

Non-trivial Spin Structures and Multiferroic Properties of the DMI-compound $\text{Ba}_2\text{CuGe}_2\text{O}_7$

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Incommensurate spiral magnets have raised tremendous interest in recent years, mainly motivated by their wealth of spin structures with potential non-trivial topology, such as skyrmions. A second field of interest is multiferroicity. Antiferromagnetic $\text{Ba}_2\text{CuGe}_2\text{O}_7$, characterized by a quasi-2D structure with Dzyaloshinskii-Moriya interactions (DMI), is interesting in both of these regards and combines them with a variety of unconventional magnetic phase transitions. $\text{Ba}_2\text{CuGe}_2\text{O}_7$ is an insulator characterized by a tetragonal, non-centrosymmetric space group ($P\bar{4}2_1m$) with lattice constants $a = 8.466 \text{ \AA}$ and $c = 5.445 \text{ \AA}$. The main features of the magnetic structure are due to the Cu^{2+} ions in a square arrangement in the tetragonal (a,b) plane with dominant nearest-neighbor AF exchange along the diagonal in the plane and much weaker FM exchange between planes, leading to a quasi-2D behaviour. Below the Néel temperature $T = 3.05\text{K}$, the DMI term is responsible for a long-range incommensurate, almost AF cycloidal spin spiral with the spins (almost) confined in the (1,-1,0) plane in the ground state. At zero external field, neutron diffraction is used for a careful examination of the distribution of critical fluctuations in reciprocal space, associated with the paramagnetic to helimagnetic transition of $\text{Ba}_2\text{CuGe}_2\text{O}_7$. Caused by the reduced dimensionality of $\text{Ba}_2\text{CuGe}_2\text{O}_7$, a crossover from incommensurate antiferromagnetic fluctuations to 2D AF Heisenberg fluctuations is observed. Recently, a new phase with a vortex-antivortex magnetic structure has been theoretically described. It has been experimentally confirmed in a pocket in the phase diagram at around 2.4K and an external field along the crystalline c-axis of around 2.2T. A lack of evidence for a thermodynamic phase transition towards the paramagnet in specific heat measurements and a finite linewidth in energy and momentum of the incommensurate peaks in neutron scattering, as opposed to the cycloidal ground state, seem to mark the vortex phase as a slowly fluctuating structure at the verge of ordering. Polarization measurements and neutron experiments including electrical field are already planned for further pinning down of the multiferroic properties.

References:

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