# Magnets are chaotic—and fast—at the very smallest scale

March 19 2013

Using a new type of camera that makes extremely fast snapshots with an extremely high resolution, it is now possible to observe the behaviour of magnetic materials at the nanoscale. This behaviour is more chaotic than previously thought, as reported in *Nature Materials* on 17 March. The observed behaviour changes our understanding of data storage, says Theo Rasing, one of the authors of the article.

Surprisingly, it would seem that the chaotic behaviour of the magnetic material is highly significant as far as the transport of magnetic information at the smallest possible scale is concerned. This is the result of research carried out by Theo Rasing's group at Radboud University Nijmegen, with colleagues from Stanford, Berlin and Tokyo. Use was made of a very special measuring instrument – the Linac Coherent Light Source (LCLS) – a unique X-ray laser at SLAC National Accelerator Laboratory. Essentially, this X-ray laser is like a camera with both an extremely short shutter time of 100 femtoseconds (one tenth of a trillionth of a second) and an extremely high spatial resolution of a few nanometers (one billionth of a meter). The measurements show that the magnetic material behaves completely different at the nanoscale than at the macroscale.

## Nanoscale spin transport

Seen at the atomic scale, all magnets are made up of lots of small magnets, called spins. Magnetic switching for data storage involves reversing the magnetisation direction of the spins: a north pole becomes a south pole, and vice versa. The magnetic material in question contained two spin types from two different elements: iron (Fe) and gadolinium (Gd). The researchers observed that, at the nanoscale, the spins were unevenly distributed: there were areas with a higher than average amount of Fe and areas with a higher than average amount of Gd – hence chaotic magnets.

It appears that magnetic switching starts with the ultrafast transport (~10nm/300fs) of spins between the Fe areas and the Gd areas, after which collisions result in the reversal. Such an ultrafast transfer of spin information has not yet been observed at such a small scale.

## Future: smaller is faster

These results make it possible to develop ultrafast nanomagnets in the future in which spin transfer is further optimised through nanostructuring. This will open up pathways for even smaller and faster magnetic data storage.

**More information:** Graves, C. et al. Nanoscale spin reversal by nonlocal angular momentum transfer following ultrafast laser excitation in ferrimagnetic GdFeCo, *Nature Material*, online 17 March 2013. DOI 10.1038/NMAT3597

Provided by Radboud University Nijmegen