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Press release

Hamburg, 2017/09/21

Stable magnetic bit of three atoms

As reported today in the journal Nature Communications a team of experimentalists and theoreticians of the University of Hamburg in cooperation with the Forschungszentrum Jülich and the Radboud University in Nijmegen have experimentally realized a ferromagnetic particle composed of only three iron atoms which can serve as a bit for the magnetic storage of information. By particular electronic interactions of the bit with the conductive substrate it is positioned on, the information the bit carries can be processed in an unusual, so called non-collinear, way, which could add new functionality to future elements of information technology.

A reoccurring challenge in storage technology is the continuing demand for smaller “bits”, which is the fundamental storage unit. In magnetic memories this information is stored in the magnetization of small magnets. The need to store more and more information in a smaller and smaller area therefore involves the question of how small we can make a magnet which still keeps its magnetization for a prolonged period of time such that the information is not lost. Recently, extensive research in this direction has approached the ultimate limit of storing information in individual atoms. A particular challenge for the use of such small storage elements was the destabilization of their magnetization by the interaction with the electrons of the substrate they are positioned on. Consequently, the prevalent approach in order to stabilize the magnetization was to strongly decouple the magnetic bit from the substrate electrons by the use of insulating layers. However, this route entails the problem that the processing of the information the bit carries for computational purposes, which is done via exactly those substrate electrons, is rather difficult to achieve. To this end, a bit made of a few atoms which are positioned directly on a conductive substrate is highly desirable.

A team of experimentalists and theoreticians of the University of Hamburg in cooperation with the Forschungszentrum Jülich and the Radboud University in Nijmegen have now experimentally realized such a bit. The bit was constructed by using the magnetic tip of a scanning tunneling microscope as a tool for putting together only three iron atoms on a conductive platinum substrate (see the Figure, left panel). They were also able to use the magnetic tip in order to write information into a storage register of two of such bits (see the Figure, right panel) which keeps the stored information for hours. By using conductive platinum as a substrate, the researchers were able to achieve an intriguing magnetic structure inside the bit and substrate (see the Figure, left panel): the magnetization of the individual constituents of the bit is not aligned parallel, as in conventional magnetic storage elements, but in a much more complex, so called non-collinear, fashion. This non-collinearity enables to transmit the stored information to neighboring components using a large variety of angles between the magnetizations, other than just 0° and 180°, which will add more flexibility to information processing schemes.

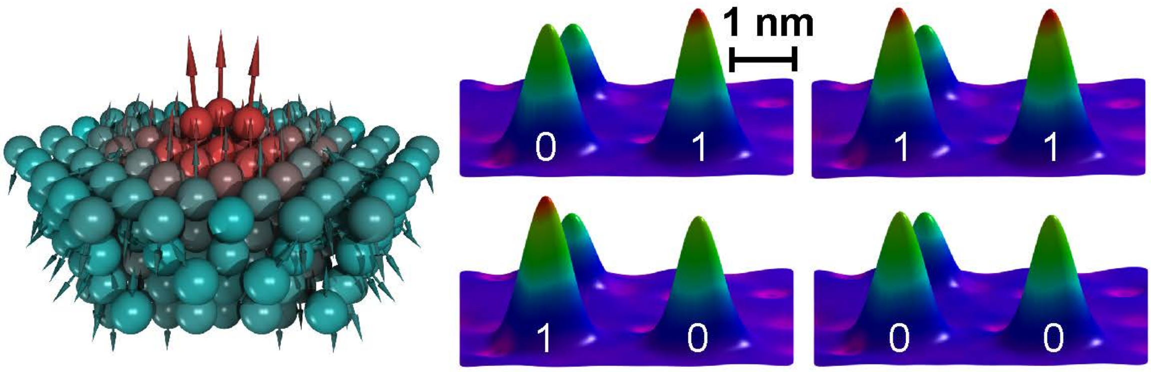

Figure: *Left panel: Illustration of the constructed magnetic bit composed of only three iron atoms on a platinum substrate. The arrows indicate the peculiar magnetization inside the bit which carries the information. Right panel: Magnetic images of the four possible states of a register of two of such magnetic bits. In these images, the height of the two bits reflects their state (0, low and 1, high). The iron atom in the back serves as a marker for the height of a tenth of a nanometer.*

Original Publication:

J. Hermenau, J. Ibañez-Azpiroz, Chr. Hübner, A. Sonntag, B. Baxevanis, K. T. Ton, M. Steinbrecher, A. A. Khajetoorians, M. dos Santos Dias, S. Blügel, R. Wiesendanger, S. Lounis, and J. Wiebe: *A gateway towards non-collinear spin processing using three-atom magnets with strong substrate coupling*, Nature Communications (2017)
DIO: 10.1038/s41467-017-00506-7

Additional web sites:

http://www.nanoscience.de
http://www.sfb668.de

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