SLAC's Lance Dixon

Page 2

DOE Pulse

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Research Highlights . . .

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).

Flux rope research comes to Earth

Scientists at DOE's Los Alamos National Laboratory have developed a method for producing plasma-current filaments in the Laboratory that replicates the massive flux ropes seen on the Sun's surface. The creation of flux ropes makes it possible to tie experimental data to prior theoretical analyses as the "mini ropes" are photographed and studied while winding helically around an imaginary central axis. When one end of a solar flux rope that was previously "tied" to the Sun's surface breaks loose, it ejects plasma, producing solar flares that can wreak havoc with everything from satellites to electrical power grids on Earth.

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Hopping hydrogen

Researchers at DOE's Pacific Northwest National Laboratory and the University of Texas at Austin discovered that a single hydrogen atom just can't keep still after it splits from a water molecule on the surface of the catalyst rutile titanium oxide. The hydrogen atom hop scotches across the oxygen atoms that stud the surface of the catalyst, while the hydrogen on what is left from water remains fixed, suggesting that the electronic structure of this popular catalyst is not entirely as it seems. By understanding how water atoms behave on the catalyst surface, scientists and engineers may be able to develop technologies that use abundant, free sun light to split water to generate hydrogen gas, a possible alternative fuel for everything from heating homes to powering automobiles. The researchers plan to study the titanium oxide material at higher temperatures to see how fast the hydrogen atoms move.

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United Kingdom and U.S. sign groundbreaking nuclear technology agreement

DOE's Idaho National Laboratory and Nexia Solutions of the United Kingdom announced an agreement to pool expertise and resources to advance the commercial nuclear power efforts of the U.S. and United Kingdom and to promote global nuclear initiatives such as the Global Nuclear Energy Partnership. INL is the U.S. Department of Energy's lead lab for nuclear energy technology research, development and demonstration. Nexia Solutions is the UK's largest commercial nuclear power research company. It will become the manager of the UK's National Nuclear Laboratory that will be established later this year.

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Precisely speaking, Higgs hunt heats up

Researchers in both collider detector collaborations at the Department of Energy's Fermilab are working fast and furious in search of the elusive Higgs boson. Using pattern- recognition techniques similar to the human brain in approach, DZero physicists have set the tightest limits ever on possible Supersymmetric (MSSM) Higgs boson production. DZero is well-placed to recognize any hint of Higgs boson decays to taus, the most massive electron cousins in the Standard Model. However, in the region currently explored by DZero, this channel is 'tautally' excluded. Across the four-mile Tevatron ring at CDF, researchers have completed a search for Higgs decays into pairs of tau particles, showing a slightly enhanced probability for the Higgs at masses between 150 and 160 GeV/c2.

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Simulations probe how enzymes crack cellulose

Harnessing the capabilities of one of the world's most powerful supercomputers, the largest biological simulation ever conducted at DOE's Oak Ridge National Laboratory is providing insights on converting cellulose from green plants into sugar. The supercomputer's ability to create a visualization of a million atoms promises to help researchers design more efficient methods for producing biofuels.

Like humans, microbes depend on sugar for energy. Fungi and bacteria obtain sugar from cellulose, the glucose polymer that composes cell walls in trees and other plants on land and in the ocean. These microorganisms produce cellulases, enzymes that work together to extract glucose from cellulose and turn the sugar into energy.

Computational biologists from ORNL and the National Renewable Energy Laboratory in Colorado, along with a researcher from Cornell University, are modeling bacterial and fungal cellulases in action at ORNL. Researchers "watch" these simulated enzymes attack digital cellulose strands, transfer a strand's sugar molecules to the enzyme's catalytic zone and chemically digest the sugar to provide the microbe with energy. The key to increasing the efficiency and lowering the cost of ethanol production using sugar from cellulose in treesand other biomass is to understand how cellulases degrade cellulose. Such understanding may lead to genetic engineering of the degradation mechanisms, speeding the biofuel production process.

John Brady of Cornell developed the original model of a cellulase molecule processing cellulose fibers under an optical microscope. Led by NREL's Mike Himmel, other collaborators include Ed Uberbacher and Phil LoCascio, researchers in ORNL's Genome Analysis and Systems Modeling Group, and Pavan K. Ghattyvenkatakrishna, a University of Tennessee graduate student who works in the GASM Group.

"We are studying the dynamics of cellulase at work on cellulose," says Uberbacher. "The model's cellulose resembles wood under a microscope. The individual strands are sugars strung together as a long polymer chain. The cellulase enzyme comes down and pulls a strand from the bundle forming the glucose polymer. The cellulase feeds the sugar fiber up to another domain of the enzyme that catalyzes the removal of the six-carbon sugar from the fiber. The process is a crucial step in making ethanol fuel from biomass."

The goals of the project include understanding how the cellulase enzyme functions, how it recognizes cellulose strands and how the chemistry is accomplished inside the enzyme. The group also hopes to determine what the rate-limiting steps are that might be genetically engineered to make cellulase more efficient at degrading cellulose into glucose.

Submitted by DOE's Oak Ridge National laboratory

SLAC's Lance Dixon searches for answers


Lance Dixon

Researchers are eager to begin analyzing the scores of data the Large Hadron Collider (LHC) will provide when it comes online later this year. They anticipate the LHC will push the boundaries of their understanding of the universe, revealing exciting new realms of physics. But given the complexity and abundance of data, it is not always clear what the results will actually mean. That's where theorists like Lance Dixon come in.

Dixon, a professor at DOE's Stanford Linear Accelerator Center, is working with colleagues Carola Berger and Darren Forde at SLAC, Zvi Bern at University of California-Los Angeles, and David Kosower at France's Saclay, to find innovative methods to predict what scientists will see at the LHC. By comparing the predictions with real data, physicists will know better if they are indeed looking at fundamentally new phenomena.

"We want to provide a tool for experimentalists," Dixon said. "It's to make sure we know we have new physics, and not get fooled by old physics."

Physicists use Feynman diagrams to calculate and visualize particle interactions, such as those at the LHC. Each diagram represents how each particle interacts, not only symbolizing the probability of each class of events, but also providing physical insight into the interaction. For more accurate predictions of complex events, the interaction can happen in a multitude of ways. A physicist who wants to know the details of important interactions at the LHC would have to calculate thousands of Feynman diagrams.

This process is highly inefficient, even for a computer. So Dixon and his colleagues are developing new mathematical and computational techniques to avoid tedious and unnecessary calculations. "We're trying to find a way to get to the answer without going into individual Feynman diagrams," he said.

When the LHC turns on, the work of Dixon and his collaborators should help scientists discern whether they are looking at phenomena predicted by known theory, or if they are in fact making radical new discoveries.

Submitted by DOE's Stanford Linear Accelerator Center