

Two-Dimensional magnetic topological materials

An exciting playground for X-tronics

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The electronic properties of two-dimensional magnetic topological materials (2DMTMs) are highly susceptible to their magnetic structure. Short-ranged magnetic interactions can be fine-tuned by small structural variations, long-range magnetic interactions that are mediated by Ruderman-Kittel-Kasuya-Yosida (RKKY) type interactions by manipulations of the Fermi surface. Magnetic couplings across the 2D building blocks, possibly leading to Moiré-type superstructures, change the overall cooperative behaviour. This allows to stabilize magnetic states beyond the established ferro- or antiferromagnetic structures, non-collinear orderings and local formation of magnetic solitons. Spin-orbit interaction in combination with structural inversion asymmetry at magnetic surfaces, interfaces, heterostructures, multilayers and nanostructures is a source of a variety of spin-dependent transport phenomena and novel magnetic textures, with the chiral magnetic skyrmions being the best known.

Recently, we established that the electronic structure in 2DMTMs depends sensitively on the magnetization direction and is characterized by mixed topological Weyl points generating topological magneto-electric effects. In non-collinear magnetic structures the local variation of the electronic structure leads to electrically controllable or detectable magnetic structures of technological potential. In addition, the vertical stacking of two-dimensional magnetic topological materials (e.g. being in a quantum anomalous Hall state) offers the possibility to create 2D stacks with variable Chern numbers.

In the last years we developed density functional theory based tools to describe these fascinating states of matter, access their exchange interactions, determine the magnetic states at zero or finite temperature and simulate their transport properties. We expect that the application of these methods to 2D magnetic materials leads to the discovery of material classes with novel functionality and response properties.

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