Non-Local Chiral Interactions In Corrugated Magnetic Nanoshells

CurvMag

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Curvilinear magnetism; Chiral effects; Magnetic domains; Curvature templates

There is one aspect, which is in common to the majority of fundamentally appealing and technologically relevant novel magnetic materials, namely their non-collinear magnetic textures like spin spirals, chiral domain walls or skyrmions. These textures are typically achieved relying on the Dzyaloshinskii-Moriya interaction (DMI), which is present in certain acentric magnetic crystals. Recently, curvature effects emerged as a novel mean to design chiral magnetic properties by relying on extrinsic parameters, e.g. geometry of thin films. Although this research field is very new, at present, the topology of curved surfaces is broadly explored with respect to new fundamental physics as well as applied device ideas. The present understanding of the field is limited to the case of ultrathin magnetic films, where curvature brings about two distinct effects stemming from emergent chiral and anisotropy interactions. In this limit, all curvature-induced chiral effects are necessarily local. Even non-local magnetostatic effects in the main approximation on the film thickness are reduced to local anisotropy terms in the energy functional.

Here, we aim to extend the fundamental understanding of magnetism in curved geometries by developing a micromagentic framework accounting for the next orders in the film thickness. Our theoretical predictions show that in the second order on thickness, non-local magnetostatics results in the emergence of the non-local chiral effects. These non-local chiral interactions are very different compared to the standard case of local effects stemming from interface-induced or bulk DMI. These non-local chiral effects are studied neither theoretically nor experimentally. The key objective of this project is to join the efforts of theoretical (group of Prof. Sheka, University of Kyiv) and experimental (groups of Prof. McCord, University of Kiel, and Dr. Makarov, Helmholtz-Zentrum Dresden-Rossendorf) teams on the investigation of this novel effect. Theoretically, we will explore the predicted existence of novel source for chiral interactions due to the coupling between surface and volume magnetostatic charges (this coupling is necessarily absent in the case of flat films). Experimentally, we will target validation of these theoretical predictions by studying the statics and mobility of magnetic domains in corrugated ferromagnetic shells. Those will be fabricated by deposition of our-of-plane magnetized thin films on curvature templates with tunable geometric characteristics (amplitude of corrugation with respect to its period). The key challenge is to find a fingerprint of the novel effect, e.g. by monitoring the tilt of magnetic domain wall with respect to the stripe axis even at remanence, and find a method, which will allow quantification of strength of this effect.

This project will deepen our understanding on the curvature effects in condensed matter help to turn the novel theoretical concepts into real experimental observables.