Computer Discover Two Dimensional Magnets

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We are all familiar with the electrons, as one of the basic components of atoms, that 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 we know of, exist in three dimension. It is of great interest to know what happens to ferromagnetic long range order when the dimensionality of the system is reduced from three to two by forming atomically thin layer, which recent experimental advances allow us to synthesis. Two-dimensional (2D) ferromagnetism, if can be stablizied, 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 computers and memories can be built based on movement of electron spin rather the charge (known as electrical current). It would be huge advantage to have 2D magnets for the realization of such technology. However, finding 2D magnets is challenging. There exists a rigorous theorm (known as Mermin-Wagner theorem) that says that stabilization of two-dimensional ferromagnetism is impossible at any finite temperature. In other words, two-dimensional ferromagnetism can only occur at absolute zero temperature (0 Kelvin or -273 degree Celcius). Through our computational study, we predict existence of two dimensional systems which show long-range ferromagnetic ordering even at finite temperature, making an exception to the conventional wisdom, given by the Mermin-Wagner theorem. The key to this exceptional behavior 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 Cu spins connected to each other through halogen atoms, exhibit 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 help them to line up parallel to each other at a finite temperature. Discovery of these ultra-thin magnets provide an important step forward in realizing spintronics devices which can be integrated into the next generation spin-transfer torque magnetic random-access memory.

Ref: 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.