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Magnetic 'handedness' could lead to better magnetic storage devices

May 28 2007

Better magnetic storage devices for computers and other electronics could result from new work by researchers in the United States and Germany.

Their findings demonstrate that chirality – a spiral-like "handedness" – in nanoscale magnets may play a crucial role in data transmission and manipulation in spintronic devices, where the spin rather than the charge of an electron is used to store data.

While the spins in ferromagnetic materials are simply oriented along one common direction, some nanomagnets were found to exhibit chirality. The term chirality refers to objects that differ from their mirror image like the human hand.

Matthias Bode, a scientist at the Center for Nanoscale Materials at Argonne National Laboratory, said, "In nature many systems have chirality, such as elementary particles with electro-weak interactions organic molecules, hurricanes and even galaxies. Solids with magnetic order of unique chirality are prime candidates for applications, because their peculiar symmetry allows the mixing of electronic, optic, magnetic and structural properties."

The researchers used spin-sensitive scanning tunneling miscroscopy (STM) and first-principles electronic structure calculations to identify the magnetic order. By making the STM technique sensitive to the spin, it allowed for the observation of the magnetism of single atoms. This extension of STM is known as spin polarized STM or SP-STM and was developed by Bode.

Using his enhanced technique, Bode demonstrated that under a magnetic field the pattern shifted in a given direction, which identified the unique chirality.

Results of the research were published in the May 10 issue of the journal Nature.

The premise for this work was inspired by the pioneering effort of Soviet physicist, Igor Dzyaloshinski. He showed that magnetic order may get twisted into helices with long-period in crystals lacking inversion symmetry, if the spin-orbit interactions are strong enough.

“In the past, this interaction had been considered unimportant in the scientific community," Bode said. "Now its relevance in nanostructures of any dimensionality such as thin films or magnetic particles is realized.”

Other researchers involved in this study are M. Heide, G. Bihlmayer and S. Blugel of Julich, Germany and K. von Bergmann, P. Ferriani, S. Heinze, A. Kubetzka, O. Pietzsch and R. Wiesendanger of Institute of Applied Physics and Microstructure Research Center, University of Hamburg, Hamburg, Germany.

Funding for this work was provided by the German Science Foundation.

Other Argonne research recently featured in Nature was conducted by Oleg Shpyrko, Eric Isaacs and their colleagues at the University of Chicago. Their findings led to a major breakthrough in the understanding of antiferromagnets. By exploiting a technique called “X-ray photon correlation spectroscopy, the researchers were able to see the internal workings of antiferromagnets, such as the metal chromium, for the very first time, thus bringing into focus previously invisible phenomena.

In addition to producing the first holograms of an antiferromagnet, the research revealed that the holograms are actually time-dependent, even down to the lowest temperatures. This implies that the antiferromagnet is never truly at rest, and the responsibility for this most likely lies with quantum mechanics and the uncertainties it imposes not only on conventional particles such as electrons and atoms, but also on objects such as domain walls in magnets. The new experiments thus help to open the prospect of exploiting antiferromagnets in emerging technologies such as quantum computing.

Work on this project at the Center for Nanoscale Materials and the Advanced Photon Source was supported by the Department of Energy's Office of Science, Office of Basic Energy Sciences. Work at the London Centre for Nanotechnology was funded by a Royal Society Wolfson Research Merit Award and the Basic Technologies program of Research Councils United Kingdom. Work at the University of Chicago was supported by the National Science Foundation.

The results of this research can be found in the May 3 issue of Nature.

Source: Argonne National Laboratory