonoluminescence in the same way.)

An extra advantage in using flexibly positioned laser light is that for transparent microfluidic chips, fluid pumping can be accomplished without external connections to the chip. Besides the reflected light reaching such a reaction technique for improving mixing in various enzyme reactions and in producing tiny pores in membranes. (Zwan et al., Phys. Rev. Lett. 98, 254501 (2007)).

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Time and Time Again

The physics world accepts the idea of spacetime, a combined metrical entity which puts...
time on the same footing as the visible three spatial dimensions. Further spatial dimensions are added in some theories to help assimilate all physical forces into a unified model of reality. But what about adding an extra dimension of time too? Itzak Bars and Yueh-Cheng Kuo of the University of Southern California do exactly that, and add an extra spatial dimension too.

The addition of an extra time and an extra space dimension, together with a requirement that all motion in the enlarged space be symmetric under an interchange of position and momentum at any instant, reproduces all possible dynamics in ordinary spacetime, and brings to light many relationships and hidden symmetries that are actually present in our own universe.

The hidden relationships among dynamical systems are akin to relationships that exist between the multiple shadows of a 3-D object projected on a 2-D wall. In this case the object is in a spacetime of 4 space and 2 time dimensions while the shadows are in 3 space and 1 time dimensions. The motion in 4+2 dimensions is actually much more symmetric and simpler than the complex motions of the shadows in 3+1 dimensions.

In addition, Bars says that his theory explains CP conservation in the strong interactions described by QCD without the need for a new particle, the axion, which has not been found in experiments. It also explains the fact that the elliptical orbit of planets remains fixed (not counting well-known tiny perturbations). This “Runge-Lenz” symmetry effect has remained somewhat mysterious in the study of celestial mechanics, but now could be understood as being due to the symmetry of rotations into the fourth space dimension.

A similar symmetry observed in the spectrum of hydrogen would also be accounted for in time=2 physics, and again explained as a symmetry of rotations into the extra space and time dimensions. There are many such examples of hidden symmetries in the macroscopic world as well as in the microscopic quantum world, Bars argues, which can be addressed for the first time with the new 27 formulation of physics. There have been previous attempts to formulate theories with a second time axis, but Bars says that most of these efforts have been compromised by problems with unitarity (the need for the sum of all probabilities of occurrences to be no greater than 1) and causality (maintaining the thermodynamic arrow of time).

The USC theorists have reformulated their model to fit into the ongoing supersymmetry version of the standard model and expect their ideas to be tested in computer simulations and in experiments yet to come. (Bars and Kuo, Phys. Rev. Lett. 99, 041801 (2007))

All-Optical Magnetic Recording

All-optical magnetic recording has been demonstrated by scientists at the Radboud University Nijmegen in the Netherlands. Instead of using the customary magnetic read head to flip the magnetic orientation of a tiny domain, they use the fields present in a short burst of circularly polarized light.

Why use light instead of a magnet? Because the magnet is relatively slow and because the magnetic field in the light pulse is intrinsically strong—up to 5 Tesla. The pulses are perpendicular to the orientation of the data on the storage medium and the resulting electrical “current” would be about 0.4 microamps. Why use light rather than voltage to drive electricity? Because the whole thing can be done on a femtosecond scale.

One of the researchers, Michael Crommie of UCB, says that it is still too early to try to store data in the form of individual polarized atoms. Rather they are seeking to understand how the spin of a single atom is influenced by its environment, with an eye toward future spintronics and quantum information applications. (Yayon et al., Phys. Rev. Lett. 99, 067202 (2007))

Hydrogen-Seven

An experiment at the GANIL facility in France is the first to make, observe, identify, and characterize the heaviest isotope yet of hydrogen, H-7, consisting of a lone proton and 6 neutrons. (An earlier experiment saw some inconclusive evidence for this state—see Kornevich et al., Phys. Rev. Lett. 90, 082501 (2003).)

All of the lighter isotopes of hydrogen have previously been seen: H-1 (ordinary hydrogen), H-2 (deuterium), H-3 (tritium), and H-4 up to H-6. Technically speaking, the H-7 state (like H-4, H-5, and H-6) is not a fully bound nucleus. It is considered a resonance since (besides being very short-lived) energy is required to force the extra neutron to adhere to the other nuclei.

In a proper nucleus energy is required to remove a neutron. In the GANIL experiment, a beam of helium-8 ions (themselves quite rare) is smashed into a carbon-12 nucleus residing in a gas of butane. In a few rare occurrences, the He-8 gives one of its protons to the C-12, producing H-7 and N-13, respectively. The H-7 flies apart almost immediately into H-3 and four separate neutrons.

Meanwhile the N-13 is observed in the active-target MAMA detector, a device much like a bubble chamber, allowing its energy and trajectory to be deduced.

By taking the conservation of momentum and energy into account, the fleeting existence of the H-7 is extracted from the N-13 data. A total of seven H-7 events was observed. A rough lifetime for H-7 of less than 10^-12 seconds can be inferred. The helium-8 nucleus (2 protons plus 6 neutrons) used to make the H-7 is interesting all by itself since it is believed to consist of a nuclear core with two “ الدولة” neutrons orbiting outside.

This radioactive species must carefully be gathered up from carbon-carbon collisions (in a separate step) and then accelerated. One of the GANIL researchers, Manuel Caamaño Fresco says that one of the chief reasons for looking at H-7 is to get a better handle on exotic nuclear matter.

The H-7 nucleus, during its brief existence, might consist of a H-3 core and plus two 2-neutron outliers, or maybe even a single 4-neutron blob outside. Larger still hydrogen isotopes, such as H-8 or H-9, might be observable. (Caamaño et al., Phys. Rev. Lett. 99, 062502 (2007))

Observing Magnetic Polarization in Single Atoms

Physicists from UC Berkeley and the Naval Research Lab have measured the spin properties of individual atoms added to a metal surface. They do this by first forming nm-sized triangular islands of cobalt on top of a copper crystal. The cobalt is ferromagnetic, which means that the spins of the cobalt atoms in the islands all line up together (half of the islands have their collective spins pointing up, while the other half point down).

Additional magnetic atoms sprinkled on top of the islands (adatoms) have spins that interact magnetically with the underlying cobalt, causing the adatom spins to either align or anti-align with the underlying island spins. Thus when a small number of iron atoms (chromium atoms were also used) are dropped onto the islands they immediately become oriented (polarized) by contact with a cobalt island.

In this way isolated atoms (up to 5 nm apart) were prepared with a definite spin polarization state. Next the quantum energy levels of the magnetic adatoms were studied using the tip of a scanning tunneling microscope (STM) which itself had been magnetized.

The quantum energy levels of the iron and chromium adatoms were sampled by observing currents flowing from the adatoms into the STM tip. Current measured in this way will be larger or smaller depending on whether the spin polarization of the tip is aligned with or against the polarization of the individual magnetic adatoms being probed. The adatoms energy states are seen to differ for spin-up and spin-down states, indicating that iron and chromium atoms couple magnetically to cobalt with opposite polarity.

One of the researchers, Michael Crommie of UCB, says that it is still too early to try to store data in the form of individual polarized atoms. Rather they are seeking to understand how the spin of a single atom is influenced by its environment, with an eye toward future spintronics and quantum information applications. (Yayon et al., Phys. Rev. Lett. 99, 067202 (2007))

Light-Directed Femtosecond Electricity

Scientists in Canada foresee the use of electromagnetic fields of laser light for inducing and reversing tiny electrical currents along molecular wires without the use of a voltage applied across leads. They would accomplish this feat by shining special laser pulses containing light waves at two different frequencies onto a molecular wire. The frequency difference creates a new frequency that acts like a junction between two metallic leads on either side.

Depending on the exact frequencies used, the time duration of the pulse, and the relative phase relation between the two components of light, the induced pulse of electric flow could consist of either a single electron or many.

For the case of one electron set in motion by the 400-femtosecond pulse of laser light, the resulting electrical “current” would be about 0.4 micromamps. Why use light rather than voltage to drive electricity? Because the whole thing can be done on a femtosecond scale with lasers.

Ignacio Franco says that a potential use of laser-driven electricity would be in future optoelectronic devices such as ultrasmall nanowires. (Franco, Shapiro and Brumer, Phys. Rev. Lett. 99, 126802 (2007))

Acoustic Quantum Dots

A new experiment at the Cavendish Lab at the University of Cambridge is the first to controllably shuttle electrons around a surface and observe their quantum properties. A quantum dot restricts electrons to a region of space in a semiconductor so tiny as to be essentially zero-dimensional. This in turn enforces a quantum regime; the electron may only have certain discrete energies, which can be useful, depending on the circumstances, for producing laser light or for use in detectors and maybe even future computers.

A quantum dot is usually made not by carving the semiconductor into a tiny grain but rather by imposing restrictions on the electron’s possible motions by the application of voltages to nearby electrodes. This would be a static quantum dot. It is also possible to make dynamic quantum dots—that is, moving dots that are created by the passage of surface acoustic waves (SAWs) moving through a narrow channel across the plane of a specially designed circuit chip. The acoustic wave itself is generated by applying microwaves to interleaved fine wires placed on a piezoelectric material like GaAs. The applied electric
fields between finger-electrodes induce a sound wave to propagate along the surface of the material. These acoustic waves have the ability to scoop electrons and chauffeur them along the surface. The tiny region confining the electron even as it moves is in effect a quantum dot. Such electronic devices–in which the electrons are, however, other potential information carriers, such as photons. Indeed a major industry, photonics, has developed around the sending of messages encoded in pulsed light. Heat pulses, or phonons, rippling through a crystal might also become a major carrier, especially from our sun, but many others come from far away. Of most interest are the highest-energy ones, which might trigger a large avalanche in electrical resistance, thus “reading” the data vested in the magnetic orientation. This is the heart of modern hard drive technology and makes possible the immense hard-drive data storage and processing. Spintrons are the general name for this budding branch of electronics. (Nobel Prize website: http://nobelprize.org/nobel_prizes/physics/laureates/2007/info.html)

2007 Nobel Prize in Physics

The 2007 Nobel Prize in Physics was awarded to Albert Fert (Université Paris-Sud, Orsay, France) and Peter Grünberg (Forschungszentrum Jülich, Germany) for the discovery of giant magnetoresistance, or GMR. GMR is the process by which a magnetic field, such as that of an oriented domain on the surface of a composite material, can drive to and from the conduction bands in a magnetic semiconductor, thus “reading” the data vested in the magnetic orientation.

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Relativistic Thermodynamics

Einstein’s special theory of relativity has formulas, called Lorentz transformations, that convert time or distance intervals from a resting frame of reference to a frame zooming by at nearly the speed of light. But how about temperature? That is, if a speeds up, carrying her thermometer with her, tries to measure the temperature of a gas in a stationary bottle, what temperature will she measure? A new look at this contentious subject suggests the temperature is actually a limit that is measured in the rest frame. In other words, moving bodies will not appear hotter or colder. You’d think that such an issue would have been settled decades ago, but this is not the case. The problem is how to define temperature in a moving frame of reference. It is not exactly known how several thermodynamic parameters change at high speeds. Absolute zero, Dunkel says, will always be absolute zero, even for quickly-moving observers. But producing proper Lorentz transformations for other quantities such as entropy will be trickier to do. (Cubero et al., Phys. Rev. Lett. 99, 176801 (2007))

Nuclear Droplet Dinosaurs

Several new heavy isotopes have been discovered, at least one of which pushes beyond the neutron dripline. Dinosaurs are, however, other potential information carriers, such as photons. Indeed a major industry, photonics, has developed around the sending of messages encoded in pulsed light. Heat pulses, or phonons, rippling through a crystal might also become a major carrier, especially from our sun, but many others come from far away. Of most interest are the highest-energy ones, which might trigger a large avalanche in electrical resistance, thus “reading” the data vested in the magnetic orientation.

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The Highest-Energy Cosmic Ray Simons

The highest-energy cosmic rays probably come from the cores of active galactic nuclei (AGN), where supermassive black holes are thought to supply vast energy for lifting the rays across the cosmos. This is the conclusion reached by scientists who operate the Pierre Auger Observatory in Argentina. This gigantic array of detectors spread an area of nearly 3000 km² looks for one thing: cosmic ray showers. These arise when extremely energetic particles strike our atmosphere, spanning a gush of secondary particles. Many of the rays come from inside our Milky Way, especially from our sun, but many others come from far away. Of most interest are the highest-energy ones, which might trigger a large avalanche in electrical resistance, thus “reading” the data vested in the magnetic orientation.

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Cooper Pairs in Insulators

Cooper pairs are the extraordinary link-up of like-charged electrons through the subtle flexings of a crystal. They act as the backbone of the superconducting phenomenon, but have also been observed in a material that is not only non-superconducting but actually an insulator. An experiment at Brown University measured electrical resistance in a Swiss-cheese-like plume of bismuth atoms made by spritzing a cloud of atoms onto a substrate with 27-nm-wide holes spaced 100 nm apart. Bismuth films made this way are superconducting if the sample is many atom-layers thick but is insulating if the film is only a few atoms thick, owing to subtle effects which arise from the restrictive geometry. It appears that Cooper pairs are present in the insulator as well with well known AGN’s. (Auger collaboration, Science 9 November 2007: Vol. 318. no. 5852, pp. 938-943)

Persistent Flow or Bose-Condensed Atoms in a Toroidal Trap

A persistent flow of Bose-condensed atoms has been achieved for the first time, of the measurement. One of the scientists on the project, Kristian Helmerson, says that neutral atoms flow as if they were particles in an early stage. It is not exactly known how several thermodynamic parameters change at high speeds. Absolute zero, Dunkel says, will always be absolute zero, even for quickly-moving observers. But producing proper Lorentz transformations for other quantities such as entropy will be trickier to do. (Cubero et al., Phys. Rev. Lett. 99, 176801 (2007))
**Senior Physicists Group 10 Years Old and Going Strong**

*By Calla Cofield*

In 1998 Dick Stronbrotte retired from a long and busy career with the U.S. Department of Transportation. Like many physicists, Stronbrotte may have retired, but his love of physics and his desire to learn hadn’t waned. Having been a member of APS for 40 years, Stronbrotte contacted APS Executive Officer Judy Franz to see if there was a local group of physicists with a similar desire to remain active in the physics community. Since there wasn’t one, Stronbrotte started it himself. He organized the first meeting that came out for the initial planning meeting, and in the past ten years, the contact list members of the organization had grown to 160.

The Mid-Atlantic Senior Physicists Group is now celebrating its ten-year anniversary. For the past decade the group has sponsored talks on physics, tours to local physics installations, and trips to more distant sites. The events are open to anyone interested in attending.

Stronbrotte says of the formation of the group, “For the first year or so, we had about three talks in the spring and three talks in the fall. Now we have a talk in most months... and tours of some installation in other months.” Four of the original ten planning committee members are still on board with the group.

Stronbrotte says they called the group “Senior Physicists” because “senior” seemed to describe the people most interested in participating. Many of the group’s members are retired, but many are still working full or part time. Some are APS members and some aren’t. Some members are senior in age, some are senior in experience, and some are both, but despite the name the activities are open to anyone.

The group’s featured talks have been about nanotechnology, global climate change, topics in astrophysics, string theory, supersymmetry, medical physics, and the evolution of standard time, to name a few. They usually take place on the third Wednesday of each month at APS headquarters in College Park, MD. Other activities have included a visit to the M.C. Escher exhibit at the National Gallery in Washington, and tours to different physics installations such as the David Taylor Model Basin at the Naval Research Laboratory, the Applied Physics Lab at Johns Hopkins, and a two-day trip to the National Radio Astronomy Observatory in Green Bank, West Virginia.

For the past ten years the group has existed as an informal part of APS. They are considering trying to become an APS Forum, which would require 200 members who belong to APS. As a forum, the group would gain additional funding and exposure, potentially uniting them with other regional groups of the same nature, or motivating others to start groups where there are none. Mainly, the group would like to make themselves known to more physicists who would be interested in joining. A website for the group is scheduled for launch later in 2008, and until then anyone interested in attending a talk or activity can contact APS Director of Membership Trish Lettieri at lettieri@aps.org or 301-209-3722.

By Michael S. Lubell, APS Director of Public Affairs

It was Washington, not Tombstone, and it was 2007, not 1881, but when Congress finally passed the Omnibus spending bill for Fiscal Year 2008 shortly before Christmas, their labor left many government activities riddled with holes.

Like the shoot-out at the O.K. Corral a century earlier, some of the facts surrounding the fiscal casualties still remain murky. And just as Tom McClary and Billy Clanton might have escaped the hail of bullets that day had Wyatt Earp and “Doc” Holliday known they were unarmed, science might have come through the partisan fusillade last year had Congress known the consequences of its actions.

But McClary and Clanton were mortally wounded. And though science is still alive, it is badly in need of life support.

The dispute between EARP and the “Cowards” dated back more than a year before the shoot-out. And so, too, with the Fiscal Year 2008 science budget: the seeds of the antagonism that led to its collapse were sown in 2006. In his State of the Union Address that year, President Bush unveiled the American Competitiveness Initiative that put the research budgets of the Department of Energy, Office of Science, the National Institute of Standards and Technology, and the National Science Foundation on a ten-year doubling path. The President’s announcement followed on the heels of the National Academies’ report, Physics 2030, the Engineering Sciences, and the House Democrats’ release of their Innovation Agenda.

With Congress still in the hands of the Republicans, who had caoted to the White House during the previous three years, Washington was back in the days of Wyatt Earp and the O.K. Corral. The pattern. But by the time the November elections rolled around, the Republicans had failed to pass any domestic appropriations bills. And after their defeat at the polls, the GOP packed its bags, leaving behind a huge fiscal mess for the 110th Democratic Congress to clean up.

As the Republicans fled, Democrats warned they would have less than a month to deal with Fiscal Year 2007 spending before the 2008 budget landed on their desks.

Shoot-Out at the O.K. Corral

**New Lab Association Elects Officers**

The Advanced Laboratory Physics Association (ALPhA) elected its first officers in November. The organization formed last spring after holding an organizational session at the 2007 APS March Meeting (see APS News, May 2007), and now has over 100 members.

The group’s election was an historic moment, as ALPhA is an organization of physicists who work for the U.S. government. The organization is designed to encourage communication among those who teach advanced undergraduate laboratory courses and pursue research in these labs; and among those instructors. “ALPhA hopes to become the central advocacy group for advanced experimental physics instruction,” in constitution states.

ALPhA will work closely with both the American Association of Physics Teachers (AAPT) and APS. ALPhA will plan sessions at AAPT and APS meetings, suggest invited talks at these meetings, award professional prizes, and plan special conferences on advanced experimental instruction. The organization held an open meeting at the January AAPT meeting, and will have a similar event at the 2008 APS March Meeting.

Recently elected ALPhA president Gabe Spalding of Illinois Wesleyan University has been teaching advanced lab for 12 years, and regards these courses as challenging. “There should be thought given to the experimental curriculum,” he said.

In addition to fitting in with the rest of the curriculum and teaching appropriate experimental skills, these courses have to teach a “mindset,” said Spalding. A good advanced lab course encourages students to take ownership of their projects, he added.

“I believe that ALPhA will have an enormous impact on the instruction and the experimental curriculum. This sort of banding together of dedicated instructors can be transformative,” said Spalding.

ALPhA has established a list-serv devoted to the teaching of advanced laboratory courses. The list-serv discusses everything from technical problems with equipment to issues of curriculum, and is open to anyone. It can be found at http://lists.aip.org/cgi-bin/lyris.pl/JOIN-ALPHA.

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**New Appiring in RMP: Recently Posted Reviews and Colleagues You will find the following in the susbsequent Reviews of Modern Physics at http://rmp.aips.org**

Four-body methods for high-energy ion-atom collisions

David Balibar, Ivan Manev and Jocelyn Hanssen

This review presents a thorough overview of the current status and present approaches to the study of the quantum-mechanical four-body theory of nucleus-atom collisions. A proper description of these collisions will require the solution of the pertinent four-body problem, which requires the evaluation of a number of inelastic collisions with special emphasis on the role of single electron capture, double electron capture, transfer and emission of one or more electrons, and processes such as the elimination of nucleons from the atomic core. Work within the four-body framework for the present is hampered by the absence of a proper Coulomb boundary condition and the lack of experimental data and shell calculations, the review analyses a number of the leading quantum-mechanical theories. The scope of the review is limited to intermediate- and high-nuclear-mass impact energies.
A Physicist for President?

By Vernon J. Ehlers

“Have you heard any candidate explain the importance of science and math education to our national defense, energy solutions, global competitiveness, health care, or the ability of our students to obtain meaningful employment in the future?”

“A scientist in the Oval Office would bring good analytical skills to decision-making in the White House, and would appreciate the need for a population well-versed in science.”

“Why do we choose to support the education of our children?”

“Physicist for President” platform would present our nation with a winning array of ideas developed to put us on the path toward sustained economic competitiveness and bolstered innovation.

In summary, the Physicist for President platform would present our nation with a winning array of ideas developed to put us on the path toward sustained economic competitiveness and bolstered innovation.

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All they could do, they said, was pass a Continuing Resolution, freezing all programs at the previous year’s level. The President’s competitive initiative, ACI, would have to be put on hold for a year.

But following an intense lobbying effort, science advocates managed to get a rare limited waiver for the three ACI agencies, and funding rose, though not as much as the President had requested. With White House science advisor Jack Marburger still sidelined by illness, the Office of Science and Technology Policy scolded the Democrats for funding only half the President’s request: a not a word about the failures of the 109th Republican Congress.

The partisan attack did not sit well with Democrats. Just hours later, House Science and Technology Committee Chairman Bart Gordon (D-Tenn.) responded, “While the President’s [FY 2008] budget includes some important funding increases, it lacks the priorities and consistency to ensure our competitiveness now and in the long run.”

So much for science bipartisanship? Still, in the coming months, Congress managed to pass overwhelmingly the America COMPETES Act that authorized the ACI doubling, and despite some grumbling, the President signed the bill.

The House also passed two pending bills with the ACI increases included. So too, did the Senate Appropriations Committee.

But the Senate leadership failed to bring any of its bills to the floor for a vote. Ultimately, the only option was an eleventh-hour $933 billion Omnibus bill, $22 billion above the White House bottom line.

The President held to his demand, adamantly refusing even to meet with House Science and Technology Committee Chairman Frank Pallone, Democratic leader, and despite some grumbling, the President signed the bill.

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