# Probing the secrets of unmagnetized magnets

June 29 2012, By Nicolas Guérin

Credit: Alain Herzog

EPFL physicists studying magnetic materials have discovered that they have some unexpected properties. Their research could lead to the development of even tinier magnets in the future.

Magnets are everywhere; stuck to our fridges, used in electric motors, built into the hard disks on our computers. Scientists have studied them for centuries, but it's only recently that a team from EPFL's Laboratory for Quantum Magnetism has probed the details of their innermost structure. This fundamental discovery will pave the way for both new research and a host of promising applications, particularly in the area of miniaturized hard disks.

## A magnet that isn't magnetized…

EPFL professor Henrik Ronnow and his team found a strange material: a magnet that's not magnetized. How can this be? The needle of a compass is made up of a number of magnetized elements that arrange themselves into a crystalline network. Like so many miniature compasses, the magnetic fields of all these atoms all point in the same direction. Trapped in this structure, the magnetic field of each atom adds itself to that of all the other atoms, producing the total magnetic field of the compass.

In the material studied at EPFL, the atoms are arranged in pairs in a very particular way: the magnetic field of one atom is the opposite of that of its neighbor. As a result, the total magnetic field of each pair is practically nil. The entire material thus loses its magnetization.

To unveil the secrets of this strange magnet, the scientists bombarded a lithium-erbium-fluoride sample with neutrons. The radiation allowed them to measure the structure of the crystalline network and its magnetic properties at very high resolution. The experiment had to be conducted at very low temperatures in order to prevent the atoms' Brownian motion from obscuring the results.

## Unexpected results and a promising future

The atoms of a magnetic material are arranged in a three-dimensional structure. The physicists' models can predict magnetic properties based on the characteristics of this structure, for example if the magnet is made up of a thin layer of atoms, known as a 2D structure. bidimensional structure. But when they measured the magnetic properties of their sample, the physicists obtained an unexpected result. In this experiment, even though the sample was much thicker, it had the magnetic properties of a single layer. "It could be due to the fact that the material is made up of a series of very thin layers piled on top of each other, each of which maintains its individual properties," explains Ronnow.

Even though these results are purely the stuff of basic research, they could nonetheless eventually have an impact in the area of hard disk technology, which is exploiting magnetic properties at increasingly miniaturized scales. Data are stored in binary form by changing the magnetic polarity of an area of the disk. With miniaturization, however, the problem is that sectors close to one another can influence each other, and spontaneously change polarity. The data would then be lost. "With these special materials, miniaturization could continue; each sector of the disk could be one of these magnetization-free pairs. The probability that the magnetic field of one atom would influence the magnetic field of its neighbor is practically nil." There's just one intrinsic obstacle that must be overcome, however, with these materials: creating a read/write head sensitive enough to decode a magnetic field that is, by definition, extremely weak.

Provided by Ecole Polytechnique Federale de Lausanne