Dipolar-stabilized first and second-order antiskyrmions in ferrimagnetic multilayers

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Skyrmions and antiskyrmions are topologically protected spin structures with opposite vorticities. Particularly in coexisting phases, these two types of magnetic quasi-particles may show fascinating physics and potential for spintronic devices. While skyrmions are observed in a wide range of materials until now antiskyrmions were exclusive to materials with D_{2d} symmetry [1].

In our recent work, we have shown first and second-order antiskyrmions stabilized by magnetic dipole-dipole interaction in Fe/Gd-based multilayers [2]. Using Lorentz transmission electron microscopy imaging, we observed coexisting first and second-order antiskyrmions, Bloch skyrmions, and type-2 bubbles and determine the range of material properties and magnetic fields where the different spin objects form and dissipate. Phase diagrams of the spin objects were created in dependence on magnetic out-of-plane field, temperature, saturation magnetization, and uniaxial magnetic anisotropy. We performed micromagnetic simulations to obtain more insight into the studied system and conclude that low values of saturation magnetization and uniaxial magnetic anisotropy lead to the existence of this zoo of different spin objects and that they are primarily stabilized by dipole-dipole interaction. Further, we investigated the nucleation process of antiskyrmions experimentally and theoretically revealing the necessity of a crossing point of three magnetic stripe domains to form an isolated antiskyrmion with an out-of-plane magnetic field.

The previous unobserved second-order antiskyrmions and the disclosed coexistence of antiskyrmions and skyrmions potentially reachable for a whole range of different materials provide great potential for further studies on quasi-particle interactions, spin dynamics as well as for possible future applications in spintronics.

References:

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