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Complex mesoscale magnetic order in the Néel-type skyrmion material GaV_4S_8

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The physics of magnetic skyrmions is presently attracting significant fundamental and applied research interest. To stabilise the topological vortex-like spin structure of the skyrmion, a crucial ingredient is broken inversion symmetry of the host crystal, since this promotes antisymmetric Dzyaloshinskii-Moriya interactions (DMIs) that compete with an otherwise isotropic exchange. Ultimately the precise skyrmion type that is realised depends on the pattern of DMIs dictated by the host crystal symmetry. Bulk materials crystallising in a chiral octahedral or chiral tetrahedral point group display the Bloch-type skyrmion. This skyrmion type is often viewed in terms of a superposition of helical modulations (a multi-k structure), and it was the skyrmion type first discovered to exist in the A-phase of MnSi [1]. Recently, a lattice of Néel-type magnetic skyrmions was proposed to be stabilised in the polar insulator GaV4S8, which displays a polar rhombohedral crystal symmetry at low temperature [2]. The Néel-type skyrmion lattice has an orthogonal helicity to the Bloch-type skyrmion, and can be viewed as formed by a superposition of spin cycloidal instead of helical modulations. However, a direct experimental proof of the cycloidal modulation, expected to be enforced due to the crystal symmetry, has remained challenging. In this talk we will show how both polarised and unpolarised small-angle neutron scattering (SANS) are indispensable tools for determining the complex microscopic magnetic order in the skyrmionic materials like GaV4S8 [2,3]. Our experiments on GaV4S8 indeed reveal the underlying modulations of the Néel-type skyrmion lattice must be cycloidal, in agreement with the symmetry considerations. In addition, SANS provides pivotal insight for identifying further key factors determining the structure of the magnetic phase diagram of GaV4S8. We use our data to argue that in this system a delicate interplay between the easy-axis anisotropy and thermal fluctuations determines the stability range of the cycloidal and skyrmion phases as compared with a competing ferromagnetic state [3].

[1] S. Mühlbauer et al., Science 323, 915 (2009)
[2] I. Kézsmárki et al., Nat. Mater. 14, 1116 (2015)
[3] S. Bordács, J.S. White et al., submitted (2017)

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