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Global Representatives Gather To Plan World Year of Physics

Sixty-two physicists representing 29 countries gathered in Montreal, Canada, on March 20-21 for the second preparatory planning conference for the upcoming World Year of Physics in 2005. In addition to Canada and the US, participants hailed from such far reaches as Botswana, Ghana, Indonesia, Tanzania, Slovenia, South Korea, India, Taiwan, Japan, Albania, Moldova, Poland, and Serbia and Montenegro, as well as from Western Europe and South America.

"This workshop was a truly global event, in keeping with what we hope will be a worldwide celebration of the centennial of Albert Einstein's miraculous year of 1905, and more generally of the excitement and promise of physics in the 21st century," said Vinaya Sathyasheelappa, APS World Year of Physics Coordinator and a principal organizer of the conference.

The APS is spearheading the US effort for 2005, with the main goal of generating widespread activity among physics departments, national labs, and other suitable organizations around the country. More information can be obtained at the special 2005 web site, www.physics2005.org.

Among the highlights of the two-day workshop was a plenary lecture by Clifford Will of Washington University in St. Louis, who related the story of how Einstein's relativity has been tested experimentally. For instance, on May 29, 1919, a total solar eclipse clearly showed the bending of starlight, a key prediction of relativity. The event made Einstein a household word, to the extent that British historian and best-selling author Paul Johnson pegs the dawn of the modern age to that date in his book *Modern Times*.

Ironically, the field of relativity languished in the ensuing years until its revival in the 1960s with the launching of a systematic program to experimentally verify its predictions. For example, in the 1970s, measurements of the decaying orbit of a neutron star around its companion revealed the effect of gravity waves, and the Gravity Probe B, launched April 17, 2004, is a 16-month experiment designed to test Einstein's prediction that a rotating body drags spacetime around with it.

Several international projects were discussed at the meeting, including an ambitious scheme to send a light signal from person to person around Earth on the night of April 18, 2005, the 50th anniversary of Einstein's death, starting from Princeton where he died. Obstacles like the Pacific Ocean would be overcome through the use of fiber optic cables. Also discussed was an international physics talent search, and a project to create a web site hosting contributions of "Stories in Physics" in many different languages.

An international poster contest, a cultural heritage project, and a project aimed at using architectural features of school buildings to teach fundamental physics concepts were among the other international activities considered at the meeting. In addition, an Einstein@home project, modeled on the popular SETI@home, was described by Caltech's Teviet Creighton. The idea is to search for gravitational waves by farming out data gathered by LIGO

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March Prize and Award Recipients

Photo Credit: Luigi D'Astolfo

Seated (l to r): Tom Lubensky, Farid Abraham, Paul Julienne, Nancy Haegel, Eugene Stanley. Standing (l to r): Richard Van Duyne, Nathaniel Stern, John Cardy, Robert White, Timothy Lodge, Chia-Ling Chien, Marcus Muller, Frans Pretorius, David Nelson, Joerg Rottler, Virgil Elings, Loren Pfeiffer, Peter Wolynes, James Wolfe.

AFM Study Shows Old Cells Lose Their Elasticity

The reason our skin becomes more leathery and thick as we age might be due to a loss of elasticity in the cells, according to Igor Sokolov of Clarkson University, who presented his latest research findings during a session on bioimaging techniques at the APS March Meeting in Montreal.

Sokolov is using atomic force microscopy to study individual human epithelial cells, which are found in skin as well as in other tissues that line the surfaces of the body, including blood vessels, kidneys, liver, brain, eyes, etc.

Sokolov and his colleagues used fast aging in in-vitro epithelial cells under laboratory conditions, and then probed the elasticity of such cells. However, a typical rigid AFM probe is too sharp to measure the cells quickly while they are alive, and is not gentle enough to get reliable statistical data. So Sokolov added a five-micron silica ball to the AFM tip. This ball presses slowly against the cell being studied and records how much deformation is caused by the pressure being applied.

Sokolov discovered that epithelial cells tend to be more rigid in old (close to senescence) cells than in young ones, which helps explain why skin often looks and feels more leathery as we age.

Previously, researchers believed the culprit was only the biochemical "glue" that holds epithelial tissue together rather than the cells themselves. This loss of elasticity has been implicated in the pathogenesis of many progressive diseases of aging including hardening of the arteries, joint stiffness, cataracts, Alzheimer's and dementia**.** Sokolov's findings could inspire the search for new treatments.

What causes this loss of elasticity? Sokolov hypothesized that the

See AFM STUDY *on page 3*

APS Hydrogen Report Attracts the Media

By Ernie Tretkoff

A variety of media outlets have covered the APS Panel on Public Affairs' report on President Bush's billion-dollar Hydrogen Initiative. The report called for more funding for basic research and concluded that major scientific breakthroughs are needed to make hydrogen-powered vehicles competitive [see *APS News*, April 2004, page 4].

On March 1, which was the day of the report's release, National Public Radio aired a story in which Peter Eisenberger of Columbia University, chairman of the report committee, described the main points. He said that "the overview should be that currently we have really no production capability, we have no material that can store it and we have no infrastructure to deliver the hydrogen to a broad market."

The Associated Press, United Press International, and *The Washington Times* have also carried articles about the POPA report. In addition, a story on hydrogen fuel in *The Dallas Morning News* mentioned the report. Several specialized publications, including *Greenwire*, *Space Daily*, *Inside Energy*, *The Electricity Daily*, and *Environment and Energy Daily*, and a Sierra Club newsletter, covered the report as well.

In response to the POPA report and a similar report by the National Academy of Sciences, the House Science Committee called a hearing, at which Eisenberger and other experts testified that the Hydrogen Initiative is overly ambitious and short on funding for basic science. David Garman, DOE assistant secretary for energy efficiency and renewable energy, defended President Bush's proposed budget, saying it provides adequate funding for basic research. Eisenberger later also briefed two Senate caucuses about the report.

The hydrogen economy was also the subject of a press conference and several sessions at the March Meeting. At the press conference, APS Director of Public Affairs Michael Lubell summarized the POPA report, and MIT Professor Mildred Dresselhaus, former president of the APS and a former

See HYDROGEN *on page 7*

Photo Credit: Joe Pouliot

Peter Eisenberger (at table on right) of Columbia University, chair of the committee that produced the APS report on the hydrogen economy, testifies on March 3 before the House Science Committee. Next to him at the table is Michael P. Ramage, ExxonMobil Research Corporation (retired), who chaired the National Academies' study. Also testifying at the hearing, at left, is David Garman, Assistant Secretary for Energy Efficiency and Renewable Energy at DOE.

Women Physicists Learn Survival Skills in Montreal

Thirty-seven women physicists at various stages of their careers gathered on Sunday, March 21, for the second annual workshop on survival skills for successful women physicists. Held just before the start of the APS March Meeting in Montreal, Canada, the event was organized by the APS Committee on the Status of Women in Physics (CSWP), and included university faculty members, researchers in industry and government labs, and aspiring postdocs and graduate students.

The CSWP first organized such a workshop at the 2002 APS March Meeting, which was very well received. The Montreal workshop was aimed at women physicists seeking advice and training to improve their skills in navigating through the waters of today's research world to advance to the

See SURVIVAL SKILLS *on page 6*

Highlights

The Scream *(1893) by Edvard Munch (National Gallery, Oslo, Norway)*

Members in the Media

"The accusations in the document are inaccurate, and certainly do not justify the sweeping conclusions of either the document or the accompanying statement."
—John Marburger, Presidential Science Advisor, on a report by the Union of Concerned Scientists on alleged scientific bias in the Bush Administration, NY Times, April 3, 2004

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"It's possible there are things we got wrong, We're not infallible, like the Vatican or the White House. But I don't think there's any reason to think we got the big picture wrong. In fact, our case is stronger now than when we produced that report."
—Kurt Gottfried, Cornell University and Union of Concerned Scientists, replying to comments by John Marburger on the UCS report, NY Times, April 3, 2004

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"I think this is as bad as it's ever been. This is an extremely serious issue. I believe it is true that there is such a thing as objective scientific reality, and if you ignore that or try to misrepresent it in formulating policy, you do so at peril to the country."
—Wolfgang Panofsky, Stanford University, on the Bush administration's science policy, NY Times, March 30, 2004

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"We even have trouble understanding what's alive and what's dead. People still wonder what a virus is."
—Richard Zare, Stanford University, commenting on how the search for life outside of earth is complicated by the fact that scientists aren't even sure what life is exactly, Los Angeles Times, March 5, 2004

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"I was talking about life not long ago with a policeman from Chico, and when I told him what I was doing and why, he quickly got totally fascinated. So we shouldn't assume that people don't have genuine curiosity about the universe we all live in."
—Francis Everitt, Stanford, on whether the public would care about validating general relativity, The San Francisco Chronicle, April 5, 2004

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"The country needs a lot of bright young people to enter these areas. If we are not reaching women, we are cutting off 50 percent of our potential resources."
—Judy Franz, APS, on the shortage of women in physics and engineering, The Ledger (Lakeland, FL) March 6, 2004

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"Fusion has not been proven to be safe, and it is too costly."
—Masatoshi Koshiba, University of Tokyo, calling on the Japanese government to drop its plans for the International Thermonuclear Experimental Reactor (ITER), NY Times, March 9, 2004,

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"Physicists relish the weirdness, but now we're starting to ask if we can put the weirdness to work,"
—John Preskill, Caltech, on applications of quantum mechanics, Business Week, March 15, 2004

Oak Ridge Fellows Frolic in Knoxville

Photo Credit: Darlene Logan

APS Past President Myriam Sarachik enjoys a moment with (l to r) APS Fellows Joe Cable, Ray Garrett and Alexander Zucker at the reception for Fellows in the Oak Ridge area. The reception took place in the Club LeConte in Knoxville, TN on March 9. The program included remarks by Sarachik, as well as APS Executive Officer Judy Franz, Director of Education and Outreach Fred Stein, Director of Public Affairs Michael Lubell, and local host Lee Riedinger, the Deputy Director for Science and Technology of the Oak Ridge National Laboratory.

This Month in Physics History

Revolutionary Pursuits

Circa May 1816: Germain Forms Theory of Elastic Surfaces

Among the more unjustly obscure figures in math and science history is Sophie Germain, one of the few women to make important contributions to math and physics despite her lack of formal education and training. Born in Paris on April 1, 1776, Germain was the daughter of a merchant who eventually became director of the Bank of France.

She became interested in mathematics as a child. One day, while browsing in her father's library, she came across an account of the death of the Greek mathematician Archimedes. Legend has it that when the Roman army invaded his home city of Syracuse, Archimedes was so engrossed in studying a geometric figure that he failed to respond to a soldier's questioning, and was unceremoniously speared to death. The young Sophie concluded that if someone could be so consumed by a geometric problem, it must be the most fascinating subject in the world.

She taught herself the basics of number theory and calculus without the aid of a tutor, and began studying Newton and Euler at night. But her parents objected to her learning such an "unfeminine" subject and did their best to dissuade her. Her father confiscated her candles and clothing and removed all heating. But Germain persevered. She kept a secret cache of candles and wrapped herself in bedclothes to keep warm while she secretly studied, even though it was often so cold that the ink froze in the inkwell. Eventually her parents relented, and her father supported her for the rest of her life, since she never married.

In 1794, when Germain was 18, the Ecole Polytechnique opened in Paris to train future mathematicians and scientists. But it was open only to men. Undaunted, Germain assumed the identity of a former student, Antoine August LeBlanc. Every week she would submit answers to problems under her new pseudonym. The course supervisor, Joseph Louis Lagrange, soon noticed the marked improvement in a student who had previously shown abysmal mathematical skills, and requested a meeting. Germain was forced to reveal her true identity, but far from being appalled, Lagrance was impressed, and become her mentor.

This image is taken from "Sophie Germain—Revolutionary Mathematician" at http://www.sdsc.edu/Sciencewomen/germain.

Among the problems that caught Germain's interest in her early 20s was Fermat's Last Theorem, first mentioned by the mathematician in 1637. This is the statement that for arbitrary positive integers x, y, and z, and for any integer n greater than 2, the equation $x^n + y^n = z^n$ has no solutions. The proof was still undiscovered more than 150 years later. [In fact, it wasn't proved until 1994.]

Encouraged by a second mentor, the German mathematician Carl Friedrich Gauss, Germain adopted a new, more general approach to the problem: instead of proving one particular equation had no solutions, she outlined a calculation which focused on the case that the index *n* in Fermat's theorem was what is now called a Germain prime number—that is, a prime number *n* for which $2n+1$ is also a prime. In that case, she was able to show, except for the special case that the integers x, y and z were multiples of n, that Fermat's theorem was true. This partial result encouraged other mathematicians to think that Fermat's Last Theorem for the case that n is a Germain prime could be fully solved.

Germain then turned to physics, intrigued by the experiments of German physicist F. F. Chladni on vibrating plates. Chladni produced curious patterns on small glass plates covered with sand and played them, as though the plates were violins, by using a bow. "The sand moved about until it reached the nodes, and the array of patterns resulting from the 'playing' of different notes caused great excitement among the Parisian polymaths.

It was the first scientific visualization of two dimensional harmonic motion." (*From the reference given in the caption*). So the Institut de France sponsored a competition with the challenge of formulating a mathematical theory of elastic surfaces in keeping with the empirical evidence observed by Chladni.

Most mathematicians didn't even bother to enter, believing the existing mathematical models were inadequate to solve the problem. But Germain spent the next 10 years attempting to solve it, submitting three separate papers—the only entrant in the competition all three years. She failed to win anything in her first two submissions, but on her third attempt, submitted around May 1816, the judges deemed her paper entitled "Memoir on the Vibrations of Elastic Plates" worthy of a prize, despite pointing out some remaining mathematical deficiencies.

Germain refused to attend the award ceremony. She apparently felt the judges did not fully appreciate her work, and that the scientific community as a whole did not show her the respect she believed she had clearly earned.

Germain had a point. Poisson, her chief rival on the subject of elasticity, was one of the judges and technically a colleague, yet he pointedly avoided having serious discussions with her, and snubbed her in public. Nonetheless, Germain became the first woman to attend lectures at the French Academy of Sciences who was not the wife of a member—the highest honor that body had ever conferred on a woman.

Late in her life, Gauss arranged to have the University of Gottingen award Germain an honorary degree. Sadly, she died of breast cancer a mere few weeks before the honor could be bestowed upon her. She was 55. Her death certificate identified her not as a mathematician, but as a "single woman with no profession."

Germain was a true social revolutionary, in keeping with someone who was born the year the American Revolution began, and started learning calculus 13 years later at the onset of the French Revolution. She succeeded in becoming a celebrated mathematician despite the social prejudices of her era.

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zero gravity

The Lighter Side of Science

Physics in Seventeen Syllables

We were recently privileged to view the winning entries of a physics haiku contest sponsored by the Society of Physics Students. The entries revealed that these up-and-coming young physicists combine their love for the field with a penchant for poetry and, at times, a wicked sense of humor. Consider this winning haiku from Ivan Arnold, a junior physics major at the University of Louisville:

one explanation
intertwining dimensions
of vibrating strings

Suzie Topalian, a freshly minted BA from Boston University, put a new spin on an old joke:

Imagine...
a spherical cow,
sure that makes a lot of sense
but how would it taste?

Brandon Swift, astrophysics student at the University of California, Berkeley, expressed his frustration in 17 succinct syllables:

Concussion
Many, many times
Will I tunnel through this wall?
Ow. Probably not

Paul Tandy, a student at the University of Louisville, took a darker tone in his winning entry:

Boltzmann kills himself
Ehrenfest does the same thing
Stat mech is harmful

There were numerous other submissions worthy of mention:

Scattering
Understanding makes
More beautiful red sunsets
And a bright blue sky
—*Brandon Swift*

Singular functions
Newton saw the fall
Of apple from tree to earth
And Einstein caught it.
—*Brandon Swift*

Maxwell mnemonic
del dot E is rho
del dot B equals zero
No source for confusion.
—*Paul Tandy*

Singular functions
Dirac's Deltas are
impulsive; integrate, they're
on the Heaviside.
—*Brandon Swift*

Singular functions
If Alexander
Graham had seen like fortune, we'd
admire his Bell curve
—*George Schuhmann*

Oops
universe expands
and when the beast's lungs are full
universe contracts
—*Ivan Arnold*

Oops
If air were water
I would swim faster than light
making optic booms
—*George Schuhmann*

Some entries dealt specifically with college life:

$110 for a book!
pricey physics text
cannot afford to buy it
too big to xerox
—*Paul Tandy*

GRE
It looms over us
Graduate Record Exam
You should go study
—*Paul Tandy*

Guinness for Strength!
It all is so clear
When you explain it with a
Guinness bottlecap.
—*Brandon Swift*

Others expressed frustration at being unlucky physics majors in love:

Not a love connection
She spoke C++
But I speak FORTRAN
wasn't meant to be
—*Paul Tandy*

To all the girls
Talking to a girl
Face cringes when major told
Goodbye, girl, goodbye!
— *Josef Norgan*

Finally, while browsing the University of Illinois Physics Department's web site, we apparently clicked on a page that was no longer there. Instead of the usual error message, we got the following:

404: A Physics Haiku
Your page is in a
Quantum superposition
Of "here" and "not here"

Enter the Haiku Contest!

All this poeticizing has inspired us to launch our own physics haiku contest, in the spirit of March 1997's *APS NEWS* limerick contest.

That contest brought in a deluge of physics-minded limericks from budding poets; we hope to get just as many haiku. Winners will receive a free copy of *Physics in the 20th Century* by Curt Supplee.

Entries should follow strict haiku format:

three lines, with five syllables in the first and third lines and seven syllables in the second line.

Submissions can be made via e-mail, fax or snail-mail to: Haiku Contest, APS, One Physics Ellipse, College Park, MD 20740; FAX: 301-209- 0867; haiku@aps.org. Deadline for submission is October 1, 2004.

The collection of APS physics limericks can be found online at: http://www.aps.org/apsnews/0397/11855.cfm.

"Smart" Drugs Target Cancer Cells

One of the bitter ironies of cancer therapy is that any treatment powerful enough to kill tumor cells also harms healthy ones, causing undesirable side effects.

Researchers at the University of Michigan's Center for Biologic Nanotechnology are developing "smart" drug delivery systems that will hopefully help prevent that problem by knocking out cancer cells with lethal doses while leaving normal cells unharmed.

The U-M group is using lab-made molecules called dendrimers —also known as nanoparticles—as the backbones of their delivery system, according to U-M graduate student Almut Mecke, who reported on the group's progress at the APS March Meeting in Montreal.

Dendrimers are tiny spheres that have been carefully engineered to have several loose ends, to which other molecules can be attached, such as a targeting agent that can recognize a cancer cell and distinguish it from a healthy cell, or a drug that kills cancer cells. This turns the dendrimer into a cancer-fighting Trojan horse. "If you have both of these functions on the same molecule, then you have a smart drug that knows which cells to attack," said Mecke.

In order for this approach to be successful, the bare dendrimer should not be toxic and should not be able to break into healthy cells, only cancerous ones.

So Mecke investigated the interaction of dendrimers with cell membranes. She found that certain kinds of dendrimers are able to disrupt membranes by literally punching holes in them—not a desirable attribute, since they do not distinguish between cancerous and healthy cells. The underlying mechanism seems to arise from the membrane wrapping itself around the dendrimer, leaving a hole.

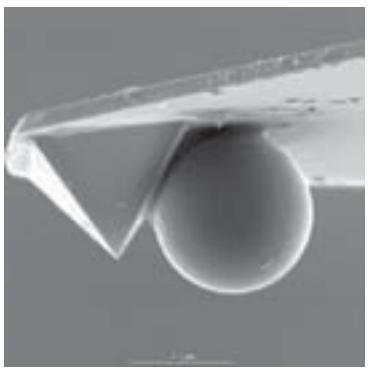
This happens because both the dendrimers and cell membranes are charged, causing the two to bind. Mecke's group modified the dendrimers chemically so that they became uncharged, and no longer punched holes in membranes. Of course, uncharged dendrimers don't attack any cells at all, so cancer-detecting targeting agents must be attached.

Mecke's group is working with a type of dendrimer called polyamidoamine, which is modified to identify cancer cells containing specific markers on their membrane surface. This causes the cancer cell to ingest the dendrimer. Once inside the cell, it releases the attached anti-cancer drug.

The data Mecke gleaned through atomic force microscopy is supported by recent research on live human cancer cells *in-vitro*, as well as animal tests conducted by team members. Initial results on mice have shown a greater efficiency and reduced side effects when cancer is treated nano-therapeutically.

The researchers hope next to add more functions to their dendrimer-drug devices, such as biosensors that can report on cancer cell death, indicating how successful a particular treatment has been.

AFM STUDY *from page 1*



A 5μm silica sphere glued to a standard AFM cantilever was used to obtain stable and repeatable measurements over the area of individual cell.

secret lay in the cell cytoskeleton, the most rigid part of the cell, and imaged it using AFM. He discovered that older cells have a higher surface density of cytoskeleton with more fibers per unit area.

Among the other interesting new bioimaging techniques described at the meeting was a new approach to facial recognition, developed by researchers at the State University of New York, Stony Brook. Most face recognition techniques use still images, and are sensitive to lighting, shadows, or such appearance modifications as makeup, natural aging, or cosmetic surgery.

According to E Guan, the group is using a technique called digital image speckle correlation (DISC) to trace the motion of the underlying musculature of a person's face. Human skin has a natural pattern of pores that is easily visible with high-resolution digital cameras.

Guan and his cohorts took two photos of a subject, showing a small change in expression, such as a slight smile. With DISC, they were able to analyze these digital images and recognize the underlying muscle structure, which is unique to individuals and is not affected by lighting or makeup. Because the motion pattern can be associated to an individual, "suspects" can be identified via a facial "print" using conventional fingerprint scanning technology.

The method could also prove useful for diagnosing nerve-related diseases like Bell's palsy, or skin disorders, based on asymmetry of facial expressions or abnormal stiffness of the skin.

It is extremely difficult for biologists to probe living cells because most optical techniques rely on forms of ionizing radiation, which can damage or destroy delicate structures, even causing mutations that morph into cancerous cells. Hence, most studies of proteins to date have been conducted using dead cells.

Eric Nelson of the University of Louisville is one of a number of researchers looking for new methods to study living cells. He is using a technique called Fluorescence Redistribution After Photobleaching (FRAP) to glean clues about how proteins function and how they move around a cell.

Nelson focused on RAD-18, a protein that has recently been found to help initiate the repair of damaged DNA. He has discovered that within the nucleus of cells, this protein tends to congregate in and bind to certain areas, suggesting the existence of DNA-repair factories within the cell. The FRAP studies also revealed that proteins move more freely in low density regions than in high density nucleic regions, probably because those in low-density regions are bound and do not diffuse. Future experiments will be aimed at determining the underlying relocation mechanisms for RAD-18.

Cold Gases, Hot Topic

By Ernie Tretkoff

Ultracold quantum gases were a hot topic at the APS March Meeting in Montreal, where several groups reported their latest results in the race to explore a new state of atomic matter. In addition to providing insight into the quantum nature of atoms in this not yet well-understood regime, the investigations could lead to better understanding of high temperature superconductivity.

At extremely low temperatures, bosons, (particles with integer spin), can all pile together into a single quantum state, known as a Bose-Einstein Condensate (BEC). The BEC, in which many atoms act like a single entity, was first demonstrated in 1995.

Unlike bosons, fermions (particles with half-integer spin), obey the Pauli exclusion principle, which dictates that they cannot share the same quantum state. But if two fermion atoms pair up, they can act like a boson. Indeed, last fall several groups coaxed fermion atoms into molecules that collapsed into a BEC.

In addition to forming strongly bound molecules, fermions can combine in weakly-bound Cooper pairs, as electrons do in a Bardeen-Cooper-Schreiffer (BCS) superconductor, or as helium-3 atoms do in a superfluid. In these pairs, the fermions are correlated in momentum space, not position space.

Between the molecule and Cooper pair extremes lies a whole spectrum of interaction strengths, known as the BEC-BCS crossover region. Researchers have recently begun to explore this terrain, and several groups have demonstrated that they can tune inter-atom forces by adjusting an external magnetic field.

Several competing researchers described their experiments at the March Meeting, including Deborah Jin of NIST, Wolfgang Ketterle of MIT, Randy Hulet of Rice, and Johannes Hecker Denschlag of the University of Innsbruck.

Between the BEC and BCS extremes lies the Feshbach resonance, in which the energy of two free atoms equals that of a bound molecule. On one side of the resonance, the interactions between atoms are strongly attractive; on the other side the interactions are strongly repulsive. By varying the magnetic field, the researchers can smoothly and reversibly tune the interaction strength around this resonance.

"This is an amazing level of control," said Ketterle. "By changing the magnetic field we can go from a boson system to a fermi system."

See COLD GASES *on page 5*

LETTERS

What is a Working Laser?

As a physicist in the laser field since 1969, I enjoyed reading the article "This Month in Physics History, December 1958: Invention of the Laser".

However, one statement about the first realization of the laser in 1960 raises some criticism. The relevant sentence should read, in my opinion, "...the same year the first working laser was built by Collins and coworkers at Bell Labs..."[1]—and not by Theodore Maiman, as stated.

What is a working laser? It is a light-amplifying device that operates above a certain threshold with mode selection. The latter gives rise to a large line narrowing and an intense emission in a drastically reduced beam angle. To support this statement, I point to the paper of Maiman et al. submitted in January 1961 to *Physical Review*. The authors write[2]: "...the nature of the output radiation from the various ruby samples which were tried could be divided into two categories:

A. Crystals which exhibited R_1 line narrowing of only 4 or 5 times, a faster but smooth time decay of the output (compared to the fluorescence), an output beam angle of about 1 rad, and no clear-cut evidence of a threshold excitation. This type of behavior was reported and discussed by Maiman [*See reference 3 below*].

B. Crystals which exhibited a pronounced line narrowing of nearly four orders of magnitude,...beam angle of about 10^{-2} rad;...a very clear-cut threshold input energy....This second category of behavior was reported by Collins *et al.* [*See reference 1 below*], and is the subject of further study reported here."

Obviously case B represents a working laser.

A. Laubereau
Munich, Germany

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1. *R.J. Collins, D. F. Nelson, A. L. Schawlow, W. Bond, C.G.B. Garrett and W. Kaiser,* Phys. Rev. Lett. 5, *303 (1960) [received August 26, 1960].*

2. *T. H. Maiman, R.H. Hoskins, I.J. D'Haenens, C.K.Asawa and V. Evtuhov,* Phys. Rev. 123, *1151 (1961) [see page 1154].*

3. *T. H. Maiman,* British Communications and Electronics 7, *674 (1960);* Nature 187, *493 (1960) [issue August 6].*

Stick to the Facts in Contentious Times

I was struck by the fact that the front page of the February *APS News* featured several items relating to government policy on national and international affairs.

These are contentious times, and the public is deeply split about our national government. The only way an organization such as ours can maintain its integrity is to be absolutely factual—no value-laden words or phrases.

Two of the front-page stories met this criteria and were both objective and informative. The Beltway article, however, featured several partisan expressions about one political party, saying, for example, "They succeeded in their mischief."

To avoid any misunderstanding, I hope that in future we can choose our words with more care.

George F. Bertsch
Seattle, Washington

No Safe Way to Sequester CO_2

The letter in the March 2004 *APS News* by Paul Weisz on the basic science constraints of a hydrogen economy states that the annual addition of carbon dioxide to the environment by fossil fuel combustion is about 2.5×10^9 tons. The global number is actually close to 2.5×10^{10} metric tons/year, of which roughly half accumulates in the atmosphere, and half is absorbed in the ocean or on land. The total US carbon dioxide emissions in 2002 were about 5.8×10^9 metric tons. A single 1000-MW coal-fired electric utility plant operating at 100% capacity releases about 24,000 metric tons of carbon dioxide into the atmosphere every day.

The Kyoto Protocol treaty signed by the United States in 1998 set an annual limit of about 4.7×10^9 metric tons by 2012.

The only alternative to reducing carbon dioxide emissions is sequestration. Weisz states that "pumping of high concentrations of carbon dioxide into deep sea or geological locations is possible but permanence of such disposal would be variable and uncertain." Pipelines carrying high pressure liquid carbon dioxide have been successfully used in the United States for oil recovery.

One example is the Sacroc pipeline system in West Texas, which has transported up to 12,000 tons/day in over 100 miles of 16" diameter pipe. But sequestering high concentrations of carbon dioxide under pressure is also a health risk. In 1986, Lake Nyos (in Cameroon), in which thousands of tons of carbon dioxide had been sequestered naturally, suddenly and without notice "erupted" and asphyxiated over 1700 people. Global warming is a serious concern, and sequestering carbon dioxide emissions on such a massive scale is both uncertain and risky.

Robert Shafer
Los Alamos, NM

Surprised by Tiny Watercolor

It was interesting to see the Michelson watercolor on your front page of *APS News*.

In 1987, for the Centennial Celebration of the Michelson Morley experiment here at Case Western Reserve (where the experiment was done), we had a couple dozen of the Michelson watercolors copied and framed. They decorate the public areas of our physics building and are so familiar to everyone here that the appearance of one tiny work on your front page came as a surprise.

Bill Fickinger
Cleveland, OH

Use Alternative Energy to Produce Hydrogen

In his letter in the March 2004 *APS News*, P. Weisz seems to miss the point that hydrogen can be produced in other ways than just by isolation from fossil fuels, a process which, as he points out, renders hydrogen as an alternative fuel mostly advantage-less. Electrolysis of water, using electricity generated by windmills, solar arrays, and even dams, comes immediately to mind.

C. Cunningham, in turn, doesn't point out probably the biggest advantage to using hydrogen generation by an alternative energy source: that generating hydrogen would alleviate the problems of highly variable output associated with alternative sources (since they depend on wind, sun and even river levels) since, even with inefficiencies, hydrogen would provide a great energy storage medium.

It would be a definite improvement over storage batteries, which require much maintainance and replacement, are often toxic or dangerous, and have their own inefficiencies. Hydrogen could even be burned right at the generating site when needed, the power carried in the existing electrical grid, and the water recycled for further use.

Cunningham does point out several other advantages to hydrogen power: environmental friendliness (both in terms of human health and terrestrial climate effects) and energy independence for the US, and the attendant advantages in terms of American foreign policies.

The time to begin seriously developing such real alternatives to foreign oil development is now, not when the ill effects of our oil and coal addiction become critical, or when these fuels begin to run out.

And what country on Earth is better equipped with scientific and technical expertise for the task? Unfortunately, to our current short-sighted administration, the term "energy independence" is essentially synonymous with drilling for more oil, regardless of the consequences, and it views with poorly-concealed contempt the very idea of energy efficiency and conservation.

The one technology the Bush administration seems to have any enthusiasm for is just that hydrogen-from-fossil-fuel technology that Weisz mentions. This has few advantages and, by a remarkable coincidence, preserves US dependence on big oil.

John Chappelow
Fairbanks, Alaska

You Can't Fool Thermodynamics

Paul B. Weisz (*APS News* March 2004) reminds us of the fundamental importance of thermodynamics: Nothing is free and, in the last analysis, a hydrogen economy has its own costs.

In the same issue, Clarence M. Cunningham optimistically suggests that we should generate hydrogen using renewable resources such as solar cells and wind energy to avoid environmental degradation.

Energy (whether it comes from coal, oil, hydroelectric sources, or someplace else) must be added to the system that produces solar cells and windmills. Of course, along the way much of this energy is lost before the assembled devices generate energy on their own.

What is the efficiency of this process? How long must manufactured devices operate before the input energy (cost) is repaid? How long will the device continue to produce energy before it wears out and needs to be replaced (more energy input)? In the end, thermodynamics is not forgiving.

Ernest L. Lippert
Toledo, OH

See LETTERS *on page 5*

Did the US Use Dirty Bombs in Iraq?

Peter D. Zimmerman discusses radiological dispersion devices (RDD's or "Dirty Bombs") and their economic and psychosocial effects in The Back Page of the March 2004 issue of *APS News*.

One of the members of the 911 families that visited Iraq in February 2003 indicated during a presentation here in Detroit that "Dirty Bombs" were dropped by the US during Operation Desert Storm. It was reported that the radiation has had a major effect on Iraqi civilians. Is it true that the US dropped "Dirty Bombs" during Operation Desert Storm? If so, why didn't Zimmerman address this example either along with or in place of the 1987 Goiania, Brazil event? It is clearly more relevant to terrorism than the Brazilian event, and should be studied extensively.

James R. Woodyard
Detroit, MI

✶✶✶

Peter D. Zimmerman wrote about the threat of terrorists using radioactive "Dirty Bombs."

However, he neglects to mention the US military's use of depleted uranium weapons in Iraq and elsewhere. The US and Britain used 1,100 to 2,200 tons of depleted uranium shells in Iraq in March and April, 2003 alone. Depleted uranium is approximately 40% less radioactive than natural uranium, but its use has still resulted in measured radiation levels 1,000 to 1,900 times higher than normal background levels in Baghdad.

This radiation is affecting our own troops and Iraqi civilians. For example, military personal who served in the 1991 Gulf war, in which approximately 630,000 pounds of depleted uranium were used, were 5.6 times more likely to develop lymphomas and 4.8 times more likely to develop leukemia than a control group. "The death rate per 1000 Iraqi children under 5 years of age increased from 2.3 in 1989 to 16.6 in 1993".

The threat of terrorists using radioactive weapons is certainly a frightening possibility, but the US military's use of radioactive weapons is a deadly reality. We must end the use of "Dirty Bombs" by our own military if we expect others not to use "Dirty Bombs" on us.

Ashley James
Minneapolis, MN

✶✶✶

Peter D. Zimmerman replies:

Contrary to the assertion by James R. Woodyard, the United States has no radiological dispersion devices or "dirty bombs" in its stockpile of weapons. RDDs are demonstrably useless as weapons intended to kill or incapacitate people in a predictable way—unless the amount of radioactive material used is so large as to prevent an aircraft from taking off because of the mass of shielding needed to protect ground and air crews. The United States did not drop dirty bombs during Operation Desert Storm or Operation Iraqi Freedom, period.

I am saddened that a member of the 9/11 families group should have been so badly taken in by Iraqi propaganda.

We did, however, as Ashley James suggests, use depleted uranium (DU) shells and warheads to engage and destroy Iraqi armor. The half-life of depleted uranium (essentially just pure U-238) is around 4.5 billion years, essentially the age of the earth. Thus, depleted uranium is, for all practical purposes, not radioactive enough to cause a health hazard.

However, as are almost all metals at the high-Z end of the periodic table, uranium is toxic and can be dangerous to the kidneys. Frank von Hippel and Steve Fetter, neither one a "hawk," demonstrated fairly conclusively that the contamination from our DU weapons posed no significant hazard to civilians in their decade-old article in the journal *Science and Global Security*.

I used DU as shielding material in some experiments I've done, and as a target in others, all with very little in the way of precautions other than handwashing and rubber gloves. Indeed, at one laboratory we used a DU shielding brick as a door stopper.

Some Iraqis were badly injured after Operation Iraqi Freedom when they "liberated" blue plastic drums used by the Iraqi atomic energy establishment to store uranium tetrachloride.

The Iraqis dumped the uranium compounds and then used the drums for water and bathing without first flushing the containers. The residual UCl_4 formed hydrochloric acid in solution and produced serious chemical burns.

New Nanodevices Target a Host of Potential Applications

The APS March Meeting in Montreal featured numerous talks on the development of a wide variety of nanoscale devices with potential applications in such areas as telecommunications, microfluidics, biology and chemistry. These included electromagnetic microsystems for cell manipulation, tunable nanosurfaces, a biosensor with artificial micro-pores, and the world's smallest motor.

Harvard University's Hakho Lee has built a microelectromagnetic matrix of wires and insulators capable of trapping and moving a cell continuously in a fluid to position cells at desired locations. Being able to hold and move a single cell is a very important capability in biological research, and is usually achieved using fluidic or optical (laser) methods.

Lee's device builds on what biologists already do: manipulate cells by using magnetic beads, a chemically modified surface that can be specifically bound to a target biological system. This bead-bound sample can be manipulated with an external magnetic field, permitting fast and easy control of the sample.

Lee's matrix has two arrays of straight wires aligned perpendicular to each other. Each wire is connected to a separate computer-controlled current source, and the current in each wire is adjusted to generate optimized magnetic field patterns for various experimental purposes.

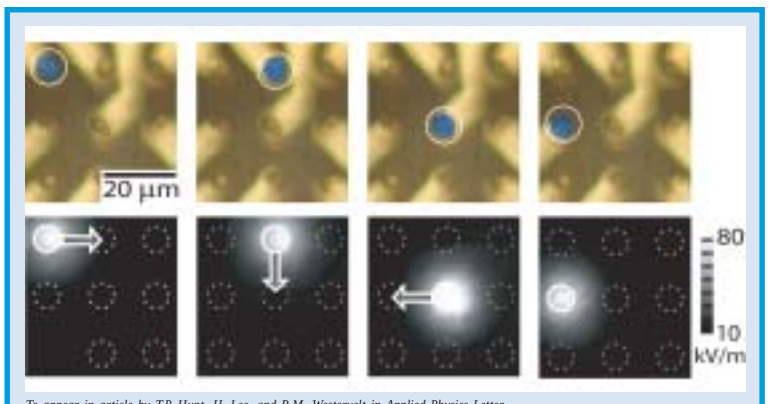
The matrix can trap a single yeast cell, for example, and move it to a desired location, move multiple cells along different paths simultaneously, or rotate or twist cells to study their mechanical properties. Simultaneous and independent control of multiple cells is Lee's ultimate goal, since this would enable bioassisted assembly nanomagnets or nanoparticles.

Lee's Harvard colleague, Tom Hunt, has adopted a somewhat different approach, using electricity to manipulate and move cells. He built a micropost matrix array of electrodes, each of which is connected to a computer-controlled voltage supply. Running a simple computer program sets up non-uniform electrical fields that were shown to move cells or particles.

Even though cells are electrically neutral, they develop small charge separations when they are placed in an electrical field (polarization). The field exerts a force on the polarized cell, trapping it without physically touching or damaging the cell. By generating the proper electric field, almost any particle, including cells and DNA molecules, can be trapped and moved without any need for special sample preparation.

Lee's and Hunt's respective matrices could one day be used to make a reprogrammable microfluidic system. Several different experiments could be performed with one generic microfluidic chamber, simply by controlling the motion of cells—not by the physical barrier of the chamber walls, but rather by electric or magnetic fields that can be dynamically reconfigured for different experiments.

In the future, advanced versions of these matrices could hold thousands of both cancerous and normal cells in individual traps. Dozens of slightly different chemotherapy drugs would wash over the cells, and the embedded sensors in the array would keep track of how many cells survived each treatment, enabling scientists to rapidly test the effects of new potential drug compounds.



To appear in article by T.P. Hunt, H. Lee, and R.M. Westervelt in Applied Physics Letter

Single cell manipulation. Top: microscope pictures of yeast cell (circled, highlighted in green) following a trap that moves in a clockwise direction. Bottom: simulations of electric trapping field. Arrows show direction of trap movement.

In a new experiment conducted at Bell Labs/Lucent Technologies, a liquid drop was maneuvered around a special surface consisting, at the microscopic level, of a forest of tiny stalks. The blades of this "nanograss" can be selectively electrified so as to move the drop from place to place, or to cause it to lose its spherical shape and wet the surface below. The result is a "tunable" surface, according to Lucent scientist Tom Krupenkin.

The conversion of the surface from being hydrophobic (the drop staying aloof at the top of the blades) to hydrophilic (the drop collapsing and flooding the plain between the blades) could result in many potential applications.

Heat mitigation is one example. Drops could be delivered to hot spots on microchips, where the drop could douse the troubled area, much like airborne drops of water can help douse a forest fire. It would absorb the heat, and then depart. Optical properties of the surface could also be switched from one state to another through electronically controlled wetting.

Potential microfluidics applications include combinatorial chemistry in microreactors, drag reduction, or altering the friction of channels. In microbatteries, electrochemicals could be kept isolated until energy was actually needed, thus extending the battery's working life and saving energy for moments of peak activity.

Other interesting nanodevices described at the meeting included the world's smallest synthetic motor, developed by Lawrence Berkeley Laboratory's Adam Fennimore.

The nanomotor uses electric instead of magnetic fields to attract the rotor to different positions, and uses nested cylinders of multi-walled carbon nanotubes to build the rotational bearing. One potential application would be its use as a full-control rotational mirror in optical switching for the telecommunications, although it could be used anywhere in MEMS devices where one needs rotational freedom.

Ian Chan of the University of California, Berkeley, has used an array of artificial micropores mounted on a chip to selectively identify many types of analytes simultaneously. This technique achieves biological sensing by detecting changes in the size of colloids, since the height of the pulse depends upon the size of the colloids. That size changes with the presence of a specific antigen to which the colloid is sensitive.

Chan hopes to extend the concept to multianalyte detection by adding different-sized colloids that are sensitive to different antigens, or by using up to six different multiple pores at one time.

Forum on Education Launches Two Initiatives

The APS Forum on Education has recently announced two initiatives to encourage APS units to be involved in physics education and outreach.

First, the FEd will make available grants of up to $500 for APS units and sections to actively engage in physics education and to address issues concerning the preparation of K-12 teachers.

The FEd is prepared to receive brief proposals from APS members for unit-sponsored activities to be held at unit and section meetings and at National APS meetings. Joint activities with American Association of Physics Teachers (AAPT) sections are encouraged.

The activity could be a session or workshop for APS members who regularly teach, such as a professional development workshop, or the activity could be aimed at communicating physics to local high school science teachers. The form of the activity is up to the APS unit. "We don't want to be too restrictive," said Wolfgang Christian, chair of the FEd.

While there is no deadline for proposals for these grants, currently available funds will support about eight such proposals per year.

The second initiative allows an APS unit to organize a session, sponsored by the FEd, at a meeting of the AAPT. The FEd will invite units with strong educational programs to give these sessions, said Christian.

In these sessions, the APS unit will present speakers and educational materials to convey the excitement of research in that unit's area of physics.

"We don't want a research session per se, but we do want a physics session," said Christian. "The content of session is truly up to the APS unit," he added.

AAPT membership consists of both high school and college teachers. "These people are very knowledgeable. This is an opportunity to reach some real opinion leaders," said Christian.

The first of these sessions, to be held at the 129th National AAPT Meeting, in Sacramento, July 31–August 4, 2004, will be presented by the Division of Physics of Beams. The DPB Education and Outreach Committee chose speakers who will present a comprehensive picture of different aspects of beam physics and accelerators and their applications to a diverse range of research areas.

The Division of Atomic, Molecular and Optical Physics (DAMOP) has been invited to organize a session for the 2005 AAPT summer meeting. This initiative should help strengthen ties between APS units and AAPT, said Christian.

Bernard Khoury, executive officer of the AAPT, also believes the initiative will benefit both societies. "This developing arrangement will bring to the AAPT meetings current physics research topics in a format likely to assist physics teachers at many levels." he said.

"AAPT and APS have so many common and overlapping interests that both organizations will benefit from this formal linkage across our meetings. While AAPT and APS no longer sponsor joint national meetings, having APS-sponsored sessions at AAPT adds to our long list of cooperative activities."

COLD GASES *from page 3*

The NIST group, which experiments with potassium atoms, approaches the crossover region from the BCS side; the MIT, Rice, and Innsbruck groups start with lithium molecules on the BEC side of the Feschbach resonance.

Although researchers can't yet tune the interaction all the way to the extreme BCS side, where true Cooper pairs would form and the gas would become a superfluid, the current data covers a large part of this crossover region. This intermediate region, with the ability to control the inter-atom interactions, may prove especially interesting, said Jin. "Ultimately, understanding the region we're in will tell us more about the connection between BEC and BCS," said Jin. "What's interesting is that we have this new knob that we don't typically have."

The research might even lead to better understanding of high-temperature superconductivity, because the strength of pairing in this crossover region corresponds to that expected for room-temperature superconductors.

Also, because these extremely low-density, low-temperature gases are relatively simple systems, they may aid in the understanding of more complicated condensed matter systems, said Ketterle.

The race to explore ultra-cold quantum gases has produced an astonishing number of developments recently, noted Randy Hulet. "I think the most exciting thing is the pace of discovery. We're going to be understanding lots of new physics."

LETTERS *from page 4*

Visa Crisis Imperils Homeland Science

The February issue of *APS News* Back Page article by W. A. Wulf addresses a timely issue of visa problems faced by foreign students and scholars. He referred to the current practice as out of balance. It'd be more direct to say that it is out of control. In the past three years at UMass Dartmouth, our graduate applicant pool in physics has dwindled from about twenty, to low teens, to single digits now. It has created a crisis in our department, negatively impacting research and teaching. Our evidence is anecdotal, but we know many small physics departments experience similar trends.

The impact on larger departments will surely follow suit as more students will look elsewhere, such as Europe or Canada. The current visa restrictions are causing great damage. This is like a fool lifting the stone just to drop it on his own feet. There is good news, though.The time graduate committees spend reviewing applications has been reduced. We owe our thanks to the infinite wisdom of our government bureaucrats and some politicians who cook up schemes, like charging $100 non-refundable fees, which amounts to a two-month salary in some countries. Better yet, if a student dares to mention words such as "atomic, biological, or nuclear" in his studies, he must be planning to make WMDs, and we just cannot allow that.

But complaining by itself will accomplish nothing. We as individuals need to spring into action, to write to our congressmen, and to bring it to the public's attention.

The APS, perhaps in alliance with other similar organizations, should redouble its effort to lobby Congress, to advocate for dismantling or severely scaling back SEVIS, and to collect data from member departments to document the damage. Unless the tide turns quickly, we may be witnessing the beginning of the dismemberment of homeland science, and the end of an era of in free scientific exchange with the US.

J. Wang
Dartmouth, MA

SURVIVAL SKILLS *from page 1*

top of their profession. "A successful career in physics, as in most other fields, requires more than hard work and good technical skills," said Dongqi Li, a physicist in Argonne National Laboratory's Materials Science Division and co-chair of the workshop, along with APS Executive Officer Judy Franz. Topics discussed included how to negotiate for resources and teaching loads, how to strategically plan one's career, and how to balance the demands of work and family.

MIT's Mildred Dresselhaus addressed the issue of establishing a scientific identity in the traditionally male dominated field of physics, drawing on her own personal perspective as well as findings of the recent Report on Women Faculty in the MIT School of Sciences. For example, when mulling over what to choose for a research topic, she suggested women consider what they do best, and also find a topic that both excites them and that other scientists will care about.

Beverly Hartline of Argonne National Laboratory focused on developing goal-oriented strategies for professional advancement, addressing such issues as hidden barriers to women's advancement, career management, and useful tools for reaching one's goals whether they be in research, teaching, management, or leadership. "Clear goals can enable you to thrive and not just survive in physics, by clarifying the professional skills, experiences, and results you will need for that desired promotion or leadership position," she said.

Laura Green of the University of Illinois, Urbana Champaign, also took a more personal, humorous twist on what she termed the "Mission impossible": balancing a career in physics with family demands. "No blueprint exists" for coping with this often harsh reality that faces women scientists, she said, because "the number of women actually doing it is still too low for a standard model to be developed."

The event concluded with a special interactive training segment run by Argonne's director of employee development, Geralyn Becker, to teach participants successful negotiation tactics and strategies. Becker adopted a role-playing approach, drawing on the steps outlined in the Harvard Law School Negotiation Project's model of negotiation, using common situations faced by scientists as examples. "For continued professional success, you must be able to identify, articulate, and advocate for the issues that help to further your career," she admonished. "People do not always say 'yes' with a smile to your requests for increased lab space and resources, decreased teaching loads, funding, or administrative support."

Response to the workshop from the 37 participants was overwhelmingly positive, and most found it "extremely helpful." Several cited their appreciation of the personal perspectives offered by the speakers. Suggestions for improvement included allowing more time for discussions, a few more tips on handling gender bias, and perhaps, in the future, organizing separate workshops for women at different stages of their careers.

The survival skills workshop was followed two days later by a networking breakfast, with over 50 attendees. The featured speaker was Joanna L. Batstone, a senior manager in IBM's Healthcare and Life Sciences Solutions unit, who gave her perspective as an industrial physicist on transitions and survival skills for the profession.

Brain Synchronization Can Give You a Headache


The Scream (1893) by Edvard Munch (National Gallery, Oslo, Norway)

By Ernie Tretkoff

Researchers studying the rhythms of electrical signals in the brain presented intriguing results at the APS March Meeting, including evidence that migraines may be related to a hyper-synchronization of brain waves, and a new technique for analyzing the brain's response to stimuli.

Physicist Sebastiano Stramaglia of the University of Bari and colleagues in Italy and at Harvard Medical School investigated how brains of migraine sufferers differ from those of healthy subjects in their response to flashes of light that simulate conditions known to trigger migraines in some patients.

An estimated 5% of Americans suffer from at least 18 days of migraine headaches a year, leading to a huge medical and financial burden. Several factors, including emotional stress, physical exertion, changes in weather, and flickering lights, are known to trigger migraines in sufferers, but no experimental model fully explains the migraine process.

Using electroencephalograms (EEG) to measure the electrical activity of the brain in 15 migraine patients and 15 controls, the researchers examined how closely signals in different regions of the brain were synchronized with each other. The researchers measured EEGs in what is known as the alpha band, 8 –12.5 hertz, which corresponds to a quiet wakeful state.

When the migraine patients were subjected to flashing light stimuli, different areas of the brain synchronized their signals more closely with each other. In control subjects, the opposite occurred—different areas of the brain decreased their synchronization with each other in response to the flashing lights.

These synchronization patterns suggest that migraines may be related to an overactive regulatory mechanism that makes patients more sensitive to environmental factors, said Stramaglia.

Though the phenomenon is not yet completely understood, Stramaglia thinks the alpha-band hyper-synchronization in migraine patients probably originates in the thalamus, a part of the brain that receives visual and auditory sensory information, then organizes and routes the information to other areas of the brain.

In another report, Peter Tass of the Institute of Medicine, Research Center, Juelich, Germany called into question the standard technique for analyzing the brain's response to stimuli and proposed a new method of analysis.

Tass seeks to understand how different areas of the brain react to pulsating stimuli and how different regions of the brain interact with each other. This information is important for the optimization of deep brain stimulation and for the study of sensory information processing.

The standard method for analyzing the brain's response to various stimuli involves averaging over a large number of trials to cancel out any background noise and extract the "real" response.

But this averaging technique, which is used in the majority of neuroimaging studies, actually cancels out a meaningful signal, leading to misleading and incorrect results, said Tass. Tass has therefore developed a more complex new analysis method, which he calls "stochastic phase resetting tomography."

In theoretical studies of a generic model of two oscillators and magnetoimaging experiments on 20 healthy subjects, Tass used his method of analysis to show that the brain's response to a stimulus is more complex than the simple resetting of the brain's rhythm that other groups have found.

Tass found that the brain often switches between qualitatively different responses across trials, a feature that the averaging analysis method fails to detect. Also, in contrast with the standard analysis, Tass said his technique provides reliable estimates of transmission times of signals between different areas of the brain.

These results could be relevant for both basic science and clinical diagnosis, said Tass. For instance, Tass's method could more reliably pick up the delay in transmission of brain signals caused by multiple sclerosis.

Plasma Physics and Laser Science Offer Distinguished Lecturer Programs

The Divisions of Plasma Physics and Laser Science are each sponsoring a distinguished traveling lecturer program this year, continuing traditions that have been very successful in the past.

The Distinguished Lecturer in Plasma Physics (DLPP) program was inaugurated in 1997 in response to a DPP Executive Committee consensus that awareness of plasma physics as a mainstream physics discipline should be brought to students and faculty in departments that do not have a significant plasma research component. The program is supported by a grant from the Department of Energy's Office of Fusion Energy Sciences.

The purpose of the Distinguished Traveling Lecturer (DTL) program of DLS is to bring eminent scientists to colleges and universities in order to convey the excitement of laser science to undergraduate and graduate students. Lecturers will visit selected academic institutions for two days, during which time they will give a public lecture open to the entire academic community and meet informally with students and faculty. They may also give guest lectures in classes related to laser science.

DTL committee chair Rainer Grobe of Illinois State University says, "As the Distinguished Traveling Lecturers stay on campus for two full days, this is a unique opportunity for our undergraduate students to meet with top-notch researchers including Nobel laureates. The DTLs are brilliant speakers and the opportunity to discuss informally with them has typically a huge impact on the students."

Don Correll of Livermore, who chaired the DPP Education and Outreach subcommittee in 1998-2002, praises the diverse range of lecture topics in plasma physics, and the commitment of the speakers over the years. "Alfvén waves to Z-pinch fusion, complex plasmas to space weather, there is something for every taste," Correll explains. "Often, other physics research areas are more widely known; therefore, DPP needs to especially inform undergraduate students that there are exciting career opportunities for them in plasma research."

R. Paul Drake of the University of Michigan, who was a lecturer in plasma physics in 2002-03, noted enhanced student curiosity about high-energy-density plasma physics once he mentioned that the National Research Council labeled it "the X-games of contemporary science."

Amanda Hubbard of MIT, who participated in the DPP program in 2000-01, particularly made a point of, and enjoyed, meeting students over lunch or coffee. She commented, "It became clear that, to some students and faculty, plasma physics is not considered a 'hot' field. Hopefully showing some of the progress in transport physics helped to change that impression."

Scott Bergeson of Brigham Young University, who recently hosted a lecturer in Laser Science, said "the DTL program is a great program. It really gives students a chance to hobnob with people that otherwise they would not get to meet. It promotes science in general, and is excellent PR for physics."

Distinguished Lecturers in Plasma Physics

The 2004 DLPP list appears on http://www.apsdpp.org/lecturers.html where the DPP publicizes the program with announcements of the speakers, the program's purpose, and instructions for arranging DLPP colloquia. The host physics department should email a speaker directly and schedule the travel. Travel arrangements and reimbursements are currently handled directly by General Atomics (in San Diego) which administers the $20,000/year DOE grant.

DPP's **2004 Distinguished Lecturers in Plasma Physics** and their topics are:

Steve Allen (allens@fusion.gat.com), Lawrence Livermore National Laboratory, "Improving Tokamak Confinement with 'Plasma Surgery' and 'Plasma Floating'"

R. Paul Drake (rpdrake@umich.edu), University of Michigan, "Connecting Laboratory Experiments with Astrophysical Phenomena"

John Goree (john-goree@uiowa.edu), University of Iowa, "Making Plasma Act Like a Crystal"

Raffi Nazikian (rnazikian@pppl.gov), Princeton Plasma Physics Laboratory, "The Scientific Frontiers of Fusion Energy Science"

John D. Sethian (sethian@this.nrl.navy.mil), Naval Research Laboratory, "The Science and Technology of Electron-Beam-Pumped KrF Lasers for Fusion Energy"

John T. Slough (slough@aa.washington.edu), University of Washington, "Development of Compact Fusion Plasmas for Deep-Space Exploration

Distinguished Traveling Lecturers In Laser Science

The DLS will cover the travel expenses and honorarium of the lecturer. The host institution will be responsible only for the local expenses of the lecturer and for advertising the public lecture. Awards to host institutions will be made by the selection committee after consulting with the lecturers. Priority will be given to those institutions that do not have extensive resources for similar programs. Applications should be sent to the DTL committee chair Rainer Grobe (grobe@ilstu.edu) and to the DLS Secretary-Treasurer Dan Elliott (elliottd@ecn.purdue.edu). The deadline for application for visits in Fall 2004 or Spring 2005 is May 31. Detailed information about the program and the application procedure is available at http://physics.sdsu.edu/~anderson/DTL/ .

Lecturers for the 2004-2005 Academic Year:

Robert Byer, Stanford University.
Lee W. Casperson, Portland State University.
Eric Cornell, University of Colorado.
Jim Kafka, Spectra Physics.
Marsha Lester, University of Pennsylvania.
Christopher Monroe, University of Michigan.
Luis A. Orozco, University of Maryland.
Carlos Stroud, University of Rochester.
Ron Walsworth, Harvard University.

ANNOUNCEMENTS

DIRECTOR OF EDUCATION AND OUTREACH PROGRAMS

The American Physical Society (APS) is seeking applications and nominations for the position of Director of Education and Outreach Programs to replace Fred Stein, who plans to retire in September. The person selected will play the leadership role in all APS education programs, including a major program to improve the physics education of K-12 teachers (PhysTEC), and will work closely with the Committee on Education and the Forum on Education. In addition, he or she will work with the Committee on the Status of Women in Physics and the Committee on Minorities in Physics in efforts to increase the number of women and minorities with careers in physics. An excellent staff is available to help with these programs.

Qualifications for the position include a PhD in physics or a related field, familiarity with the physics research and education communities, experience in managing large projects, some experience in working with teacher education programs, and excellent interpersonal and communication skills.

For consideration, send a cover letter, resume, and professional references to Judy Franz, APS Executive Officer, franz@aps.org, by June 15.

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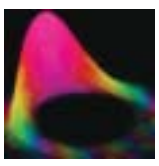
E. T. Samulski/Univ. of North Carolina

A New Direction for Liquid Crystals
After decades of searching, researchers identified a new type of liquid crystal where the molecules align in two dimensions, rather than one.



C. Stroud/Univ. of Rochester

A Tiny Solar System After All
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New Job Web Site for APS

If you're looking to fill or find a job, the new APS Online Job Center at **http://careers.aps.org** is your one-stop shop. Jobseekers and employers alike will find the APS Job Center, which now receives over a million hits from 20,000 unique visitors monthly, to be an invaluable resource.

The APS Job Center contains hundreds of new jobs posted monthly and offers a database of thousands of resumes. It covers all physics fields plus related fields such as materials science, computing, biology, chemistry, and engineering.

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Whether you're an HR manager or a member of technical staff looking to hire, you can take advantage of valuable services for a low cost.

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If you have any questions about any of the services, please contact us at **jobs@aps.org.**

APS Membership Department News

New Member Benefit for 2004

APS will offer a new journal benefit to members in 2004. APS Member Article Packs will be available for $50, allowing members 20 APS journal article downloads (*excluding PROLA and RMP*). This is a considerable savings on single APS article downloads. *Look for more information in your 2004 Renewal Packet.*

In addition, APS members can already purchase AIP Journal Packs at a 50% discount on http://store.aip.org/articlepacks/.

2004 APS Member Directory

Members will be contacted at the end of the year and asked to request either a paper or CD-ROM copy of the 2004 Directory. Members will have to notify APS of their choice by February 23, 2004, to receive one of the available versions. Online directory access is always available at http://www.aps.org/memb/enter-directory.html.

APS Bulletins

Starting in 2004, the APS Membership Department will no longer be processing orders for APS Bulletins. The paper version will be distributed onsite at meetings to attendees. Open access to all APS Bulletins (current and archived) will be available online at http:/www.aps.org/meet/.

Contact Information:
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Nanofoam Exhibits Surprising Magnetic Properties

By Ernie Tretkoff

A new form of carbon exhibits surprising magnetic properties that could make it useful in future spintronics or biomedical applications, researchers reported at the APS March Meeting. The material, called carbon nanofoam for its low density and web-like structure, is the only form of pure carbon known to be ferromagnetic.

Carbon nanofoam is structurally distinct from the other four known forms of carbon—graphite, diamond, fullerenes (buckyballs), and nanotubes. With a density of about 2 mg/cm^3, comparable to that of aerogel, carbon nanofoam is one of the lightest known solid substances.

But what's most remarkable about the material, the researchers said, is that unlike other forms of carbon, the nanofoam is ferromagnetic, like a refrigerator magnet. However, at room temperature, the nanofoam's magnetization disappears a few hours after the material is produced.

A collaboration of researchers from Greece and Australia produced the carbon nanofoam by shooting a high-powered, ultra-fast laser at disordered solid carbon in an argon-filled chamber.

By imaging the material using a high-resolution electron microscope, John Giapintzakis of the University of Crete and colleagues found that the nanofoam has a sponge-like structure, made up of carbon clusters a few nanometers in diameter randomly linked together into a web-like foam.

Because pure carbon is not normally ferromagnetic, the group tested their sample for impurities that might be causing the magnetic behavior. Although they did find traces of iron and nickel, the small amounts of these magnetic elements could not account for all of the ferromagnetism in the nanofoam. The researchers concluded that the magnetic properties come from the complex structure of the nanofoam itself.

David Tománek of Michigan State University, who collaborated with the group on theoretical interpretation, believes that the carbon clusters in the foam are made up of nanotubes joined together into tetrapods. In these four-legged structures, some carbon atoms have a free electron, one that does not form a chemical bond. These unpaired electrons carry a magnetic moment that may lead to the magnetism.

Chemists have long known about such carbon radicals, said Tománek, but until now they have only been found in carbon connected to another element. In this case, the structure is entirely carbon.

The researchers have also done some preliminary studies that suggest that the novel magnetic behavior found in carbon nanofoam could be present in other nano-structured solids of elements that are not normally magnetic, including a compound of boron and nitrogen.

If this behavior turns out to be a general phenomenon, researchers will have to think more about what makes a material magnetic, said Tománek. "We need to revisit our magnetic prejudice."

Giapintzakis suggested that carbon nanofoam could be used in spintronic devices, which are based on a material's magnetic properties. The unique material may also find uses in biomedicine. For instance, the tiny ferromagnetic clusters could be injected into blood vessels to enhance magnetic resonance imaging. The nanofoam could also be implanted in tumors, where it could turn radio waves into a source of heat that would destroy the tumor but leave surrounding tissue unharmed.

GLOBAL REPS *from page 1*

to personal computers. The computations would run in the background, enabling the public to contribute significantly to ongoing physics research.Those interested in participating can get more information at www.physics2005.org/events/einstein.html

Two sessions of the meeting were comprised of reports from the various representatives on their respective countries' or organizations' plans for the World Year of Physics. Judy Jackson of Fermilab reported the launching of Interactions.org in April 2003, intended to enable particle physics labs to share resources and develop common scientific methods with the ultimate goal of increasing global support for research. She also described plans for "Reality Particle Physics," in which participating labs would choose two to three physicists to have their daily research activities documented on the Web over the course of 2005. "We hope to tell the story of particle physics research as it unfolds in real time around the world," said Jackson.

Two workshop sessions rounded out the meeting, one on how to deal with the media, and the other on outreach through physics demonstrations. The latter was organized by several members of American "Physics on the Road" teams, who will be traveling the country in 2005 as part of the World Year of Physics celebrations.

HYDROGEN *from page 1*

Director of the DOE Office of Science, spoke about a similar report produced by a workshop that she chaired under the auspices of the DOE Office of Basic Energy Sciences [see *APS News*, Nov. 2003].

The Hydrogen Economy on the web: 3 reports, & slides from 5 talks

Three reports on the hydrogen economy have been issued, by the Department of Energy's Office of Basic Energy Science (http://www.sc.doe.gov/bes/hydrogen.pdf), by the National Research Council (http://www.nap.edu/catalog/10922.html) and by the APS Panel on Public Affairs (http://www.aps.org/public_affairs/index.cfm). All three conclude that significant basic research is needed to overcome the technical barriers to a competitive hydrogen economy. The APS sponsored a plenary symposium at the March meeting with five speakers from academia and industry. The slide presentations can be viewed at http://www.aps.org/meet/MAR04/symposium/index.cfm

The Back Page

The BLOOD-RED SKY of the SCREAM

By Donald W. Olson, Russell L. Doescher, and Marilynn S. Olson

The Scream by Norwegian artist Edvard Munch (1863-1944) has uniquely become the symbol of anxiety in our modern age. It is of interest to scientists because the lurid sky in the painting is the catalyst of the figure's anxiety. Munch's own words make it clear that the spectacular twilight in *The Scream* was inspired by an actual event:

I was walking along the road with two friends—then the Sun set —all at once the sky became blood red—and I felt overcome with melancholy. I stood still and leaned against the railing, dead tired— clouds like blood and tongues of fire hung above the blue-black fjord and the city. My friends went on, and I stood alone, trembling with anxiety. I felt a great, unending scream piercing through nature.

Munch never forgot that sky, and during his lifetime he wrote many such accounts of this memorable evening.

Munch painted the most famous version of *The Scream* in 1893 as part of *The Frieze of Life*, a group of works derived from his personal experiences. Between 1892 and 1896 he created multiple variations of the scene. In each painting the same spectacular twilight sky appears, with figures on a road, a prominent railing, a peninsula extending into the fjord, and a few buildings representing the city of Christiania. Could these details allow us to find this precise location? Toward which compass direction is the view shown in *The Scream*? When did Munch walk along the road? What did Munch see in the sky?

Aware that one of Munch's prose accounts about the red sky was written on January 22, 1892, art historians judged that the original experience was an autumn sunset that occurred shortly before, in the fall of 1891. This explanation did not seem adequate to us, because Munch attached such great importance to what seemed to be a unique event.

We began by searching astronomical and meteorological records from the years just prior to January 22, 1892, looking (without success) for an impressive event, perhaps an aurora or a volcanic twilight, that could have so dramatically affected Munch. [We later learned that Alan Robock (Rutgers) had been the first to suggest that *The Scream* showed a volcanic sunset. But Robock identified the Awu eruption of June 7, 1892, which falls after Munch's written account.]

As we learned more about Munch, we realized that the twilight experience could have been much earlier than 1892. Many paintings created in the 1890s for *The Frieze of Life* were inspired by events from years before. We found support for this idea in a book by art historian Arne Eggum, who prefers the summer of 1886 as the date for Munch's walk along the mountain road.

During a stay in Nice in the winter of 1891-1892, Munch discussed art with a friend, and a conversation from that time period indeed suggests that the *Scream* event occurred considerably earlier: In recalling his time spent in Nice, Munch himself explicitly mentioned that 1884 was the year of the original inspirations for three of the paintings in *The Frieze of Life*.

The Bohemian Days of the 1880s

Munch also dated the origin of *The Scream* to a specific era:

You don't have to go so far in order to explain the genesis of The Frieze of Life—its explanation lies in the bohemian time itself.

Although Munch's connection to the bohemian community of artists and writers is well documented for 1884, the bohemian days of his memory can plausibly originate in the second half of the previous year, when Munch was sharing a studio in Christiania with six other young artists. It was in 1883 that Munch exhibited his paintings publicly for the first time and almost certainly attended the wildly controversial Christiania premiere of Henrik Ibsen's play, *Ghosts*, on October 17, 1883.

The play, which contrasted the honest, free life of the bohemian artists to the hypocritical conventionality of Norwegian society, polarized the capital. Arne Eggum notes that Munch "at the same time" painted a portrait of one of his friends in the characteristic pose of the bohemian, Osvald, in the play.

This eventful season for artists was also an eventful time for skywatchers, and we realized that science could explain the blood-red sky in *The Scream*—the end of 1883 and the first months of 1884 had the most spectacular twilights of the last 150 years.

Krakatoa Twilights

The volcanic island of Krakatoa erupted in a cataclysmic explosion on August 27, 1883, sending dust and gases high into the atmosphere. Magnificent fiery sunsets and sunrises resulted, first in the southern hemisphere, then near the equator, and eventually in northern latitudes, as the cloud of volcanic aerosols spread worldwide in the following months.

A report issued by the Royal Society in London devoted more than three hundred pages to "Unusual Optical Phenomena of the Atmosphere," with a section collecting the "Descriptions of the Unusual Twilight Glows in Various Parts of the World, in 1883-4."

Newspapers published hundreds of accounts from astonished observers. The effects had reached New York by November 1883:

*Soon after 5 o'clock the western horizon suddenly flamed into a brilliant scarlet, which crimsoned sky and clouds. Many thought that a great fire was in progress... . The clouds gradually deepened to a bloody red hue, and a sanguinary flush was on the sea...(*New York Times*, November 28, 1883).*

Colored stripes and bands in the sky, like those painted in The Scream, appeared to Pennsylvania residents, who...*witnessed a most beautiful and startling phenomenon in the eastern heavens... . The sky that morning was fairly aglow with crimson and golden fires, when suddenly, to their great astonishment, an immense American flag, composed of the national colors, stood out in bold relief high in the heavens, continuing in view for a considerable length of time. (*Hanover Spectator*, December 19, 1883).*

In England, *Nature* published a lengthy series of reports under the heading THE REMARKABLE SUNSETS, beginning in December 1883. William Ascroft, a diligent English observer of the twilights, concluded that the "finest occurred midwinter 1883-84, when some deepened into the richest crimson, and were known as 'Blood Afterglows.' " The English poet Alfred Lord Tennyson remembered this season and later used the image:

Had the fierce ashes of some fiery peak

Been hurl'd so high they ranged about the globe?

For day by day, thro' many a blood-red eve...The wrathful sunset glared... .

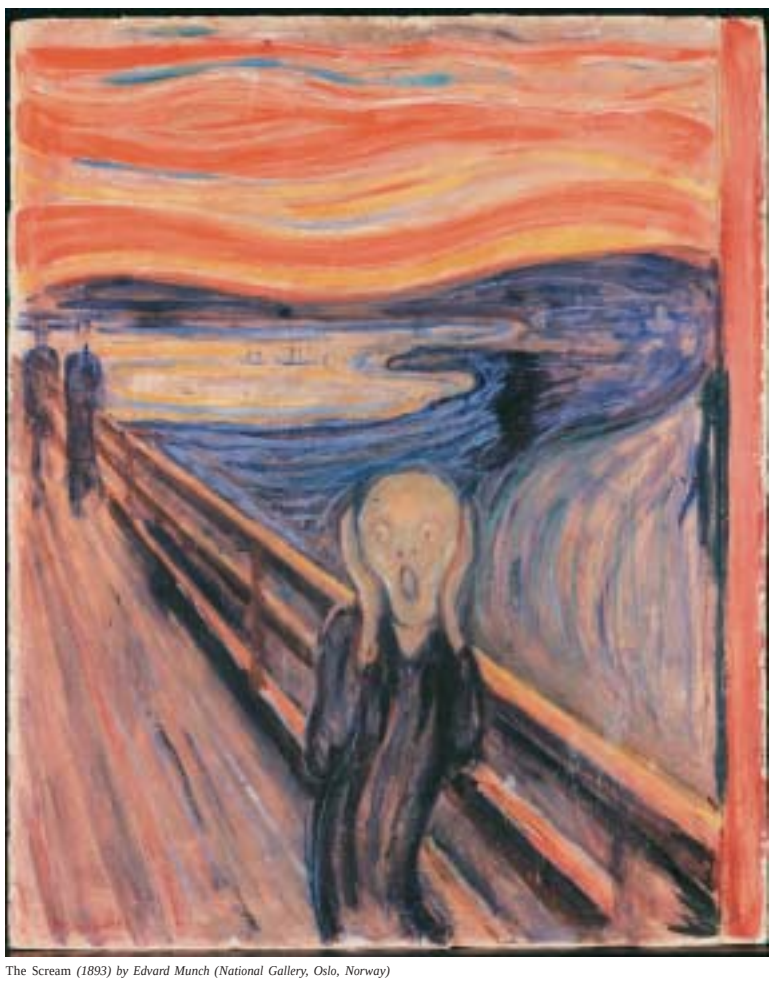
("St. Telemachus," 1892).

But could Munch have seen the Krakatoa twilights at Christiania's high northern latitude? The Royal Society reports show that the unusual twilight glows appeared in Norway from late November 1883 through the middle of February 1884. At the end of November, astronomers at the Christiania Observatory first noticed the "very intense red glow that amazed the observers" and developed into a "red band."

Dark Lunar Eclipses

Krakatoa's optical effects have not been equalled in the last 120 years, but observations after some recent volcanic eruptions have given us an idea of what the skies must have been like in 1883-1884.

Colorful twilights of 1991-1992 and the very dark lunar eclipse on December 9-10, 1992, followed the eruption of Mount Pinatubo in the Philippines. High concentrations of volcanic aerosols increase the opacity of the Earth's atmosphere, and less light refracts into the Earth's shadow. The lunar eclipse of December 30, 1982, and the red twilights seen in that year were similarly affected by the volcano El Chichon in Mexico.



The Scream *(1893) by Edvard Munch (National Gallery, Oslo, Norway)*

Trip To Norway

If volcanic aerosols from Krakatoa colored the skies when Munch and his friends took their walk, then this experience must have been between the end of November 1883 and the middle of February 1884, therefore near the winter solstice. Such a view of a Krakatoa sunset must have been toward the southwest.

We traveled to Oslo to find the precise location where Munch was walking when he saw the blood-red sky. Since we were interested in the location of Munch's original experience, rather than how he reworked the motif, we knew that one drawing in particular was the most important for this purpose.

Art historians agree that this sketch (called T126 p. 10 R) is the initial study for the first version of *Despair*, which Munch called "the first *Scream*." This drawing contains specific details—a cliff on the left, a road with a railing turning left and descending beyond the cliff, and, in the fjord beyond, an island with a prominent round hill. Munch's viewpoint for the drawing had a rather low elevation, not far above the water level.

All of the later painted versions, including the most famous *Scream*, have a much higher viewpoint, looking down to small and distant ships in the harbor below, with the city suggested on the right.

So, we were actually searching for two locations—with the lower location the more important one because the original experience occurred there. During our visit in Oslo we found both the lower and upper viewing locations on the slopes of a 465-foot hill called the Ekeberg.

The upper location is a viewpoint on a rocky ledge 420 feet above the harbor. The panorama from this spot was illustrated on dozens of postcards and lantern slides from Munch's time. Although the view toward the fjord is generally towards the west and southwest, this upper location *cannot* be the precise spot where Munch saw the red twilight and "leaned against the railing, dead tired." Early maps that we examined at the Oslo city museum make it clear that no road (and railing) reached this overlook. The rocky ledge can still be reached by hiking to the northwest slope of the hill, now rather overgrown by trees.

The lower viewpoint, the one employed for Munch's first sketch, is on a road that wraps around the western slope of the Ekeberg hill. Art historian Frank Høifødt (Munch Museum) helped us find a 19th-century photograph showing this road, then called the Ljabrochausséen, bordered by railings exactly like those drawn and painted by Munch. The road is only 50 feet above the water level. By studying the perspective of the cliff and the distinctive round hill on Hovedø island, we could determine Munch's position with remarkable precision, within about 10 feet. From this spot, Munch's direction of view in the drawing was toward the southwest—exactly where the Krakatoa twilights appeared in the winter of 1883-1884.

Munch's own words, along with our topographic results, provide strong evidence that these blood-red afterglows are the connection between one of the world's most famous volcanoes and one of the world's most famous paintings.

Don Olson and Russell Doescher teach in the Physics Department, and Marilynn Olson in the English Department, at Texas State University. *The complete version of this article appeared in* Sky & Telescope *(February 2004).*

APS News welcomes and encourages letters and submissions from its members responding to these and other issues. Responses may be sent to: letters@aps.org.