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Scientists reveal inner workings of magnets, a finding that could lead to faster computers

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(PhysOrg.com) -- Using the world's fastest light source -- specialized X-ray lasers -- scientists at the University of Colorado Boulder and the National Institute of Standards and Technology have revealed the secret inner life of magnets, a finding that could lead to faster and "smarter" computers.

Using a light source that creates X-ray pulses only one quadrillionth of a second in duration, the Boulder team was able to observe how magnetism in nickel and iron atoms works, and they found that each metal behaves differently. One quadrillionth of a second is a million times faster than one billionth of a second.

The results of the study were published online this week by the Proceedings of the National Academy of Sciences. Six of the study's 19 co-authors are located at CU-Boulder.

Many technology experts believe that next-generation computer disk drives will use optically-assisted magnetic recording to achieve much higher drive capacities, according to NIST scientist Tom Silva, who worked with CU-Boulder physics professors Margaret Murnane and Henry Kapteyn on the research. However, many questions remain about how the delivery of optical energy to the magnetic system can be optimized for maximum drive performance. And this finding could help researchers answer some of their questions.

"The discovery that iron and nickel are fundamentally different in their interaction with light at ultrafast time scales suggests that the magnetic alloys in hard drives could be engineered to enhance the delivery of the optical energy to the spin system," Silva said.

Magnetism exists because all of the "spins" in a magnet -- each of which is like a very small bar magnet with a north and south pole -- are lined up to point in the same direction, much like members of a marching band who are moving in unison, explained Murnane, who also is a fellow of JILA, a joint institute of CU-Boulder and NIST.

"The powerful laser pulse scrambles the magnetic spins in the metal, as if the members of the marching band started moving in different directions across the football field, causing the magnetization to rapidly disappear within a mere fifty quadrillionths of a second, a process known as ultrafast demagnetization," Murnane said.

While ultrafast demagnetization has been a well-known phenomenon since its discovery in 1996, the CU and NIST researchers saw for the first time that different kinds of spins in metal scramble on different time scales. Until now, it was assumed that all the spins in a metal alloy behaved in the same way due to a powerful quantum mechanical effect known as the exchange interaction, which lines up all the individual spins in the same direction.

"What we have seen for the first time is that the iron spins and the nickel spins react to light in different ways, with the iron spins being mixed up by light much more readily than the nickel spins," said Silva. "In the end, the exchange interaction still pulls the two spin systems back into synchronization after a few quadrillionths of a second. Seeing such a difference was only possible by taking advantage of the extremely fast X-ray technology developed at the University of Colorado and elsewhere."

The laser technology used in the experiment, known as "high harmonic generation," can generate laser-like beams of X-rays that span a wide portion of the electromagnetic spectrum, including the spectral region where nickel and iron interact very strongly with X-rays.

Provided by University of Colorado at Boulder

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