Computer discovers two-dimensional magnets making way for efficient RAM for next-generation devices

Scientists at the S N Bose National Centre for Basic Sciences (SNBNCBS), an autonomous institute under the Department of Science & Technology (DST) have predicted existence of two dimensional ferromagnetic systems at finite temperature using computational study.

The research by Tanusri Saha-Dasgupta, Senior professor from SNBNCBS, published in the journal Physical Review Research which challenges conventional wisdom that 2D ferromagnetic materials cannot exist at finite temperature could be a significant step towards high capacity random-access memory (RAM) in next-generation computers.

Electrons, one of the basic components of atoms, are the glue binding atoms together. Electron, in addition to its charge, contains spin, which crudely can be described as spinning-top rotating around its axis. Ferromagnetism is the phenomena in which electron spins line up parallel to each other forming long-range ordered pattern. Most ferromagnetic materials exist in three dimensions. The study allows us to know what happens to ferromagnetic long-range order when the dimensionality of the system is reduced from three to two by forming an atomically thin layer.

Two-dimensional (2D) ferromagnetism, if stablized, can bring in important advances both in scientific knowledge as well as technological development owing to its low-dimensionality. For example, one of the upcoming fields in technology is spintronics, in which devices such as computers and memories can be built based on the movement of electron spin rather the charge (known as electrical current). It would be a huge advantage to have 2D magnets for the realization of such technology. However, finding 2D magnets is challenging.

Through computational study, Professor Dasgupta and her team predicted the existence of 2D systems which show long-range ferromagnetic ordering even at finite temperature, making an exception to the conventional wisdom, given by the Mermin-Wagner theorem which says that two-dimensional ferromagnetism can only occur at absolute zero temperature (0 Kelvin or -273 degree Celcius).

The key to this exceptional behaviour turned out to be governed by a special property of these materials, namely the magnetic anisotropy. As opposed to magnetically isotropic materials for which there is no preferential direction for an object's spin, for magnetic systems with finite values of magnetic anisotropy, the spins prefer to point towards a specific direction. The studied two-dimensional systems comprised of a single layer of Copper(Cu) spins connected to each other through halogen atoms, exhibiting the anisotropy property so that the Cu spins prefer to orient in the out of plane direction as opposed to in-plane, which in turn helped them to line up parallel to each other at finite temperature.

Discovery of these ultra-thin magnets will provide an important step forward in realizing spintronic devices which can be integrated into the next generation spin-transfer torque magnetic random-access memory.

*Publication: 2D ferromagnetism in layered inorganic-organic hybrid perovskites, Dhani Nafday, Dipayan Sen, Nitin Kaushal, Anamitra Mukherjee, and Tanusri Saha-Dasgupta, Phys. Rev. Research **1**, 032034(R) – Published 9 December 2019. DOI: 10.1103/PhysRevResearch.1.032034*

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