Antiferromagnetic Skyrmions

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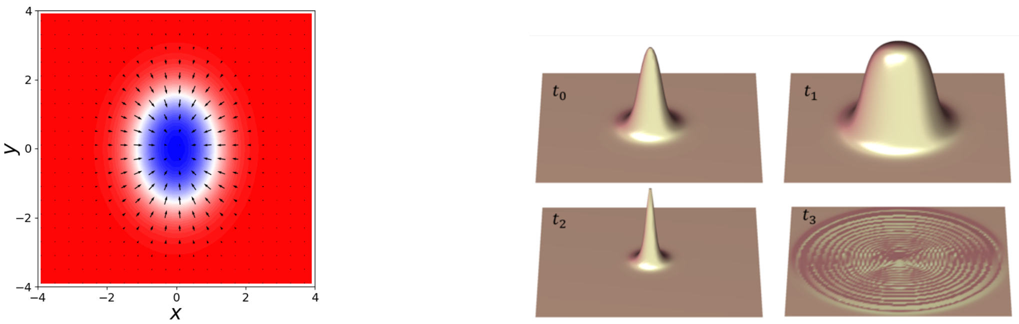
ABSTRACT

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 with a Newtonian or relativistic character in antiferromagnets, or with Hall features in ferromagnets.

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, which is the appropriate order parameter. In the first example, we show that skyrmions [1] and vortices [2] in chiral antiferromagnets can be traveling as solitary waves with velocities up to a maximum value that is due to a topological phase transition induced by the dynamics. We calculate the traveling skyrmion, as shown in Fig. 1(left), or the vortex configuration.

In the second example [3] we study breathing oscillations of skyrmions in the nonlinear (large amplitude) regime. We predict theoretically and observe numerically skyrmion collapse and subsequent annihilation events, as shown in Fig. 1(right). 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.



(Left) A skyrmion traveling along the x direction represented via the projection of the Néel vector on the plane. (Right) Snapshots of a skyrmion annihilation event represented via surface plots of the perpendicular component of the Néel vector.

REFERENCES

[1] S. Komineas and N. Papanicolaou, 2020. SciPost Phys. **8**, 086.
[2] R. Tomasello and S. Komineas, 2021. Phys. Rev. B **104**, 024431.
[3] S. Komineas and P. E. Roy, 2022. arXiv:2203.04157.