DOE Picks University of California to Head Los Alamos Management Team

The Department of Energy announced in December its decision to award the contract to manage Los Alamos National Laboratory to Los Alamos National Security, LLC (LANS), a partnership led by the University of California, partnered with Bechtel Corporation, a huge engineering, construction and project management company.

The University of California has run Los Alamos National Lab since the lab was created in 1943. But a series of safety, security, and financial problems in the past two years cast doubt on the university’s ability to manage the lab, and the DOE decided to put the contract out for a competitive bid.

Some at Los Alamos believe the problems have been blown out of proportion, and the contract didn’t need to be rebid. Other major labs have similar levels of safety and security, said Brad Holian, a Los Alamos physicist. “It’s not that Los Alamos is singularly bad. It seems to me is it a very bad idea.”

The LANS partnership that will take over the management of the lab includes the University of California, Bechtel Corporation, BWX Technologies, and Washington Group International. They are competing for the contract against a team led by Lockheed Martin and the University of Texas.

“Both proposals were strong and exceptionally high caliber,” said Energy Secretary Samuel Bodman at a press conference in December announcing the decision to award the contract to the UC/Bechtel team.

Bodman stressed that the new contract would not be a continuation of the previous contract. “This is a new contract, with a new team, marking a new approach to management at Los Alamos.”

That new approach includes a new attitude towards monetary compensation. The new contract, which begins June 1, has an initial term of seven years, with a provision to extend it to 20 years. Under the new contract, the LANS team will receive up to $79 million per year, depending on performance. Previously, the University of California had received about $9 million per year to manage the lab.

The new contract “begins a new era for Los Alamos,” University of California President Robert Dynes said in a statement after the announcement. “I believe this was an excellent decision and one that is right for both Los Alamos and the country.”

Details on how operations at the lab will change under the new management have not been announced. “This new contract will put in place concrete measures of accountability, ensuring that the tax dollars spent at Los Alamos are well spent,” said Bodman.

The March 12 offer led by the University of California, which is headed by Bechtel Corporation, a huge engineering, construction and project management company.

This year two named APS lectureships will bring distinguished foreign scientists to speak at the March and April meetings. The speakers were selected by the APS Committee on International Scientific Affairs (CISA), from nominations submitted by various APS units.

The Beller Lectureship was endowed by Esther Hoffman Beller for the purpose of bringing distinguished physicists from abroad as invited speakers at APS meetings. The lectureship provides support for speakers at the March and April meetings.

The March Lectureship, endowed by Ruth Marshak in honor of her late husband and former APS president, Robert Marshak, provides travel support for physicists from a developing country or Eastern Europe invited to speak at APS meetings.

The March Beller lecture will be given by Pierre-Gilles de Gennes, of the Collège de France. De Gennes is a leading exponent of soft condensed matter physics. He received the 1991 Nobel Prize in Physics for his generalization of physical order descriptors to complex soft matter. At the March Meeting, de Gennes will present a talk on “The Nature of Memory Objects in the Brain.” De Gennes was nominated for the Beller Lectureship by the Division of Polymer Physics.

The 2006 Marshall lecturer will be Zohra Ben Lakhdar of the University of Tunis. She will give a talk at the March Meeting entitled “Scientists in Developing Countries: Is there an effective way to support meaningful research?” Ben Lakhdar’s research focuses on atomic spectroscopy, and she is devoting her career to carrying out applied research to meet national needs in Tunisia. She is the recipient of the 2005 UNESCO–L’Oréal prize for Women in Sciences for her experiments and models on infrared spectroscopy and its applications to pollution, detection and medicine. Ben Lakhdar was nominated for the Marshall lectureship by the Forum on International Physics.

At the April Meeting, the Beller Lecture will be given by Albrecht Wagner, director of DESY, the German particle physics laboratory. Wagner has been a leading proponent of the APS Endowed Lectures.

As a closing event for the World Year of Physics, students from about 20 different countries attended a special “Physics Young Ambassadors” symposium in Taipei from December 31, 2005 to January 4, 2006. These students, ages 10-18, were chosen to attend the event through an international program, the WYP 2005 Talent Search.

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You don’t have to be a soldier in Iraq to know that the world is filled with mines. And not all of them are improvised explosive devices, concealed in a constantly shifting neutral zone. No, the ones I have in mind are visible, and they pack a delayed charge, one that can cripple America the mighty.

Once you go down that road it is very difficult to make a U-turn and go back to where you were.” - Mike Lubell, APS and CUNY, on budget cuts that will cause layoffs and cutbacks at RHIC, Associated Press, January 2, 2006

“Black hole processes are perhaps the most exciting source of gravitational waves. Don’t you think that a region of the universe from which no escape is possible, even in principle, is exciting?” - Richard Price, University of Texas at Brownsville, on gravitational waves and black holes. The Associated Press, December 28, 2005

I n 1967, when Jocelyn Bell, then a graduate student in astronomy, noticed a strange “bit of scruff” in the data coming from her radio telescope, she and her advisor Anthony Hewish thought initially they might have detected a signal from an extra-terrestrial civilization. It turned out not to be aliens, but it was still quite exciting: they had discovered the first pulsar. They announced their discovery in February 1968.

Bell, who was born in Ireland in 1943, was inspired by her high school physics teacher to study science, and went to Cambridge to pursue her PhD in astronomy. Bell’s project, with advisor Anthony Hewish, involved using a new technique, interplanetary scintillation, to observe quasars. Because quasars are farther away than other objects, Hewish thought the technique would be a good way to study them, and he assigned a radio-telescope to do so.

Working at the Mullard Radio Astronomy Observatory near Cambridge, starting in 1965 Bell spent about two years building the new telescope, with the help of several other students. Together they hammered over 1000 posts, strung over 2000 dipole antennas between them, and connected it all up with 120 miles of wire and cable. The finished telescope covered an area of about four and a half acres.

They started operating the telescope in July 1967, while construction was still going on. Bell had responsibility for operating the telescope and analyzing the data—nearly 100 feet of paper every day—by hand. So she had to design and scintillating sources and interference.

The discovery also explains why this black hole is so bright in infrared light. “As a scientist, I’d think some- thing was wrong if this signal were not a new physical phenomenon,” wrote Dicke, who was then a graduate student in astronomy. “If it were a new phenomenon, it might have some interesting cosmological consequences.”

But soon they managed to rule out extraterrestrial life as the source of the signal, when Bell noticed another similar signal, this time a series of pulses about 2 seconds apart, coming from an entirely different area of the sky. It seemed quite unlikely that two separate groups of aliens were trying to communicate with them at the same time, from completely different locations. Over Christmas 1967, Bell noticed two more such bits of scruff, bringing the total to four.

By the end of January, Bell and Hewish submitted a paper to Nature describing the first pulsar. “Nature was not impressed,” Bell said. “Just a few days before the paper was published, Hewish gave a semi- nary lecture in London, saying that we announce the discovery, they still had some difficulty believing the nature of the source. The announcement caused quite a stir. The press jumped on the story—the possible finding of extra-terrestrial life was too hard to resist. They became even more excited when they learned that a woman was involved in the discovery. Bell later recalled that there was a lot of media attention in a speech about the discovery: “I had a lot of people just standing up, leaving their chairs and taking photos of me.”

Other astronomers were also energized by the finding, and soon the world was looking for more pulsars and to figure out what these strange sources were. By mid-1968, dozens of pulsars had been discovered. Soon Thomas Gold showed that pulsars are actually rapidly rotating neutron stars, which form from the collapsed remnants of massive stars after a supernova, have strong magnetic fields that are not aligned with their rotational axis. The strong field and rapid rotation produces a beam of radiation that sweeps around as the star spins. On Earth, we see this as a series of pulses as the neu- tron star rotates, like a beam of light from a lighthouse.

After discovering the first pulsars, Jocelyn Bell finished her analysis of radio recordings, completed her PhD, got married and changed her name to Cornell. She left radio astronomy briefly in 1968 and then returned, and today her husband’s frequent moves and her father’s work as a weaver brought her attention in a speech about the discovery: “I had a lot of people just standing up, leaving their chairs and taking photos of me.”

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As for little green men, they haven’t been found yet, but proj- ects such as the Search for Extra Terrestrial Intelligence (SETI) are still looking for them.

Don’t Give Me No Bad News!

By Michael S. Lubell, APS Director of Public Affairs

You don’t have to be a soldier in Iraq to know that the world is filled with mines. And not all of them are improvised explosive devices, concealed in a constantly shifting neutral zone. No, the ones I have in mind are visible, and they pack a delayed charge, one that can cripple America the mighty.

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As for little green men, they haven’t been found yet, but projects such as the Search for Extra Terrestrial Intelligence (SETI) are still looking for them.
Charles Duke existed inside Xerox,” says Duke. But that would never happen nowadays. “You would now have different pieces done in different places.”

A threat that Duke worries about now is globalization. The United States is facing increased competition from other countries, including China. “They are producing engineers at a rate where we have been extremely successful. He has been elected to the National Academy of Sciences and the National Academy of Engineering, has won several prestigious prizes, including most recently the 2006 APS Prize in Materials Physics. He joined Xerox Corporation in 1972 in a materials researcher for the materials section, and has remained at Xerox in various positions since then.

Even though a career in physics was not his original plan, Duke has been extremely successful. He has been elected to the National Academy of Sciences and the National Academy of Engineering, has won several prestigious prizes, including most recently the 2006 APS Prize in Materials Physics. He joined Xerox Corporation in 1972 in a materials researcher for the materials section, and has remained at Xerox in various positions since then.

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Berman's Back Page Defended

Marshall Berman's call to arms against the pernicious doctrine of creationism ("Back Page", October, 2005) is to be applauded, and I look forward to it receiving in the December, 2005 Letters.

Creationist attacks on the theory of evolution, arising because of its incompatibility with a literal interpretation of the early chapters of Genesis, are met with an offensive range of scientific defenders, some of whom overstate their case by assigning to evolutionary theory a greater certitude than it merits. In his defense of Lane, in identifying these overstates-

Science Reporting or Junk Writing?

I read with amused distress the two articles "Living the Scientific American Dream" and "Science matters at USA Today" in your November 2005 issue. The first, while a list of names of the authors, with lyrical eloquence, assures us that is possible to become a single universal genius who upon need can use all the wisdom of writing meaningful, nay, inspiring reports on all scientific topis--quark confinement to laser technology, from polymer science to molecular genetics, etc., all the way to the cosmology.

It is necessary to achieve such a feat, one ought to be something like Lavoisier, Darwin, Planck, Einstein, Heisenberg, Crick, Higgs, etc. Such a feat cannot be achieved by human beings, even if not they are supported by the APS. The outcome of such an enterprise is at best a hotchpotch, mixed with PR publicity propaganda, "gee-whiz" show biz, as we are, sadly, accustomed to from our papers and journals. Even reading editorial-short reviews published in Physics Today, one sometimes finds a sentence in a paper, beyond his ken and did not quite understand the topic. The good news is that therefore there is room for a more specific, targeted and focused journalism.

Astrophysicists wanted a time scale that represented the Earth's movement, and the clock community wanted a smooth scale that represented the Earth's rotation. They agreed by setting a round number of days in a year. This agreement has turned out much respect. For women especially, we must make sure that the quality of graduate school that the applicants encounter matters. Of course, we can never ignore all statements by religious believers raises the question of why we should continue to meet their checks. It implies that our theory of the world is in fact more and more elastic. For women especially, we must make sure that the quality of graduate school that the applicants encounter matters. Of course, we can never ignore all statements by religious believers raises the question of why we should continue to meet their checks. It implies that our theory of the world is in fact more and more elastic. 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**Introduction**

Physics News in 2005, 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 and Ben Stein. The items in this supplement were compiled by Ernie Tretkoff of the American Physical Society. 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 in 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/physnews/update and APS's Physical Review Focus website at http://focus.aps.org/.

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**The Most Distant Craft Landing in the Solar System**

The Huygens probe, given long passage by the Cassini spacecraft into the middle of Saturn’s minor planetary system, has successfully parachuted onto the surface of Titan, the only moon with a considerable atmosphere. Pictures taken from miles above the surface during the descent and pictures taken on the surface itself suggest the presence of boulders or ice chunks and some kind of shoreline, perhaps of a hydrocarbon lake or sea. The data gained so far include a sort of acoustic sampling of the atmosphere during the descent and some color photographs. The Titan probe is named for Christian Huygens, who also in 1656 was the first to provide the proper interpretation of Saturn’s ring system.

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**The Biggest Splash of Light from Outside the Solar System**

The biggest splash of light from outside the solar system to be record- ed here at Earth occurred on December 27, 2004. The light came from an object called SGR 1806-20, about 50,000 light years away in our own galaxy. SGR stands for “soft gamma repeater,” a class of neutron star possessing a gigantic magnetic field. Such “magnets” can erupt violently, sending out immense bolts of energy in the form of gamma rays and light at other wavelengths regions of the electromagnetic spectrum. The eruption was first seen with orbiting telescopes at the upper end of the spectrum over a period of minutes and then by more and more telescopes; radio wavelengths emissions were monitored for months. For an instant the flare was brighter than the full moon. (NASA press conference, 18 February; www.nasa.gov/press/2005/sgrburst; many telescopes participated in the observations, reports appeared in the 28 April 2005 issue of Nature.)

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**Zeptogram Mass Detection—Weighing Molecules**

Michael Roukes and his Caltech colleagues have performed mass measurements with near-flawless precision! (Graphite) for molecules that give the impacting liquid something to push off of; remove the surrounding atmosphere, and surprisingly the splash becomes less. At about one-fifth atmosphere the splash disappears altogether, leaving a tiara-like crown of splash droplets. Remove some of the ambient atmosphere, and surprisingly the splash becomes less. At about one-fifth atmosphere the splash disappears altogether, leaving a tiara-like crown of splash droplets. Remove some of the ambient atmosphere, and surprisingly the splash becomes less. At about one-fifth atmosphere the splash disappears altogether, leaving a tiara-like crown of splash droplets. Remove some of the ambient atmosphere, and surprisingly the splash becomes less. At about one-fifth atmosphere the splash disappears altogether, leaving a tiara-like crown of splash droplets. Remove some of the ambient atmosphere, and surprisingly the splash becomes less. At about one-fifth atmosphere the splash disappears altogether, leaving a tiara-like crown of splash droplets. Remove some of the ambient atmosphere, and surprisingly

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**Superfluid Solid Hydrogen**

Last year Moses Chan (Penn State) announced the results of an experiment in which solid helium-4 was revolved like a merry-go-round. It appeared that when the bulk was revolved at least part of the solid remained stationary. In effect part of the solid was passing through the rest of the solid without friction. Chan interpreted this to mean that a frictionless sample had become superfluid, a class of neutron star possessing a gigantic magnetic field. Such “magnets” can erupt violently, sending out immense bolts of energy in the form of gamma rays and light at other wavelengths regions of the electromagnetic spectrum. The eruption was first seen with orbiting telescopes at the upper end of the spectrum over a period of minutes and then by more and more telescopes; radio wavelengths emissions were monitored for months. For an instant the flare was brighter than the full moon. (NASA press conference, 18 February; www.nasa.gov/press/2005/sgrburst; many telescopes participated in the observations, reports appeared in the 28 April 2005 issue of Nature.)

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**Direct Detection of Extrasolar Planets**

Direct detection of extrasolar planets has been achieved for the first time. Previously the existence of planets around other stars has been inferred from subtle modulation of the light emitted by the star. Now light from the planet itself has been recorded directly at infrared wavelengths by the Spitzer Space Telescope (www.spitzer.caltech.edu). The planets, one with the planet RZ Cephei (153 light years away), the other TR ES-1 (489 light years away), orbit their stars more tightly than does Mercury around our sun. This makes the Jupiter-sized planets hot enough to be viewed by Spitzer. (NASA press conference, 23 March; report published in Nature, 7 April.)
Superfluidity in an ultracold gas of fermion atoms has been demonstrated in an experiment at MIT, where an array of vortices has been set in motion in a molecular Bose-Einstein condensate of potassium atoms. The researchers have observed the formation of superfluid vortices in Li-6, but the presence of vortices observed in the new experiment clinches the case since vortices manifest the most characteristic feature of superfluidity, namely persistent flow.

Wolfgang Ketterle and his colleagues use laser beams to hold the chilled atoms in place and separate laser beams to whip up the vortices. Gaseous Li-6 represents only the second known superfluid among fermi atoms, the other being lithium-3. There are great advantages in dealing with a neutral superfluid in dilute gas form rather than in liquid form: in the gas phase (with a material density similar to that of the interstellar medium), inter-atomic scattering is simpler, furthermore, the strength of the pairing interaction can be tuned at will with an imposed external magnetic field.

Superfluidity is commonly associated with helium-4, in which the nuclei of two helium atoms share an electron. At a temperature of 1.2 degrees Kelvin, helium-4 is in the first “high-temperature” superfluid state. Considering the ratio of the critical temperature (Tc) at which the superfluid transition takes place to the fermi temperature (Tf), the temperature (or energy) divided by Boltzmann’s constant (k_B), the ratio for ordinary superconductors, Tc/k_B is about 10^{-4}; for superfluid helium-3 it is 10^{-3}; for high-temperature superconductors 10^{-2}; and for the new lithium superfluid it is 0.3. (Zwierlein et al., Nature, 23 June 2005)

ULTRAVIOLET FREQUENCY COMB

Physicists at JILA, the joint institute of NIST and the University of Colorado, have created a new optical approach to extend the production of coherent radiation into the extreme ultraviolet region of the electromagnetic spectrum. This process takes advantage of the fact that ultrashort laser pulses of femtosecond widths, separated by nanoseconds, manifest themselves as a series of sub-wavelength fine structures or “sidebands” that are created owing to a polarization of the vacuum—with virtual quarks, electrons, and W and Z bosons belonging to other families of particles. The Fourier transform of these short pulses is a long series of evenly spaced spikes that look like the tines of a comb. The JILA researchers have pushed the coverage of the frequency comb into the extreme ultraviolet region of high harmonics of the original, near-infrared laser frequency comb (A comparable result has also been achieved by Ted Hänsch’s group in Munich.)

In the JILA experiment, 50-femtosecond-long pulses, spaced 10 nanoseconds apart, are sent into a coherent storage device—an optical build-up cavity. The cavity length is determined so that each time of the incoming frequency comb is matched to a respective cavity resonance mode. In other words, the pulse train is matched exactly into the cavity such that a pulse running around inside the cavity is reinforced by a steady stream of incoming pulses. After a thousand or more such cycles, the infrared laser light becomes sufficiently energized to directly ionize xenon atoms inside the cavity. The quick repatriation of the xenon electrons to their home atoms produces light pulses of high frequency harmonics that are coherent with each other. In other words, the two techniques, typically involving single, actively amplified, ultrashort laser pulses.

The new approach demonstrated in the JILA work has drastically improved the spectral resolution of these high harmonic generated light sources by many orders of magnitude and will also allow for measurements of the harmonic generation process. Moreover, the buildup of intense UV light happened without the need for expensive or bulky amplifying equipment. Optical frequency combs have led to demonstrations of optical atomic clocks and are finding other applications in precision spectroscopy and laser cooling and control. Jun Ye and his colleagues believe that the new ultraviolet frequency comb promises to provide an important tool for ultrahigh resolution spectroscopy and precision measurement in that spectral domain. It will open the door to unprecedented spectral resolution, making it possible for scientists to study the fine structure of atoms and molecules with coherent XUV light. (Jones et al., Phys. Rev. Lett. 94, 193010, 2005)

GEONEUTRINOS DETECTED

Physicists at the University of Innsbruck have demonstrated that atom pairing in Bose-Einstein condensates (BECs) using photoassociation is coherent. Coherent pairing of atoms has been observed before using a tuned magnetic field—a Feshbach resonance between the atoms. But molecules made that way are only feebly attached. In the photoassociation technique, light is used to fuse two atoms into one molecule—allows more deeply bound molecule states to be established. The trouble is that the same laser light can also be absorbed to dissociate the molecules. The countermeasure, used by the Innsbruck researchers is to create a “dark state” in which the light cannot penetrate. A dark state is a condition under which it consists of three quantum energy levels, two stable ground states and one excited level. If laser light at the two frequencies needed for the transitions from both the ground states to the excited state are present simultaneously, the two atoms are destructively interefere with each other if there is phase coherence between the ground states. The consequence is that no light gets absorbed and the molecules are stable. Such “electromagnetically induced transparency” has been observed before for transitions between more than one quantum state of an atom.

In their experiments, the two-color laser light that creates the dark state is also the light that photoassociates rubidium atoms into molecules. Johannes Hecker Denschlag says that atom-molecule dark states are a convenient tool to analyze the atom-molecule system and to optimize the conversion of atomic into molecular BECs. BECs of ultracold molecules represent, because of their many internal degrees of freedom (vibrational and rotational), a new field of research beyond atomic BECs. (Winkler et al., Phys. Rev. Lett. 96, 053202, 2005)

ATOM-MOLECULE DARK STATES

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**HOW EFFECTIVE WILL FLU VACCINE BE?**

A new way of predicting the flu vaccine's efficacy by using the tools of statistical physics was described by Michael Deem of Rice University at the APS March Meeting.

To predict efficacy, researchers examine each strain's hemagglutinin (H) protein, the major protein on the virus's surface that is recognized by the immune system.

In one standard approach, researchers study all the mutations in the entire H protein from one season to the next. In another approach, researchers study the ability of antibodies produced in ferrets to recognize either the vaccine strain or the mutated flu strain, which had been thought to be a better indicator of vaccine efficiency.

However, these approaches are only modestly reliable indications of the vaccine's efficacy. Deem and his Rice University colleagues point out that each H protein has 5 “epitopes,” antibody-triggering regions mutating at different rates. The Rice team refers to the other teams' results as “ delayed” epidemics. Drawing upon theoretical tools originally developed for nuclear and condensed-matter physics, the researchers focus on the fraction of amino acids that change in the dominant epitope from one flu season to the next.

Analyzing 35 years of epidemiological efficacy data, the researchers believe that their focus on epitope mutations correlates better with vaccine efficacy than do the traditional approaches. Deem and his colleagues Vishal Gupta and Robert Earl believe that this new measure may prove useful in designing the annual flu vaccine and in interpreting vaccine efficacy studies.

**PARTICLES OF HEAT**

The phonon Hall effect, the acoustic equivalent of the electrical Hall effect, has been observed by physicists at the Max Planck Institut für Festkörperforschung (MPI) and the Centre National de la Recherche Scientifique (CNRS) in France.

In the electrical Hall effect, when an electrical current is being driven by an electric field, a perpendicular magnetic field causes a force perpendicular to both the original current and the magnetic force, causing the electrical current to be deflected to the side. The "current" of heat can consist of free electrons carrying thermal energy or it can consist of phonons, which are vibrations rippling through the lattice of atoms of the sample.

Previously, some scientists believed that in the absence of free electrons, a magnetically induced deflection of heat could not be possible. The MPS-CNRS researchers found, however, that the acoustic mirror effect of phonons was possible, and they have demonstrated it experimentally in insulating samples of Terbium Gallium Garnet (a material often used for its magneto-optical properties) where no free charges are present. The sample was held at a temperature of 5 kelvins, corresponding at one side, creating the thermal equivalent of an applied voltage. Application of a magnetic field of a few Tesla led to an extremely small (less than one thousandth of a degree), yet detectable temperature difference.


**DID YOU SAY HYDROPHOBIC WATER?**

Hydrophobic water sounds like an impossibility. Nevertheless, scientists at Pacific Northwest National Lab have produced and studied monolayers of water molecules (resting on a platinum substrate) which prove to be poor templates for subsequent ice growth. Picture the following sequence: at temperatures below 60 K, isolated water molecules will stay put when you place them on a metallic substrate. At higher temperatures, the molecules become mobile enough to begin forming tiny islands of two-dimensional ice. New molecules landing on the metallic substrates will fall off the edges into the spaces between the islands. In this way the metal surface becomes icy over completely with a monolayer. But because the water molecules' four bonds are now spoken for (1 to the Pt substrate and 1 to the Pt substrate, 1 to the Pt substrate, 1 to the Pt substrate), the addition of more water does not result in layer-by-layer 3D ice growth. Only when there is an amount of overlying water equivalent to about 40 or 50 layers does 3D ice-crystalline completely cover the hydrophobic monolayer. The PNNL researchers are the first to observe this effect. For the novel hydrophobic process, to show itself, the water-substrate bond has to be strong enough to form a stable monolayer. Weak bond results in a “classical” hydrophobic state, in which the water merely balls up immediately; in other words, not even a first monolayer of ice forms.

This research is of interest to those who, for example, study the seeding of clouds, where ice is nucleated on particles in the atmosphere (Kimmel et al., Phys. Rev. Lett. 95, 161102, 2005)

**THE 2005 NOBEL PRIZE IN PHYSICS**

The 2005 Nobel Prize in Physics was devoted to optics, with half of the prize going to Roy G. Gilson of Harvard University for his quantum theory of optical coherence, and one-quarter each going to John L. Hall (JILA, University of Colorado and National Institute of Standards and Technology, Boulder, CO) and Theodor W. Hänsch (Max Planck Institute for Optics and Quantum Electronics, Garching, Germany, Ludwig-Maximilians-University, Munich, Germany), for their development of ultra-high-precision measurements of light.

Glauber described optical coherence and the detection of laser light in the language of quantum mechanics. Glauber’s theory provided understanding of quantum “noize,” jitter and decoherence in the physics of light. This in turn put limits on the limits of measuring light, as well as the as understanding of optical detectors that count single photons at a time. Single-photon detectors are important for applications such as quantum computing, quantum communication, and quantum cryptography.

Meanwhile, Hall and Hänsch developed techniques for measuring the frequency of light to what is currently 15 digits of accuracy. These frequency-measurement techniques helped scientists devise fundamental definitions of physical units (for example, Hall and others measured the watt in terms of the speed of light). This in turn put limits on the limits of measuring light, as well as the as understanding of optical detectors that count single photons at a time. Single-photon detectors are important for applications such as quantum computing, quantum communication, and quantum cryptography.

**HYPER-ENTANGLED PHOTON PAIRS**

Physicists at the University of Illinois at Urbana-Champaign have demonstrated--for the first time the entanglement of two objects not merely in one aspect of their quantum natures, such as spin, but in a multitude of ways.

In the Illinois experiment, two photons are produced in a “down-conversion” process whereby one photon enters an optical crystal and sunders into two lesser energy correlated daughter photons. The two daughter photons are entangled not just in terms of polarization, but also in a number of other ways: energy, momentum, and orbital angular momentum.

The photon pair can be produced in either of two crystals, and the uncertainty in the production details of the individual photons is what provides the ability to attune elements of the pair to the other. All the other elements are entangled.

Is it better to entangle two particles in ten ways or ten particles in two ways? They’re probably equivalent, says Paul Kwiat, leader of the Illinois group, but for the purpose of quantum computing or communication it might be of some advantage to have multiple quantum bits (or qubits) of information can be encoded in a single pair of entangled photons. Kwiat says that his lab detects a record two million entangled photon pairs per second with ample determination of numerous properties, allowing a complete characterization of the entanglement produced. (Barreiro et al., Phys. Rev. Lett. 95, 260501, 2005)

**SUPER LENSING IN THE MID-INFRARED**

Physicists at the University of Texas at Austin have made a “super lens,” a plane-shaped lens that can image a point source of light down to a focal spot only one-eighth of a wavelength wide. This is the first time such super lensing has been accomplished in a functional device in the mid-infrared range of the electromagnetic spectrum.

Historically, lensing required a lens-shaped optical medium for bringing the diverging rays coming from a point source into focus on the far side of the lens. But in recent years, researchers have found that in “negative permittivity” materials, in which a material’s response to an applied electric field is opposite that of most normal materials, light rays can be refracted in such a way as to focus planar waves into nearly a point–albeit over a very truncated region, usually only a tenth or so of the wavelength of the light.

This near-field optics are not suitable for such applications as reading glasses or telescopes, external magnetic field, the charge carriers in certain kinds of nanoscale imaging of large biological molecules than can be damaged by UV light. The micron-sized Texas lens, reported in October at the Frontiers in Optics meeting of the Optical Society of America, consists of a silicon carbide membrane between layers of silicon oxide. It focuses 11-micron-wavelength light, but the researchers hope to push on into the near-infrared range soon. Furthermore, the lensing effect seems to be highly sensitive to the imaging wavelength and to the lens thickness. Possible applications of the lenses include direct laser nanolithography and making tiny antennas for mid-IR-wavefree space telecommunications.

**UNCOVERING NEW SECRETS IN A DNA HELPER**

The protein RecA performs some profoundly important functions in bacteria. Two independent papers shed light on how the bacterial protein helps (1) identify and (2) replace damaged DNA while making few mistakes. Error-correction mechanisms keep DNA fidelity during replication to within an average of one error per billion “letter” or base pair. This research offers insight on how damage to existing DNA from processes such as UV radiation can be detected and repaired efficiently in living organisms, including humans, who carry evolutionary cousins of RecA.

When the double-helix DNA is seriously damaged, single-stranded DNA is exposed and RecA polynucleotide (DNA) oligomers act as a biochemical SOS signal.

To do this, Tsvi Thury and his colleagues at the Weizmann Institute and Rockefeller University suggest that RecA performs “kinetic proofreading” in which RecA can precisely identify a damaged strand and its length by using ATP (the energy-delivering molecule in cells) to inspect (proofread) the DNA’s binding energy and to detach after a certain time delay (the “kinetic” part) if the DNA has the “wrong” binding energy.

**WALKING MOLECULES**

A single molecule has been made to walk on two legs. Ludwig Bartels and his colleagues at the University of California at Riverside, guided by theorist Talat Rahman of Kansas State University, created a molecule–called 9,10-dihydroanthracene (DHA)–with two “feet” configured in such a way that one only foot at a time can rest on the substrate.

Activated by heat or the nudge of a scanning tunneling microscope tip, DHA will pull up one foot, put down the other, and thus walk in a straight line on a flat surface. The plant-like structure supports itself but also keeps the body of the molecule from veering or stumbling off course.

In tests on a standard copper surface, such as the kind used to manufacture microchips, the molecule has taken 10,000 steps without faltering. According to Bartels, possible uses of the novel molecular “ratchets” or base pairs. This research may provide insight on how damage to existing DNA from processes such as UV radiation can be detected and repaired efficiently in living organisms, including humans, who carry evolutionary cousins of RecA.

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ADVANCED OPTICAL MATERIALS

**The Confinement of Light in the Mid-Infrared**

Historically lensing required a lens-shaped optical medium for bringing the diverging rays coming from a point source into focus on the far side of the lens. But in recent years, researchers have found that negative permittivity materials, in which a material’s response to an applied electric field is opposite that of most normal materials, light rays can be refracted in such a way as to focus planar waves into nearly a point–albeit over a very truncated region, usually only a tenth or so of the wavelength of the light.

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EVIDENCE FOR QUANTIZED DISPLACEMENT

Physicists at Boston University have found evidence for quantized displacement in nanomechanical oscillators. They performed an experiment in which tiny silicon pillars, etched into a surface by a BEC excitation beam, were taken from a heat sink, seem to oscillate together in a peculiar manner: the paddles can travel out to certain displacements but not to others. The setup for this experiment consists of a lithographically prepared structure looking like a double-sided comb.

Next, a gold-film electrode is deposited on top of the spine. Then a current is sent through the sample. The electromagnetic field is applied. This sets the structure to vibrate at frequencies as high as 1 gigahertz. This makes the structure the fastest man-made oscillator. At relatively warm temperatures, this rig behaves approximately like a rigid bunch of elastic bands in the large. The larger the driving force (set up by the magnetic field and the current moving through the gold electrode) the greater the excursion of the paddles.

At millikelvin temperatures, however, quantum mechanics takes over. In principle, the excitation can be quantized, and this in turn should show up as a proportional sensitivity of the paddles (500 nm long and 200 nm wide) to displacement only by discrete amounts. The Boston University experiment sees signs of exactly this sort of behavior. (Gaidarzhy et al., Phys. Rev. Lett. 94, 030402, 2005)

NIKEL-78, THE MOST NEUTRON-RICH OF THE DOUBLY-MAGIC NUCLEI

Nickel-78, the most neutron-rich of the doubly-magic nuclei, has had its lifetime measured for the first time, which will help us better understand how heavy elements are made.

The researchers argue that the RecA protein performs the precise binding and unbinding actions that are necessary for kinetic proofreading through “assembly fluctuations,” a protein’s structural changes brought about by constant binding and dissociation of RecA from its target. According to the authors, this is the first known process in which kinetic proofreading and assembly fluctuations are combined (Tustay et al., Physical Review Letters, 17 December 2004, Phys. Rev. Lett. 93, 238103 (2004)).

Meanwhile, two separate teams (Kevin Dorfman and Jean-Louis Tiersy) have studied how RecA exchanges a damaged strand with a similar copy. In bacteria, RecA protein catalyzes this process by binding to a healthy single DNA strand to form a filament that “searches” for damaged double-stranded DNA (dsDNA). At odds with this common view, the researchers suggest that two bonds are necessary to repair the more active partner in this mutual search. Unbound, it first diffuses towards the more rigid dsDNA, caused only by thermal motion, allow the base pairs of the filament to align and pair with the strand of replacement DNA. (Dorfman et al., Phys. Rev. Lett. 93, 268102, 2004)

COMPLEX HYBRID STRUCTURES

Complex hybrid structures, part vortex ring and part soliton, have been observed in a Bose-Einstein condensate (BEC) at the Harvard lab of Lene Vestergaard Hau. Hau previously pioneered the technique of slowing and then stopping a light pulse in a BEC in constant of a few million atoms chilled into a cigar shape about 100 microns long.

In the new experiment, two such light pulses are sent into the BEC and stopped. The entry of these pulses into the BEC set in motion tornado-like vortices. These swirls are further modulated by solitons, waves which can propagate in the condensate without losing their shape. Now scientists have found evidence that these and other orbital processes can slow down dramatically—to as long as 0.1 seconds, a slowing by 14 orders of magnitude—for electrons (at the Max Planck Institute for the Physics of Complex Systems, Dresden), have devised a theory to explain the strange BEC excitations and believe their new work will help physicists gain new insights into the superfluid phenomenon and into the breakdown of superconductivity. (Ginsberg, Brand, Hau, Phys. Rev. Lett. 94, 040403, 2005)

DEGENERATE GAS STUCK IN OPTICAL LATTICE

Physicists at the E1h lab in Zurich have, for the first time, not only made a quantum degenerate Fermi gas that has a superfluid of unconventional properties, but also have been able to load the atoms into the crystal lattice of an optical lattice, an artificial 3D crystal in which atoms are held in place by the electric fields of well-aligned laser beams.

By adjusting an external magnetic field, the pairs of atoms loaded in their specified sites can be made to interact with each other in the same way the “Feshbach resonance” with a varying strength. According to Tilman Esslinger, it is this ability to put atoms where you want them in a crys	-particle accelerator around the year 2007. Each of its two 7-TeV proton beams will consist of 2808 bunches of 10 000 K, but carbon bonds are tougher and can persist. The experiment was performed by physicists from UC Berkeley, the Paul Scherrer Institute (PSI) in Switzerland, Lawrence Berkeley National Lab, Kansas State, and Lawrence Livermore National Lab. A team member, Steve Johnson, says that one next step will be to study carbon, as other materials, at even higher temperatures in order to look at warm dense matter, “a realm of matter too hot to be considered by conventional solid state theory but too dense to be considered by conventional plasma theory. (Johnson et al., Phys. Rev. Lett. 94, 054707, 2005)

240 ELECTRONS SET IN MOTION

A soccerball-shaped carbon-60 molecule, possessing a mobile team of up to about 240 valence electrons holding the structure together, is sort of halfway between being a molecule and a solid. To explore how these electrons can move as an ensemble, a team of scientists working at the Advanced Light Source in Berkeley used a high-energy-photoelectron gun to turn the C-60 molecules into a beam (by first ionizing them) and then shot ultraviolet photons at them. When a photon is absorbed, the energy can be converted into a collective movement of the electrons referred to as a phonon.

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Electron clouds can freeze into an “Orbital Glass”

Electron clouds can freeze into an “Orbital Glass” at low temperatures. In the modern picture of quantum mechanics, electrons take the form of “clouds” within the atoms and energies of the oscillating paddles are quantized, and this in turn should show up as a proportional sensitivity of the paddles (500 nm long and 200 nm wide) to displacement only by discrete amounts. The Boston University experiment sees signs of exactly this sort of behavior. (Gaidarzhy et al., Phys. Rev. Lett. 94, 030402, 2005)
Physicists believe gold and other heavy elements (beyond iron) were built from lighter atoms inside star explosions billions of years ago. In the “t-process” (standing for rapid) unfoiling inside the explosion, a succession of nucleus built up on the many available neutrons. This process promises to provide an unpreceded window into the early universe. The 2-GHz, or 2-Gigahertz, radio waves (which writing can be accomplished) is faster than static RAM (or SRAM) memories, currently the fastest memories, can accomplish. Furthermore, the magnetic memories are non-volatile, which means that the status of the memory does not change when the power is turned off. (Schumacher, Appl. Phys. Lett. 87, 042504, 2005). 

A NEW KIND OF NANOPHOTONIC WAVEGUIDE

A new kind of nanophotonic waveguide has been created at MIT, overcoming several long-standing design difficulties. The device might lead to single-photon, broadband and more compact optical transitions, switches, memories, and time-delay devices needed for optical computing and telecommunications.

If photons is to keep up with electronics in the effort to produce smaller, faster, low-power circuitry, then photonic devices will have to be made at the nanoscale—smaller than the wavelength of light. But so far the exact conditions and site for the process are still unknown. With the magnetic memories are non-volatile, which means that the status of the memory does not change when the power is turned off. (Schumacher, Appl. Phys. Lett. 87, 042504, 2005).
external magnetic field opposed to the prevailing magnetic orientation of the crystal can cause a sudden reversal of spins of the molecules. The reverse propagates along a front through the crystal (which can be thought of as a stack of nanomagnets) just as a flame moves through a stack of wood in a conflagration. In the case of a conventional combustion, much heat will be generated as the spits get flipped (the heat energy being equal to the difference in energy of the before and after spin states), but there will be no destructive burning. The "law" consists of the molecule burning in molecular magnets has several of the qualities of regular burning (a flame front and combustion) but not the destructiveness. Myriam Sarachik says that magnetic burning might offer a more controlled way of learning how to control and channel flame propagation. (Suzuki et al., Phys. Rev. Lett. 95, 147201, 2005)

QUANTUM SOLVENT

Scientists at the Ruhr-Universität Bochum in Germany have performed high-precision, ultracold chemical studies of nitrogen oxide (NO) molecules by inserting them into droplets of liquid helium. NO, Science magazine’s “molecule of the year” for 1992, is important because of its role in atmospheric chemistry and in signal-transduction mechanisms. A radical is a molecular entity (sometimes charged and sometimes neutral) which enters into chemical reactions as a unit. To understand the chemistry of this important molecule and its reactions, it would be desirable to cool it down, the better to observe its complex spectra of quantum levels corresponding to various vibrational and rotational states.

In the new experiment, liquid helium is shot from a cold nozzle into vacuum. The resultant balls, each containing about 3,000 atoms, are allowed to fall into a pipe where NO molecules are lurking. The NO is totally enveloped and, within its superfund-heli um cocoon at a temperature of about 0.4 Kelvin, it spins freely. The helium acts provide a quantum solvent, which, just as a conventional solvent would, induce a high-resolution infrared spectrum of NO in fluids could be recorded for the first time. In has been observed before in the gas phase, but never before has such a high resolution spectrum be seen in the helium environment. (Haehl et al., Phys. Rev. Lett. 95, 215301, 2005)

MEASURING HIGHER-LEVEL QED

Another view, pioneered by Randall and Raman Sundrum, holds that if gravity is localizable on a 3D defect in the multi-dimensional universe and if spacetime is sufficiently warped, then the other spatial dimensions are of two or more. Randall confirms the existence of a 3D "universe" that is much more complex than the 3D universe we inhabit. This new 3D universe is called the "brane" and is thought to be the only reality that we can observe. The particles that constitute matter are thought to be quantized because they are confined to the 3D brane. On this brane, particles can have only certain discrete energies and can only move in certain directions. The 3D universe is thought to be embedded in a higher-dimensional space, and it is these higher-dimensional spaces that are thought to be responsible for the existence of gravity and other fundamental forces.

GUIDED SLOW LIGHT

Guided, slow light in an ultracold medium has been demonstrated by Mukund Vengaloptim and Mara Prentiss at Harvard. Slow light pulses in a sample of atoms had been accomplished before by more indirect methods that use a highly dispersive medium—that is, a medium in which the index of refraction varies greatly with frequency. Previously, this dispersive quality had come about by tailoring the internal states of the atoms in the medium. In the present Harvard experiment, by contrast, the dispersive qualities come about by tailoring the external qualities of the atoms, namely their motion inside an embedded magnetic trap.

In the lab setup, two pump laser beams can be aimed at the trap in the dense cloud, neon, which acts as the gas phase of the medium. The cloud of atoms is isochronous (atoms at a temperature of about 10 micro-Kelvin) can be made more or less dispersive in a process called recoil-induced resonance, or RIR. If now a separate probe laser beam is sent along the trap central axis, it can be slowed by varying degrees by adjusting the intensity of the pump laser beam. Furthermore, the probe beam can be amplified or attenuated depending on the degree of dispersiveness in the atoms. This process can be used as a switch for light or as a waveguide.

A TERA-ELECTRO-VOLT GAMMA RAY ORIGINATING IN THE MILKY WAY

The most energetic parahalos of electromagnetic radiation-Tera-electronvolt gamma rays—ever determined to have originated in the plane of our home galaxy were observed recently by the Milagro detector, located at high mountain elevations in New Mexico. The potential photons are believed to have been part of the debris spawned when even more energetic cosmic rays struck the matter-dense heart of the Milky Way. Photons in the TeV range arrive at the Earth very rarely, not often enough to permit observation from a space-based gamma telescope. Therefore, terrestrial gamma observations are usually carried out by large-area-arrays attached to the ground.

Milagro, operated by scientists from nine institutions, records the arrival of energetic photons at Earth by observing the air shower of secondary particles generated when the gamma rays hit the atmosphere. These particles betray their presence by the light (Cerenkov radiation) emitted when the particles pass through a 6 million-gallon pond instrumented with photodetectors. This method of observation offers a rough ability to determine the direction of arrival. For the Milagro experiment, 75,800 TeV photons events from within a region of the Milky Way plane were culled from an inventory of about 240 million TeV events seen so far from seen the same region. These numbers, says team member Roman Flesher of New York University, are consistent with the most stringent observational constraints.

And where do the cosmic rays get their 100 TeV-and-more energies? Jons in the interstellar medium, perhaps near a collapsed star or an active galactic nucleus (AGN), can get caught up by shock waves and accelerated to high energies. (Atkins et al., Phys. Rev. Lett. 95, 251103, 2005)
Undergrad Awards Promote Student Participation at DNP Meeting

Last September about 75 undergraduates were able to mix the pleasures of attending a nuclear physics conference with the business of hanging out on the beach in Hawaii. The students were in Maui attending the annual American Physical Society conference as part of the Conference Experience for Undergraduates (CEU). Each year the CEU program brings between 70 and 90 undergraduates to the DNP meeting. The students, who have done research in nuclear physics or related fields during the previous academic year, also attended a special undergraduate poster session. CEU draws applications from students around the country. These applications are reviewed by a committee, and about half receive travel and lodging awards. Funding for the CEU awards is provided by the NSF and DOE. Even those students who don’t receive awards are often able to attend the APS meeting with the help of their advisors. For many of the students, the DNP meeting is the first professional conference they attend, and their first taste of what it means to be a working physicist. In September 2005 the DNP meeting was held in Maui as a joint meeting with the Japanese Physical Society (see APS News, January 2005). In addition to the American students, 16 Japanese students attended. It was a good exchange between American and Japanese students, said CEU organizer Warren Rogers of Westmont College. It was my first experience of CEU. It is more than just getting the students to present their research, said Rogers. Each year the CEU includes a number of trips and events for undergrads, including two special nuclear physics seminars presented at an advanced undergraduate level. Other events for the students included a reception, an ice cream social, and a graduate school information fair. In addition, CEU representatives met with students to discuss graduate school opportunities. Many of the students attended the socials in the meeting, and are encouraged to attend as many of the regular sessions as possible.

“I felt like I could go to any talk I wanted, and felt privileged to have that opportunity to be in the company of research scientists,” said Fatima Mahmood, a CEU participant from Union College. “I did attend several talks in the regular program. I enjoyed hearing about modern research in nuclear physics, and even when I couldn’t understand all the scientific things, I was glad to find certain terms and ideas were familiar to me through my own experience in research and from my study of physics.”

Several 2005 CEU students said that the opportunity to present their work at the meeting was the most valuable part of the meeting.

“People were interested and asked interesting questions. It was great to get feedback, and felt privileged to have that opportunity to be in the company of research scientists,” said Fatima Mahmood, a CEU participant from Union College. “I did attend several talks in the regular program. I enjoyed hearing about modern research in nuclear physics, and even when I couldn’t understand all the scientific things, I was glad to find certain terms and ideas were familiar to me through my own experience in research and from my study of physics.”

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How do we know the world's real warming is “balanced” by one of the few skeptics. Meanwhile a few respectable scientists took on the role, appropriately in science, of playing devil's advocate–raising counter-arguments that spurred their colleagues to more rigorous studies (which dismissed those arguments) and eventually led to their colleagues setting aside the IPCC, plus many of the world's leading science academies and societies, only says that serious global warming is more likely than not. After all, hardly anything that relates to economic or social progress is ever really conclusive (as we face a serious climate risk is now stronger than the kind of evidence we normally use in deciding police investigations in costly highways, and the like. How do we know the whole world is really warming up? One way to answer such questions is to look for unprecedented melting back of glaciers, exposing archeological finds like the Alpine “skeletons” frozen in the snow for thousands of years. The atmospheric temperature fluctuates hour by hour, so it seems a natural phenomenon to track average global temperature and see if it has gotten a few tenths of a degree warmer. It has indeed been a monumental task, the work of thousands of scientists. Most of the heat energy added by the greenhouse effect isn't stored in the wispy and incon- stant atmosphere anyway. It mainly winds up in the oceans. The heat energy seeps down gradually through the seasaw, a very poor conductor, or is carried away by slow-moving currents. The latest analysis of the temperature structure in all the main ocean basins shows a strong and rapid warming in recent decades. Moreover, the geographic and depth patterns closely match the predictions that computer models make for greenhouse gas warming. The patterns cannot be matched to other causes, such as people in the Sun. How do we know the computer models are any good? Never before have the models of the atmosphere, the oceans, and the nation asked to stake major policies on such complex scientific calculations. I find it a hopeful sign, a big advance in rationality, that all govern-ments now take this issue seriously. (The IPCC's) To give the same say, “How can sci-entists predict the climate a century ahead? We can’t predict the weather a year ahead?” The short answer is that we are not alone in this farsighted, since the advisory group's climate estimate is the average of all the season's weather. It's an average over weeks. Continuing to melt back, like many other mechanisms that might push toward government reg-ulation, the advisory group's conclusions would have to be consensual across the board, not impressive still, the models can track all this through the seasons, as if we are seeing a model predicted in advance to generate the assumptions global cooling would be possible in the 20th century. How do we know the model is accurate? What if we are wrong? But is there anything we can do? Here we are impeded by a view-point, supported by interests that are afraid to change their business models or their political models, which insists that it is impossible to reverse the rise of greenhouse gases without wrecking our economy. Even some people think that governments can take many steps that actually save money and benefit the overall economy. For instance, we can use more efficient light bulbs. By replacing incandescent bulbs, which will be beneficial in many ways, such as reducing the inefficiencies in cars that only add to global warming but make many countries spend huge sums to get foreign oil. For a start, why not subsidize global warming? Currently tens of billions of dollars are wasted in open and hidden subsidies of fossil fuel industries and other contributors to greenhouse emis-sions. (Many groups are working on this; one starting point is the Pew Center for Climate Change, http://www.pewclimate.org/). What we need is a change in the climate–of opinion. Americans in particular ought to make their nation not the world's laggard, but its leader in addressing the problem. We should be challenging other nations to match us in staving off global warming. Many tools are at hand and many more can be developed. If the climate does turn bad, we may have to use most of them. The necessary large change in public attitudes is certainly possible, for leaders of many corpora-tions, state and local governments, and others have noticed the danger and are starting to take action on it. How urgent is it? We don't know, and therefore it's urgent. Come again? Well, if you don't know what's happening on this fire, there's a good chance it might, that's urgent. Even if there's only a small chance that it will ever catch fire, you're willing to spend a sig-nificant fraction of your wealth on insurance. For climate, one mech-anism that suggests we are at urgent risk can be explained to almost any one to grasp elementary physics. As cold regions grow warmer, the bright snow and ice cover that reflect sunlight back into space are retreating earlier in the spring, exposing dark soil and open water, which absorb sunlight, which leads to further warming, and so on. That's why global warming is showing up first in the Arctic: an effect scientists have predicted since the 19th century. You might also mention a second risk, recognized more recently. The world's vast expanses of frozen tundra store fossil carbon, and as the permafrost begins to melt, methane begins to escape. Methane is an even more potent greenhouse gas than carbon dioxide, and leads to further warming. Geoscientists have identified several al-ternative mechanisms that might pos-sibly push the climate abruptly into a dangerous state. Possibly we are approaching a tipping point. We can probably arrest the process before it becomes irre-verse. The cost may be no worse than we spend on other kinds of insurance. But if we keep putting off effective action. Every sci-entist has a public responsibility to be well informed about cli-mate change to answer the ques-tions that we may be asked. And we all have a responsibility to engage in the effort to change the climate of opinion, and quickly, on what might be the most crucial issue of our times. Just possibly, better. Actually much more likely. Spencer Weart is director of the Center for History of Physics at the American Institute of Physics.