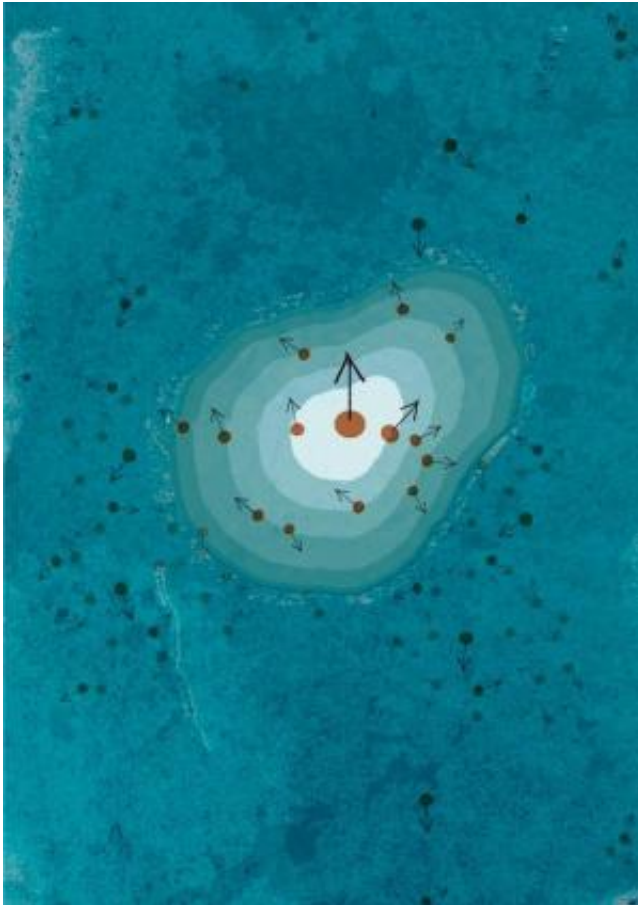


Electrical control of single atom magnets

December 8 2013



When directly on a metal surface, the magnetism (black arrows) of a single cobalt atom (orange circles) is screened by strong interactions with the surrounding metallic sea (blue). By moving these atoms towards the center of an island of thin insulator material (white), we can gradually decrease that strength of that interaction, which results in a remarkable enhancement of the magnetic anisotropy. Credit: Alfaró Cuevas/ alfarocuevas.blogspot.com. Creative Commons Attribution/No-Derivatives licence

The energy needed to change the magnetic orientation of a single atom – which determines its magnetic stability and therefore its usefulness in a variety of future device applications – can be modified by varying the atom's electrical coupling to nearby metals.

This striking result was published today in the journal *Nature Nanotechnology* by an international group of scientists working at the London Centre for Nanotechnology (LCN) at UCL (UK), the Iberian Nanotechnology Laboratory (Portugal), the University of Zaragoza (Spain), and the Max Planck Institute of Microstructure Physics (Germany).

Anyone playing with two magnets can experience how they repel or attract each other depending on the relative orientation of their magnetic poles. The fact that in a given magnet these poles lie along a specific direction rather than being randomly oriented is known as magnetic anisotropy, and this property is exploited in a variety of applications ranging from compass needles to hard drives.

"For 'large' pieces of magnetic material," emphasized Dr Joaquín Fernández-Rossier from the INL, "magnetic anisotropy is determined primarily by the shape of a magnet. The atoms that form the [magnetic material](#) are also magnetic themselves, and therefore have their own magnetic anisotropy. However, atoms are so small that it is hardly possible to ascribe a shape to them, and the magnetic anisotropy of an atom is typically controlled by the position and charge of the neighbouring atoms."

Using a scanning tunnelling microscope, an instrument capable of observing and manipulating an individual atom on a surface, LCN researchers and their colleagues discovered a new mechanism that controls magnetic anisotropy at the atomic scale.

In their experiment, the research team observed dramatic variations in the magnetic anisotropy of individual [cobalt](#) atoms depending on their location on a copper surface capped with an atomically-thin insulating layer of copper nitride.

These variations were correlated with large changes in the intensity of another phenomenon – the Kondo effect – that arises from electrical coupling between a magnetic atom and a nearby metal. With the help of theoretical and computational modelling performed in Germany and Portugal, the researchers found that, in addition to the conventional structural mechanisms, the electronic interactions between the metal substrate and the magnetic atom can also play a major role in determining magnetic anisotropy.

"Electrical control of a property that formerly could only be tuned through structural changes will enable significant new possibilities when designing the smallest possible devices for information processing, data storage, and sensing," said LCN researcher Dr Cyrus Hirjibehedin.

In contrast to the more conventional mechanisms, this contribution to the magnetic anisotropy can be tuned electrically using the same process that drives many transistors, the field effect. These results are particularly timely because they support efforts to find material systems with large magnetic anisotropy that are free of rare earth elements, scarce commodities whose mining has large environmental impact.

More information: 'Control of single-spin magnetic anisotropy by exchange coupling' is published online in *Nature Nanotechnology* today. [DOI: 10.1038/NNANO.2013.264](https://doi.org/10.1038/NNANO.2013.264)

Provided by University College London

Citation: Electrical control of single atom magnets (2013, December 8) retrieved 25 April 2024 from <https://phys.org/news/2013-12-electrical-atom-magnets.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.