Skyrmion and Antiskyrmion in rank-1, -2, and -3 DMI materials

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The research on skyrmions – localized two-dimensional topological magnetization solitons – focused mainly on Bloch-type skyrmions in B20 alloys with cubic symmetry and Néel-type skyrmions stabilized by (111) oriented interfaces compatible with the growth mode introduced by sputtering techniques. Considering the micromagnetic theory both belong to the same equivalence class as in both types of systems, the Dzyaloshinskii-Moriya (DM) spiralization tensor \( D \) is characterized by a single parameter and both lie in the same orbit generated by a O(2) rotation symmetry. Also, antiskyrmions lie in this orbit but for solids of different symmetries e.g. D_{2d} symmetry.

In a recent work [1] we extended the scope of skyrmions and antiskyrmions, and introduced a classification scheme partitioning chiral magnets into isotropic rank-three DM bulk and rank-two DM film magnets, with a DM interaction described, as above, by a single spiralization constant, for which antiskyrmions are stable only for bulk crystals with certain point group symmetries. Newly introduced are the anisotropic rank-two DMI film magnets, where skyrmions and antiskyrmions can coexist, while the sign of \( \text{det}(D) \) determines which of the two has the lower energy. Finally, zero determinant indicates a rank-one DMI material, for which skyrmions and antiskyrmions have the same energy.

In this contribution, I discuss our new classification scheme and give with Fe on W(110) an example of an anisotropic rank-two solid, for which we conjecture the presence of antiskyrmions based on DFT calculations combined with atomistic spin-dynamics carried out with the spirit code. Finally, we discuss the potential of rank-one solids for the design of a race track memory based on the coexistence of skyrmions and antiskyrmions of the same energy [2] as an alternative to the recently suggested race-track memory based on a combination of bobbers and skyrmions [3].

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Reference: