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DOE Pulse

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Research Highlights . . .

Particle physicists create a buZZ

Scientists working on the Collider Detector at DOE's Fermilab have identified a handful of proton-antiproton collisions that indicate the simultaneous production of two Z bosons, mediators of the electroweak force that is responsible for radioactive decay and makes the sun shine. The CDF result tests the predictions made by subatomic theories and shows the rapidly improving capability of experiments at Fermilab to record rare and hard-to-detect particle interactions.
The observation is a major step toward finding the long-sought Higgs boson. Collisions producing a ZZ pair occur only once per 60 billion collisions at Fermilab's Tevatron accelerator. Scientists expect the Higgs boson to emerge from up to one in every 200 billion collisions, perhaps putting it within reach of the CDF and DZero collider experiments.

[Kurt Riesselmann, 630/840-3351, kurtr@fnal.gov]

A new permanent magnet alloy

Researchers at DOE's Ames Laboratory have designed a new high-performance permanent magnet alloy that operates with good magnetic strength at 200 degrees Celsius (392 F). The work is helping advance electric drive-motor technology for future ultragreen vehicles and is part of the Department of Energy's Vehicle Technologies Program to develop more energy-efficient and environmentally friendly highway transportation technologies. The Ames alloy design replaces pure neodymium in the neodymium-iron-boron 2-14-1 permanent-magnet crystal structure with a combination of neodymium, yttrium and dysprosium. The 2-14-1 crystal structure is maintained but with far less degradation of magnetic properties.

[Kerry Gibson, 515/294-1405, kgibson@ameslab.gov]

Understanding neutron-rich helium-8

Researchers at DOE's Argonne National Laboratory have trapped and characterized the nucleus of the helium-8 atom, the most neutron-rich material on Earth. Helium-8 possesses a "halo" of four extra neutrons that group themselves around the isotope's two-proton, two-neutron nucleus. Physicists Peter Mueller, Zheng-Tian Lu and University of Chicago graduate student Ibrahim Sulai identified the charge distribution of helium-8, a quantity that identifies the distance of the extranuclear neutrons from the nucleus. According to Muller, the result will allow scientists to better understand rare isotope dynamics and the behavior of neutron stars.

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DNA guides nanoparticles to form 3-D crystals

In an achievement some see as the "holy grail" of nanoscience, researchers at DOE's Brookhaven Lab have used DNA to guide the creation of three-dimensional nanoparticle crystals. Such 3-D structures are essential for producing functional materials that take advantage of nanoscale properties such as enhanced magnetism, catalytic activity, or responses to light. The assembly method relies on the attractive forces between complementary strands of DNA, the molecule that carries the genetic code of all living things. Using this DNA "glue," scientists may be one step closer to building materials by design from nanoscale building blocks for a wide range of applications, such as devices for energy storage and conversion, sensors, and information processing.

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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).

New nanomaterial zaps toxic metals

A sulfur-containing acid used in treating people poisoned by mercury, lead and other heavy metals also shows promise for removing the toxins from contaminated solutions.

Researchers at Pacific Northwest National Laboratory combined iron oxide nanoparticles with dimercaptosuccinic acid, or DMSA, to create a highly dispersible sorbent that binds to the metals and can be isolated with a magnet.

"We took a method developed for the production of materials for protein detection and moved it into environmental remediation applications," said co-principal investigator Marvin Warner.

The rust-colored nanoparticles look like the finest ground black pepper and have a surface area of 1,227 square feet (114 square meters) per gram for capturing toxic metals. Mercury, silver, lead, cadmium and thallium bind to the free sulfur on the DMSA strands, while arsenic binds to the iron oxide. A strong magnet can separate the metal-laden particles from the solution in about one a minute.

Scientists used river water, groundwater and seawater, plus human blood and plasma, loaded with toxic soft metals to compare the characteristics of the nanoparticles to other sorbents.

"The DMSA-modified particles removed 30 times more mercury than conventional resin-based sorbents," Warner said. The particles also removed 99 percent of lead from a solution containing one milligram per liter of the metal. The resulting liquid was well below the Environmental Protection Agency limit of 0.015 Mg/L for lead in drinking water.

The research team included scientists from PNNL, the University of Oregon and Chulalongkorn University in Bangkok, Thailand. Investigations now focus on the nanoparticles' ability to detect lower levels of contaminants in complex samples, such as urine, saliva and sea water.

Grants from the National Institutes of Health and PNNL's Homeland Security Initiative funded the research, which was conducted in the Department of Energy's Environmental Molecular Sciences Laboratory, a national scientific user facility located at PNNL.

Submitted by DOE's Pacific Northwest National Laboratory

The Sound of Science

Paul Johnson

Ever wonder what success sounds like?

For Laboratory researcher Paul Johnson of the Los Alamos National Laboratory Geophysics group, the "Eureka Moment" sounded like a whip crack; it was a sound that some of his research colleagues didn't expect to hear.

Johnson had been following research by Joan Gomberg of the U.S. Geological Survey indicating that earthquake activity sometimes increases thousands of miles away from an earthquake epicenter, presumably out of range of the "aftershock zone" common for many quakes. He and several colleagues wondered how sound waves could trigger faraway quakes. His initial work on the topic, with Gomberg and Xiaoping Jia of the Université de Marne-la-Vallée, appeared in Nature in 2005. In that work they proposed how triggering could happen, supported by earthquake triggering observations.

Johnson has worked at DOE's Los Alamos since 1984, and he holds a doctorate from the Sorbonne.

More recently, Johnson contacted Chris Marone of Pennsylvania State University, who had developed a machine to mimic earthquake behavior. The machine squeezes plates atop a layer of tiny glass beads. The plates are similar to tectonic plates that surf above Earth's mantle. Like tectonic plates, when enough stress is applied to the plates in the earthquake machine, they skitter across the glass beads—unleashing a earthquake that can be observed in a laboratory setting.

"I told Chris Marone I wanted to test whether sound waves could trigger an earthquake," said Johnson. "He was doubtful at first but welcomed a try." Johnson traveled to Penn State to modify the earthquake machine. They found that sound waves applied for a short period just before an expected earthquake could induce smaller quakes.

"When the machine goes off and you get a quake, you get this really loud, sharp crack," said Johnson. "We found that sound could cause a quake immediately. That was truly a eureka moment. The most intriguing aspect, however, was that the applied sound was 'remembered' by the glass beads, as manifest by delayed quakes, as well as delays in the occurrence of a larger, expected quake. "

Johnson, Gomberg, and Marone joined Heather Savage and Matt Knuth of Penn State in publishing their findings in a recent issue of Nature. The research ultimately may help crack the mysterious behavior of earthquakes worldwide.

Submitted by DOE's Los Alamos National Laboratory