Highlights

ACTIVITY C Innovative materials with strong interplay of spin orbital charge and topological degrees of freedom-2020

Spontaneous skyrmionic lattice from anisotropic symmetric exchange in a Ni-halide monolayer

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Magnetic skyrmions are localized topological spin structures carrying an integer topological charge Q. Their topological properties ensure the inherent stability that makes them technologically appealing for future memory devices. Typically, isolated skyrmions and skyrmion lattices can be realized by applied magnetic field in chiral magnets. Taking as a prototype system a monolayer of NiI_2, a centrosymmetric and semiconducting van der Waals helimagnet in its bulk form, and combining density functional theory and Monte Carlo calculations, this work unveils a novel mechanism leading to a thermodynamically stable skyrmion lattice with well defined topology and chirality. When combined with magnetic frustration, arising from competing exchange interactions in a geometrically frustrated triangular lattice, the anisotropic part of the symmetric exchange tensor may act as an emerging chiral interaction, thus leading to a stable lattice of Q=2, nanosized antibiskyrmions shown in Fig. 1 (left).

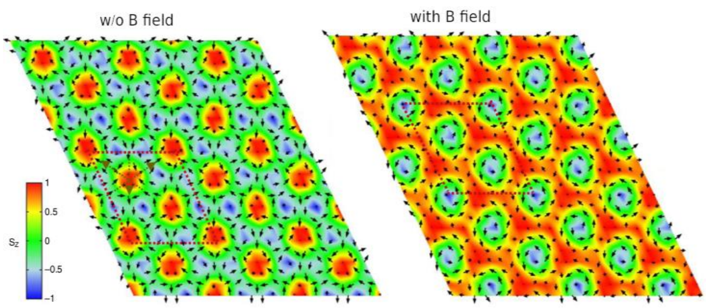

Fig. 1: Snapshots of spin configurations obtained from Monte Carlo calculations at T=1K showing the spontaneous antibiskyrmion lattice (left) and the magnetic field-induced skyrmion lattice (right) predicted in NiI_2 monolayer. Black arrows represent in-plane components of spins, while the out-of-plane Sz component is indicated by the color map.

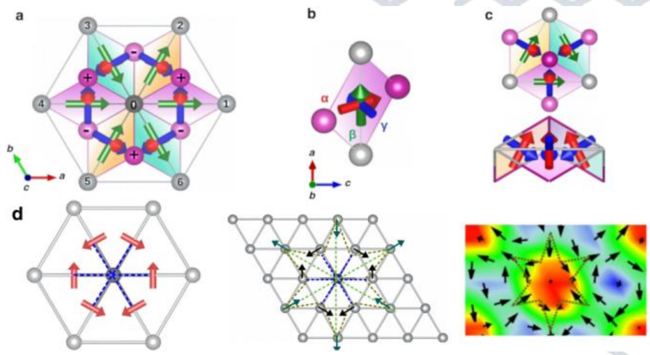

Fig. 2: Top view of NiI_2 (a), highlighting the principal axes of the exchange tensor within each Ni_2I_2 plaquette (b), that arrange in a non-coplanar fashion within the triangular lattice (c). The local spin configuration around each antibiskyrmion core is dictated by the principal axes of the anisotropic symmetric exchange (red arrows) shown in (d).

Indeed, the non-coplanarity of the principal axes of the exchange tensors introduces an additional frustration in the relative orientation of neighboring spins, thus determining the local topological spin configuration (Fig. 2). Furthermore, it is predicted that a magnetic field applied perpendicularly to the layer drives a topological transition to a Q=1 skyrmion lattice, shown in Fig. 1 (right). The proposed mechanism does not rely on the typically invoked antisymmetric and chiral Dzyaloshinskii-Moriya interaction, and as such it enlarges the kind of short-range magnetic interactions able to drive the stabilization of topological spin lattices.