Skyrmions in antiferromagnets

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Magnetic skyrmions are swirling configuration of the magnetic order parameter that are stable in materials with the Dzyaloshinskii-Moriya (DM) interaction. They are commonly observed in magnetic films, typically extending a few or tens of nanometers laterally, and their nontrivial topology makes them robust against perturbations. Skyrmions exhibit particle-like dynamics which, together with their small size, lead to properties that make them suitable as the constituent information carriers in memory and logic devices or memristor elements in artificial synapses for neuromorphic computing architectures.

The chiral DM interaction is crucial also for the dynamics of solitons, in addition to its role in their stabilization. We study antiferromagnetic skyrmions described via the Néel vector, that is the appropriate order parameter. In the first example [1], we show that skyrmions in chiral antiferromagnets can be traveling as solitary waves with velocities up to a maximum value that depends on the DM parameter. We calculate the traveling skyrmion configuration, as shown in Fig. 1a. The solitonic behavior of skyrmions in antiferromagnets is in stark contrast to the dynamical behavior of their ferromagnetic counterparts.

In the second example [2], we study breathing oscillations of skyrmions in the nonlinear regime, and the features of larger amplitude oscillations. We predict theoretically and observe numerically skyrmion collapse and subsequent annihilation events, as shown in Fig. 1b. The process is efficient when the skyrmion is mildly excited so that its radius initially grows, while the annihilation event of the topological texture is eventually induced by the internal breathing dynamics.

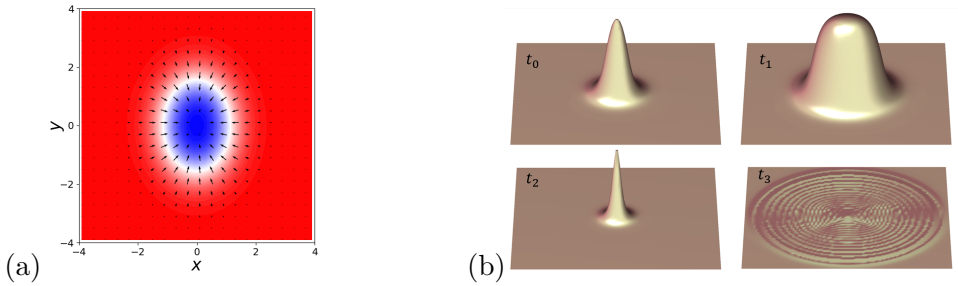

Figure 1: (a) A skyrmion traveling along the x direction represented via the projection of the Néel vector on the plane. (b) Snapshots for a skyrmion annihilation event represented via surface plots of the perpendicular component of the Néel vector.

References

[1] S. Komineas and N. Papanicolaou, SciPost Phys. 8, 086 (2020).

[2] S. Komineas and P. E. Roy, arXiv:2203.04157 (2022).

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