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Magnetism in Nanosystems

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Magnetism is an old physics topic that has been receiving new concept in recent years. One of the reason is the discussion of magnetism in nanostructured systems, especially in two-dimensional (2D) thin films. Among different types of magnetic couplings, ferromagnetism is the simplest but most useful one. In the present talk, I will discuss some ferromagnetic thin films with their novel and interesting properties. Using first-principles calculations we have discovered and demonstrated a series of transition metal (TM) liganded ferromagnetic tri-layer thin films, including FeC_2, MnO_2, and RuI_3. The 2D FeC_2 can be chemically exfoliated from bulk $ThFeC_2$ compound, which has a Curie temperature of ~245 K, and shows a 100% spin polarization at the Fermi level. The MnO_2 layer has a strain modulated Curie temperature in the range of 140–220 K, and shows a semiconducting conductivity. Furthermore, we show that the MnO_2 is a good substrate to support a single layer of Sb/Bi. The combined system possesses a large band gap of quantum spin Hall effect (without time-reversal symmetry) and a large anomalous Hall effect, in their low energy state. In order to achieve intrinsic and robust quantum anomalous Hall effect in experimentally feasible 2D materials, we propose that TM halide family is a good candidate. Using ferromagnetic RuI_3 thin film as an example, we show that its Curie temperature is ~360 K. At the Fermi level it shows a clear Dirac cone in the spin down channel, which can be opened once the spin rotational symmetry is broken by including spin-orbit coupling. We demonstrate a large band gap of quantum anomalous Hall effect emerges inside the band gap, and the metallic edge band can be clearly seen in a nanoribbon model. These findings broaden the potential applications of low-dimensional magnetic materials.