Structure control unlocks magnetization and polarization simultaneously

January 26 2015

This advance has potential application in information storage and processing

Scientists at the University of Liverpool have controlled the structure of a material to simultaneously generate both magnetisation and electrical polarisation, an advance which has potential applications in information storage and processing.

Researchers from the University's School of Physical Sciences demonstrated that it is possible to unlock these properties in a material which initially displayed neither by making designed changes to its structure.

Magnets, such as the one in your fridge door or in the hard disk of your computer, have separate North and South poles, i.e. they are magnetically polar and have magnetisation. There are also materials with positively and negatively charged electrical poles which have electrical polarisation. Control of the direction of the magnetisation or the polarisation is a way of storing information.

To make a single material that has these two distinct properties – magnetisation and electrical polarisation – is difficult because the electronic requirements for obtaining them in a material are typically contradictory: materials characteristics, such as the crystal structure or the atomic composition, which favour polarisation often disfavour magnetisation.

However, materials where polarisation and magnetisation coexist at room temperature are potentially important for low-energy information technology applications.

Energy consumption

For information storage, these materials can combine low-power electrical writing of information with non-destructive magnetic reading, while logic devices using them for information processing can work without charge current flow. The increasing energy consumption of computers and internet-enabled devices could be a significant future sustainability challenge.

Liverpool Materials Chemist, Professor Matthew Rosseinsky, said "We were able to demonstrate that the magnetisation and polarisation are coupled by measuring the linear magnetoelectric coefficient, a key physical quantity for the integration of such materials in a device. This coupling arises because both properties are produced by the same single set atomic motions that we built in to the material."

"There are a number of challenges still to address, particularly switching the polarisation and making the material more electrically insulating, before applications of this material for information storage can be considered."

"By designing-in the required atomic-level changes using both computation and experiment together, we produced three properties (polarisation, magnetisation, magnetoelectricity) from a material that initially displayed none of them.

"Design of materials properties at the atomic scale is difficult, as it is quite a different problem from designing a large-scale object like a bridge or a car, but would be very desirable across the whole spectrum of properties. We are currently working on materials design in other areas, such as batteries or solar energy harvesting, where improvements are also needed."

The research is published in *Science*.

More information: "Tilt engineering of spontaneous polarization and magnetization above 300 k in a bulk layered perovskite" *Science* 23 January 2015: Vol. 347 no. 6220 pp. 420-424 DOI: 10.1126/science.1262118

Provided by University of Liverpool

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