Skyrmion phase in a frustrated triangular lattice with next-nearest neighbours

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Skyrmions in magnetic materials are topologically protected whirled spin configurations that behave like quasiparticles and have been suggested for several practical implementations including memory devices, logic gates, and microwave resonators. Known for a while now they were first experimentally discovered in a ferromagnetic (FM) bulk sample with their stabilization attributed to the presence of the Dzyaloshinskii–Moriya interaction. The latter is very often the cause of skyrmions creation, though recently some other mechanisms came into the spotlight, one of them being the presence of frustration in the system [1]. It was shown that antiferromagnetic (AFM) next-nearest neighbours interactions on a triangular FM Heisenberg lattice favour skyrmion and antiskyrmion lattices (SkL/ASkL) with equal probability. We study AFM Heisenberg triangular lattice with second and third neighbour interactions (J1-J2-J3) in the presence of the external magnetic field [2]. First, we construct a zero-field phase diagram in J2 - J3 plane by means of Luttinger-Tisza approximation for zero-temperature calculations and massively parallelized GPU-implemented parallel tempering Monte Carlo simulations for the finite temperatures. We identify two already known phases [3] as well as several multiple-q phases and two spiral spin liquid ones according to the J2/J3 ratio.

In the case of a non-zero magnetic field, we show that for a certain ratio of the coupling strengths the SkL/ASkL lattice is present in a narrow temperature-field region. Unlike in the FM case [1], the J2 and J3 magnitudes required for that are rather small. The AFM SkL/ASkL, similarly to [4], follow the three-sublattice decomposition natural for the triangular AFM lattices and form a regular hexagonal lattice on each of the three interpenetrating sublattices. Due to the presence of the rotational symmetry in the plane perpendicular to the external magnetic field antiskyrmions and skyrmions with random helicity (Bloch, Néel, and intermediate) are stabilized spontaneously. We expect that in real materials the presence of common additional interaction (single-ion anisotropy, bond anisotropy, or dipolar interactions) will lift this spontaneity, and topological objects with fixed helicity will be stabilized.

References

[1] T. Okubo, S. Chung, H. Kawamura, Phys. Rev. Lett. 108, 017206 (2012).
[2] M. Mohylna, F. A. Gómez Albarracín, M. Žukovič, H. D. Rosales, Phys. Rev. B 106, 224406 (2022).
[3] L. Messio, C. Lhuillier, G. Misguich, Phys. Rev. B 83, 184401 (2011).
[4] H. D. Rosales, D. C. Cabra, P. Pujol, Phys. Rev. B 92, 214439 (2015).