Experimental report

16/10/2018

Proposal: **5-41-981** **Council:** 4/2018

Title: SANS investigation of a new magnetic phase of the chiral skyrmion material Cu2OSeO3

Research area: Physics

This proposal is a new proposal

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Samples: Cu2OSeO3

Instrument	Requested days	Allocated days	From	To
D33	6	3	06/10/2018	09/10/2018

Abstract:

Studies of cubic chiral magnets reveal a universal magnetic phase diagram, composed of helical spiral, conical spiral as well as skyrmion crystal phase. By combining neutron diffraction with magnetisation measurements we have found a remarkable deviation from this universal behavior. We have observed a new "tilted spiral" conical state in Cu2OSeO3, where the spiral wave vector is tilted away from the magnetic field direction and gives rise to strong diffuse scattering. We now wish to extend previous SANS measurements and investigate the multiferroic properties of this new phase. We also wish to investigate the effect of thermal and magnetic history searching for the co-existence of conical and titled conical phase, as the stabilization of metastable states is an topical issue in chiral magnetism.

Magnetic skyrmions are topologically protected spin textures with particle like properties. In bulk cubic helimagnets, they appear under magnetic fields and condense spontaneously into lattices in a narrow region of the phase diagram just below the transition temperature, the so-called A-phase. Theory, however, predicts skyrmions to occur over a wide range of magnetic fields and temperatures.

During this experiment on D33 we by carefully applied the magnetic field along the three major crystal- lographic directions, [111], [110] and [001], either after zero-field cooling (ZFC) or fast-field cooling (FFC) through the A-phase. In this way, we generated extremely robust low-temperature skyrmionic phases for all field directions and over large areas of the phase diagram, as shown in Fig. 1. Most importantly, we found that at low temperatures, the magnetic history becomes an important factor as the memory of metastable skyrmionic correlations persists, possibly in the form of torons, even when skyrmions have collapsed and their scattering has disappeared.

These skyrmionic states are thermodynamically stable or metastable depending on the orientation and strength of the magnetic field. Their (meta)stability is granted by cubic and exchange anisotropy and they can be generated following different nucleation mechanisms. Most importantly, the 'memory' of the metastable skyrmionic states persists in the field-polarized state, possibly in the form of torons, even when the skyrmions have collapsed and their scattering has disappeared. These findings highlight the paramount role of magnetic anisotropy in stabilizing novel skyrmionic states and open up new routes for manipulating these quasi-particles towards energy-efficient spintronics applications.

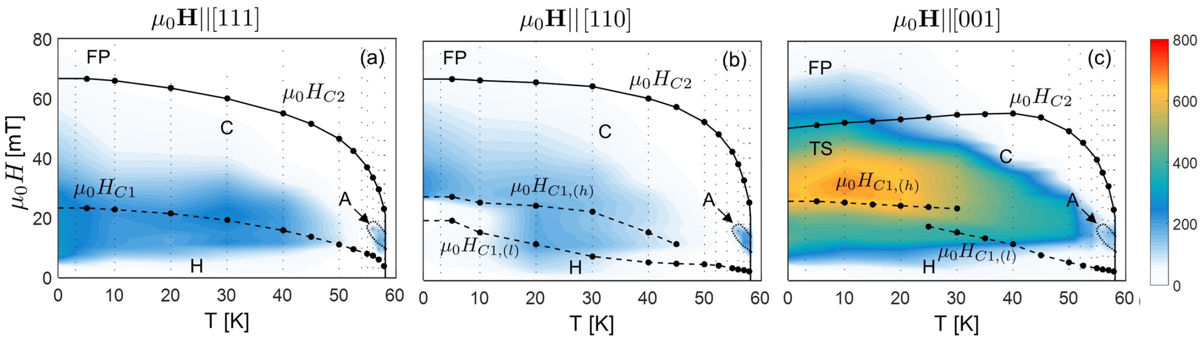

Fig. 1: Contour plots of the total neutron scattering due to SKL correlations and measure with the magnetic field applied along the neutron beam (H||ki) and along the (a) [111], (b) [110] and (c) [001] crystallographic directions and averaged using the masks shown in Fig. S1 of the supplement. The lower (μ0HC1,(l)) and upper (μ0HC1,(h)) helical-to-conical, conical-to-field polarized (μ0HC2) transition lines as well as the boundaries of the Skyrmion Lattice phase just below TC (A- phase) have been derived from susceptibility measurements[41]. The letters A, H, C TS and FP stand for the A-, helical, conical, tilted spiral and field polarized phases respectively.