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Magnetic LEGO: van der Vaals interlayer magnetism

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In two-dimensional (2D) materials, due to weak interlayer van der Waals (vdW) interaction, the crystal structure can be tuned through the control of interlayer stacking with a rather low increase in energy. Whereas most previous work has focused on the electronic and optical properties associated with the vdW stacking, the recent discovery of magnetism in 2D materials extends this research area to magnetic properties. CrI_3 and $CrBr_3$ are two isostructural ferromagnetic 2D materials, which maintain out-of-plane ferromagnetism down to the monolayer limit. However, as confirmed through recent experiments based on mechanically exfoliated samples, CrI_3 bilayers exhibit interlayer antiferromagnetism, while $CrBr_3$ bilayers exhibit interlayer ferromagnetism. Such a striking difference in the magnetic properties between bilayers of CrI_3 and $CrBr_3$ prompts a thorough investigation of the mechanisms governing the interlayer magnetic coupling.

Recently, a group led by Prof. Chunlei Gao in collaboration with Prof. Shiwei Wu from Fudan University and Prof. Xiaodong Xu from University of Washington demonstrated that the interlayer magnetic coupling of $CrBr_3$ bilayers depends on the stacking order and can be either ferromagnetic or antiferromagnetic. On their films grown by molecular beam epitaxy, two kinds of stacking order with different layer twisting angles were found in the bilayer system: R-type stacking structure, where the adjacent layers are oriented in the same direction, and H-type stacking structure, where the adjacent layers are oriented in the opposite direction. By utilizing *in situ* spin-polarized scanning tunnelling microscopy, they were able to directly correlate the interlayer stacking with the magnetic coupling. The H-type stacking films show a ferromagnetic interlayer coupling as evidenced by the simple rectangular hysteresis loop, while the R-type stacking films show a complex four-plateaus hysteresis loop indicating an antiferromagnetic interlayer coupling. This work opens up possibilities for manipulating 2D magnetism based on twisted bilayers and heterostructures.

Lifeng Yin (Fudan University, Shanghai, China)
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