DOE Pulse
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Research Highlights . . .

The weathermen of Mars

Researchers at Los Alamos National Laboratory, the University of Arizona Lunar Planetary Laboratory and Cornell University Center for Radiophysics and Space Research have discovered further evidence for the possible existence of a changing, and perhaps predictable, Martian climate. Using data gathered by a neutron spectrometer aboard NASA's Mars Odyssey spacecraft, scientists have mapped large deposits of hydrogen in areas centered on Arabia Terra and the Mars equator. The distribution of hydrogen deposits cannot be explained by the general north-south latitude gradient of water vapor in the present Martian atmosphere, thereby requiring different climatic conditions in the relatively recent past.

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Cracks measured in time

A system designed and built at DOE's Idaho National Engineering and Environmental Laboratory reconstructs breaks in common structural materials, such as carbon and stainless steels. The technique, known as microtopography, uses the crack's edges to map the fracture process—from an initial defect to component failure. Featured in the February issue of Engineering Fracture Mechanics, the invention promises to boost scientists' basic understanding of how structures break under the strain of accidental overloads, such as earthquakes. INEEL researchers predict the advance will lead to improvements in building design and analysis that bolster the safety of everything from aircrafts to waste storage tanks.

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Disappearing neutrinos support case for neutrino mass

Results from the first six months of experiments at KamLAND, an underground neutrino detector in central Japan, show that anti-neutrinos emanating from nearby nuclear reactors are "disappearing," which indicates they have mass and can oscillate or change from one type to another. These results provide independent confirmation of earlier studies involving solar neutrinos and show that the Standard Model of Particle Physics, which has successfully explained fundamental physics since the 1970s, is in need of updating. U.S. participation in the KamLAND experiments, which included researchers with DOE's Lawrence Berkeley National Laboratory, was primarily funded by DOE's Office of Science.

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Absolutely no bang for the bucks

What looks like high-explosive? Smells like high-explosive? And even feels like high-explosive—but won't even burn? The answer is high-explosive simulants designed to make air travel safer. Developed through joint internal and FAA funding at DOE's Lawrence Livermore National Laboratory, these compounds impersonate the most popular international energetic materials, including C-4, Semtex and TNT. They're used to calibrate airport detection devices, to train bomb-sniffing canines, and to facilitate realistic bomb-squad training. "These materials are physically and chemically as close to the real thing as we can get. All we left out was the bang," remarked chemist John Kury, Livermore's principal investigator.

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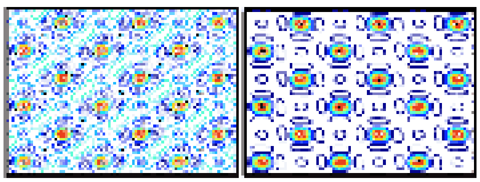
DOE Pulse highlights work being done at the Department of Energy's national laboratories. DOE's laboratories house world-class facilities where more than 30,000 scientists and engineers perform cutting-edge research spanning DOE's science, energy, national security and environmental quality missions. ***DOE Pulse*** (www.ornl.gov/news/pulse/) is distributed every two weeks. For more information, please contact Jeff Sherwood (jeff.sherwood@hq.doe.gov, 202-586-5806).

COBRA produces striking thin-film imagese

Scientists have developed and tested a new imaging technique that reveals the atomic structure of thin films with unprecedented resolution. For the first time, the technique has shown very precisely how the atoms of the first layers of a film rearrange under the action of the substrate on which the film is grown. This technique will also be used to study the properties of nanomaterials, which are the size of a few atoms.

Thin films are currently used in many technologies, including electronic chips, coatings, and magnetic recording heads. To improve the properties of these materials and create even thinner structures—such as smaller electronic chips—scientists are now trying to understand how the films interact with the substrate on which they are grown.



Electron density map of one of the layers of the gadolinium oxide film close to the gallium arsenide substrate (left) and a layer in the substrate (right), by using the COBRA imaging technique. A comparison of both maps shows that the gadolinium atoms (around the yellow-red peaks) rearrange so that the maps mimic each other.

In the new technique, x-rays are projected onto the film and the substrate pattern, which is then used to determine the positions of the atoms inside the film. The diffraction pattern of thin films is composed of ridge-like features called "Bragg rods," hence the name of the technique: coherent Bragg rod analysis (COBRA).

Yizhak Yacoby, physicist at the Hebrew University in Jerusalem and lead author of the study, started developing the technique four years ago. He first applied it to known structures by using x-rays produced at the National Synchrotron Light Source at DOE's Brookhaven National Laboratory, which allowed him to refine the technique. In their recent study, Yacoby and his collaborators applied the technique to a film made of gadolinium oxide grown on a gallium arsenide substrate using brighter x-rays at the Advanced Photon Source at DOE's Argonne National Laboratory.

The scientists now intend to investigate the properties of various other films. Yacoby, who has already submitted patents for the COBRA technique, is confident that it will have many applications in the design of electronic devices based on thin films, the self-assembly of layers made of metal oxides used in catalysis, and the study of films made of large organic molecules, such as proteins.

Submitted by DOE's Brookhaven National Laboratory

LINKING THE ASTROPHYSICS AND PARTICLE PHYSICS COMMUNITIES

Larry Wai

Dr. Larry Wai is one of the young "particle astrophysicists" working on the Gamma-Ray Large Area Space Telescope (GLAST) Mission at DOE's Stanford Linear Accelerator Center. Having worked at DESY in Hamburg, Germany, and on the Super-Kamiokande project in Japan, he represents the young particle physicists who are finding ready uses for their skills in the emerging fields of astrophysics and experimental cosmology.

Wai is currently in charge of the department of "Integration, Facilities, Configuration, and Test" within the group responsible for constructing the SLAC facilities in which much of the GLAST satellite instrumentation will be assembled, tested, and qualified before flying into space.

"People who have made the transition from particle physics to astrophysics," Wai noted, "have tended to be successful because a lot of the instrumentation training we go through is fairly rigorous. We tend to be good instrumentalists: Building detectors, debugging them, understanding problems with data...we have all these skills in our bag of tricks."

In noting that "This is the first major satellite-building project at SLAC," Wai said, "It's different from the typical particle physics effort because it is in an aerospace environment. There is a lot more rigor in terms of contamination and process control, because you have only one shot. You shoot it up and it has to work. Here on the ground, you can go back in and fix whatever is wrong. Not so in space. The imperative for excellence is very challenging and stimulating."

Part of the NASA Office of Space Science Strategic Plan, GLAST is an international and multi-agency mission planned for launch in 2006. It will study the cosmos looking at objects that emit high-energy wavelengths of light—celestial gamma-ray sources in the energy band extending from 10 MeV to more than 100 GeV.

Submitted by DOE's Stanford Linear Accelerator Center