DOE Pulse
Science and Technology Highlights from the DOE National Laboratories
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Research Highlights . . .

Building a new use for crop waste

Researchers at DOE's Idaho National Engineering and Environmental Laboratory are partnering with universities and industry to make critical advancements in the fields of agriculture-based bioenergy and bioproducts. The team is working to use the renewable materials from wheat and other crops to provide many of the basic chemical building blocks to produce fuels and a wide range of consumer goods normally produced from petrochemicals. Of regional importance, the INEEL is working to develop selective straw stem harvesting, bioprocessing and chemical separation technologies for converting wheat straw into fuels and chemicals.

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Measuring molecules may be easier with improved NMR

A team led by John Clarke and Alexander Pines at DOE's Lawrence Berkeley National Laboratory has obtained nuclear magnetic resonance spectra in liquids using magnetic fields a million times weaker than the typical NMR set-up. The secrets to success: using a superconducting quantum interference device (SQUID) detector cooled by liquid helium while heating the sample itself to room temperature; prepolarizing the sample with a stronger magnetic field; and, because the "chemical shift" used in high-field NMR is lost at low fields, measuring instead the scalar coupling (J-coupling) between specific atomic nuclei, which is independent of field strength.

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Combustion method cuts emissions

Engineers from DOE's Lawrence Livermore National Laboratory have developed a unique combustion method that results in lower power plant pollutant emissions by combining stage-combustion with nitrogen-enriched air. The new technology, dubbed Staged Combustion with Nitrogen-Enriched Air, could help power plants comply with strict Environmental Protection Act requirements for decreasing plant emissions. SCNEA can replace or enhance current pollutant control technologies at a lower cost while at the same time further reducing pollutants. In addition, existing power plants can be easily retrofitted to use the SCNEA combustion method without a huge cost increase.

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Seeing black holes in a new light

Emil Mottola, a researcher at DOE's Los Alamos National Laboratory, is creating a new theory of black holes. Along with Pawel Mazur, of the University of South Carolina, Mottola has developed an explanation that conceptualizes black holes not as "holes" in space where matter and light inexplicably disappear, but as spherical voids surrounded by an extremely durable form of matter. The researchers call these extraordinary bubble-like objects Gravastars. The explanation solves a failing in current black hole theory. Physicists have long struggled to account for the huge entropy of black holes. Unlike black holes, Gravastars would have very low entropy.

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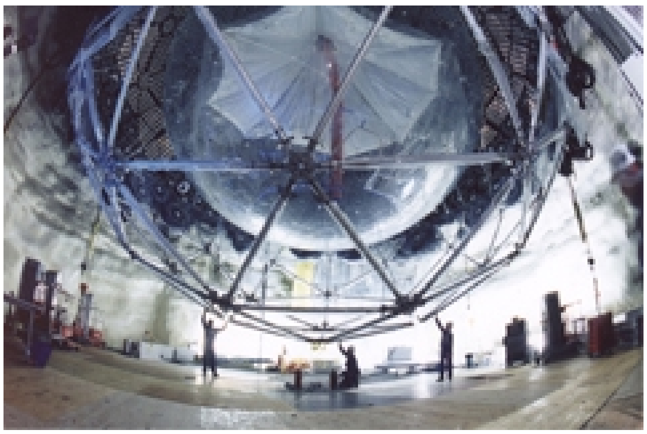
DOE Pulse highlights work being done at the Department of Energy's national laboratories. DOE's laboratories house world-class facilities where more than 30,000 scientists and engineers perform cutting-edge research spanning DOE's science, energy, national security and environmental quality missions. ***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).

Labs help SNO detector see solar neutrinos in a new way

On April 20, a team of scientists from institutions in Canada, the U.S., and the U.K. announced the results of a unique new measurement of the total number of all known neutrino types reaching Earth from the sun. Using data from the Sudbury Neutrino Observatory (SNO) in Canada, the team, which includes scientists from Brookhaven, Los Alamos, and Lawrence Berkeley national laboratories, was also able to determine that the observed number of electron neutrinos (the type produced by the sun) is only a fraction of the total number. This shows with great certainty that neutrinos from the sun change from one type to another before reaching the Earth.

Chemist Richard Hahn, leader of the Brookhaven group, said, "These results are exciting because they demonstrate the full potential of the SNO neutrino detector. All of the collaboration's hard work over many years is really paying off now."



Neutrinos are particles with no electric charge and very little mass. They are known to exist in three types related to three different charged particles — the electron and its lesser-known relatives the muon and the tau. The sun emits electron-neutrinos, which are created in the thermonuclear reactions in the solar core. Previous experiments have found fewer electron-neutrinos than suggested by calculations based on how the Sun burns. This famous "solar neutrino puzzle" was first revealed in the early 1970s when Brookhaven scientist Ray Davis's pioneering research in a South Dakota gold mine documented the missing neutrinos.

SNO uses the unique properties of heavy water – where the hydrogen has an extra neutron in its nucleus – to detect not only electron-neutrinos through one type of reaction, but also all three known neutrino types through a different reaction.

The new results showed that the number of electron-neutrinos observed is only about 1/3 of the total number reaching Earth. This shows unambiguously that electron-neutrinos emitted by the sun have changed to muon- or tau-neutrinos before they reach Earth.

Brookhaven's primary role in the experiment is to ensure that SNO's heavy water (D2O), a critical part of the neutrino detector, and the surrounding light water (H2O) remain ultrapure, both chemically and in terms of naturally occurring radioactive contaminants. Lawrence Berkeley designed and built the geodesic-dome support structure for the 9,500 photomultiplier tubes that surround the SNO D2O vessel, while Los Alamos is a major participant in the design and construction of the gas-filled neutron counters that will be deployed in the SNO detector in 2003. Both Lawrence Berkeley and Los Alamos are also actively involved in data analysis.

Submitted by DOE's Brookhaven National Laboratory

Abolhassan Jawahery: What's the matter?

Abolhassan Jawahery

Since 1993, Abolhassan Jawahery has been trying to understand the origin of charge conjugation parity (CP) violations – one expression of a tiny difference between matter and anti-matter. Studying CP violation is the key to understanding how the present matter-dominated Universe could have emerged from one that contained exactly equal amounts of matter and antimatter during the earliest moments of the Big Bang.

Jawahery, a physics professor at the University of Maryland, is the Physics Analysis Coordinator for the BaBar experiment at DOE's Stanford Linear Accelerator Center. The BaBar experiment, which began taking data in May, 1999, was designed to measure these tiny differences between matter and its mirror image, anti-matter.

Jawahery and the BaBar physics are measuring this difference by looking at the decay of a B-meson and an anti B-meson, when they go to the same final state. If this is done in a decay to a Charmonium mode and a K^0 meson (K short or K long), the difference is a measure of the quantity "sin2beta." This quantity can be directly related to the CP violating mechanism of the standard model of particle physics.

Last August, after observing nearly 30 million B-meson decays produced by a quarter of a billion positron-electron collisions, the BaBar group produced the first ever observation of CP violation in B mesons.

"It was one of the most important discoveries in particle physics of the last ten years," says Jawahery. "We consider sin2beta our golden measurement." And so far, the measurement looks to be consistent with the standard model, he says.

"It's still possible that the CP violation we are observing could deviate from the standard model," he says. "In that case, it would be an indication of new physics beyond the standard model."

Submitted by DOE's Stanford Linear Accelerator Center