Argonne NATIONAL LABORATORY

News Release

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Argonne scientists discover new class of glassy material

Dynamic frustration may lead to better understanding of glass in nature

ARGONNE, Ill. (July 28, 2008) – Scientists at U.S. Department of Energy's Argonne National Laboratory are dealing with an entirely new type of frustration, but it's not stressing them out. Dynamic frustration has been found to be the cause of glassy behavior in materials that previously had none of the features of a normal glass.

This discovery may allow scientists to tune the degree of frustration and therefore develop a better understanding of how glasses are formed in nature.

"This has been a puzzle for 10 years now," Argonne physicist Raymond Osborn said.

Conventional wisdom states that glassy materials, such as common window glass, result when frustration prevents the atoms from forming a well ordered crystal structure, and the material freezes into a disordered state like a frozen liquid.

In spin glasses, the magnetic moments on each atom, rather than the atoms themselves, freeze into a disordered state at low temperatures, so they point in random directions. However, there has to be some disorder in the atomic structure and some frustration in the magnetic interactions to prevent the magnetic moments from ordering so they can freeze into spin glasses.

Scientists have struggled for more than a decade to understand why $PrAu_2Si_2$ (a compound of praseodymium, gold and silicon) is a spin glass. There is no sign of atomic disorder in the compound and no reason for the magnetic interactions to be frustrated.

Using the results of neutron scattering experiments, Osborn and his collaborators concluded the frustration results from temporal or dynamic frustration rather than static frustration.

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Although $PrAu_2Si_2$ seems to have an ordered structure, by delving deeper, Osborn found that the magnetic moments are continually fluctuating in magnitude causing the equivalent of temporal potholes that appear and then disappear long enough to disrupt the magnetic alignment.

These fluctuations occur because the magnetic moments in this material are unstable and can be destroyed temporarily by electrons scattering off the atoms.

"The discovery of dynamic frustration reveals a whole new class of glassy materials whose behavior is governed by dynamic rather than static disorder," Osborn said.

Funding for this research was provided by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences. The mission of the Basic Energy Sciences (BES) program -- a multipurpose, scientific research effort -- is to foster and support fundamental research to expand the scientific foundations for new and improved energy technologies and for understanding and mitigating the environmental impacts of energy use.

A paper on Osborn's work can be seen in the upcoming edition of *Nature Physics*.

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