ID 0598

Curvilinear Antiferromagnetic Spin Chains: Interplay Between Geometry And External Magnetic Field

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Antiferromagnetically ordered (AFM) spin chains arranged along space curves represent a useful playground to study various possibilities of altering the sample's magnetic response by its geometry modification. The influence of curvature (κ) and torsion (τ) is characterized by effective magnetic interactions, namely anisotropic and Dzyaloshinskii–Moriya-like, which originate from exchange, dipolar interaction and intrinsic anisotropy [1, 2]. The strength of these interactions depends on κ and τ, determining the ground state and spin dynamics of such systems [2, 3].

Here, we investigate theoretically the interplay between geometrical and magnetic field effects in intrinsically achiral anisotropic spin chains shaped as rings (constant κ, no torsion) and helices (constant κ, τ) exposed to uniform static and rotating magnetic fields. Exposed to static magnetic field, bulk AFMs possess a high-field spin-flop state, characterized by reorientation of the order parameter. In contrast to the spin-flop phase for the model of a bulk easy-axis AFM, in ring-shaped spin chains the spin-flop state comprises two topologically different ground states depending on κ. We attribute them to the influence of curvature-induced Dzyaloshinskii–Moriya interaction, as well as the spin-flop transition being of first or second order depending on the ring curvature and the presence of an intermediate canted state for large κ [4]. In the helix-shaped spin chain, a rotating magnetic field induces domain wall propagation with velocity, which is proportional to the field frequency. The relation between the external field and geometrical parameters determines two motion modes: oscillating one and rigid motion with a constant velocity. Curvature and torsion strongly influence domain wall velocity and stability conditions of the rigid motion mode.

Keywords: Antiferromagnetic spin chains, 1D antifferomagnets, Spin-flop state, Curvilinear magnetism, Dzyaloshinskii-Moriya interaction, Domain wall propagation

Acknowledgements:

Y. B. and D. Sh. acknowledge the financial support by the program “Magnetism in Ukraine Initiative” (IEEE Magnetics Society and the Science and Technology Center of Ukraine, Project No. 9918).

This work is financed in part via the German Research Foundation (DFG) under the Grants MC 9/22–1, MA 5144/22-1, MA 5144/24-1, and UKRATOP-project (funded by the BMBF; Reference No. 01DK18002).

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Track: Nanomagnetism & Magnetic Materials (NMM)
Presentation type: Oral Presentation
Status: Accepted for presentation