Contribution ID: **8** Type: **Short talk**

Non-trivial Spin Structures And Multiferroic Properties Of The DMI-Compound Ba2CuGe2O7

Monday 19 June 2023 16:30 (15 minutes)

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: Helical spin structures are in general ferroelectric[1], enabling the coupling of the electric and magnetic properties. Both fields present enormous potential for future devices, where spin and charge degrees of freedom are coupled. Antiferromagnetic Ba2CuGe2O7, characterised by a quasi-2D structure with Dzyaloshinskii-Moriya interactions (DMI), is a material that is interesting in both of these regards and combines them with a third one: a variety of unconventional magnetic phase transitions. Ba2CuGe2O7 is an insulator characterized by a tetragonal, non-centrosymmetric space group (P-421m) with lattice parameters a = 8.466 Å and c = 5.445 Å. The main features of the magnetic structure are due to the Cu2+ ions in a square arrangement in the tetragonal (a,b) plane with dominant nearest-neighbor AF exchange along the diagonal in the (a,b) plane and much weaker FM exchange between planes, leading to a quasi-2D behaviour. Below the Néel temperature TN = 3.05K, 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[2,3].

Our research is concentrated on two central aspects: 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 Ba2CuGe2O7. Caused by the reduced dimensionality of Ba2CuGe2O7, a crossover from incommensurate antiferromagnetic fluctuations to 2D antiferromagnetic Heisenberg fluctuations is observed, highlighting the rich cornucopia of magnetic phase transitions in spiral magnetic textures. Recently, a new phase with a vortex-antivortex magnetic structure has been theoretically described[4]. 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 high resolution 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. Experiments including electrical field in order to investigate its interplay with an external magnetic field are already planned and will allow for further pinning down multiferroic properties of Ba2CuGe2O7 [5].

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Session Classification: Parallel 1