Experimental report

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Proposal: 5-15-605 **Council:** 10/2012

Title: Skyrmion Lattice Phase FeCoSi

Research area: Physics

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Samples: Fe1−xCoxSi

Instrument	Requested days	Allocated days	From	To
D33	3	3	03/05/2013	06/05/2013
D22	3	0		

Abstract:

We propose to follow the appearance of the skyrmion lattice A-Phase in FeCoSi by SANS, In this way we will establish the phase diagram and address the debated questions of weather the A-Phase consists of several sub-pockets or not.

The pseudo-binary $Fe_{1-x}Co_xSi$, together with the archetype chiral system MnSi, belongs to the family of non-centrosymmetric cubic helimagnets (space group $P2_13$, B20-type structure), the ground state of which can be understood on the basis of a simple Hamiltonian containing three hierarchically ordered interaction terms [1]. The energy scales of these terms are so well separated that it is possible to distinguish between the different contributions: the strongest ferromagnetic exchange interaction fixes the spins at the longest range, the weaker Dzyaloshinskii-Moriya (DM) term, which arises from the lack of inversion symmetry of the B20 lattice structure, rotates the spins at the intermediate scales, whereas the weakest anisotropy term fixes the directions on the spins on the crystallographic lattice. $Fe_{1-x}Co_xSi$ exhibits helical spin order with a relatively long period, much longer than MnSi, in a concentration range $0.05 \leq x \leq 0.8$ and shows all intriguing features found in MnSi [2-5].

The experiment on D33 complemented previous studies of $Fe_{0.7}Co_{0.3}Si$ (x=0.3) under magnetic field applied using SANS [3], which found that at T=40 K, just below T_C, there is a field range around 30 mT perpendicular to the neutron beam, where one observes distinct diffuse spots, one pair along the field direction and another pair perpendicular to the field at the same time. This state known as the A-phase has more recently been identified as a skyrmion lattice state [5]. The experiment on D33 was performed with the magnetic field applied parallel to the neutron beam, the configuration where the 6-fold symmetry of the skyrmion lattice becomes visible. The wavelength was 6 Å. Below T_C magnetic irreversibilities become important and the results strongly depend on the magnetic history. For this reason measurements were mainly performed with the following protocols:

1. Zero Field Cooling: the sample was cooled down to the lowest temperature at zero magnetic field, then the magnetic field was applied and the patterns were recorded by increasing temperature
2. Fast Field Cooled: the sample was rapidly cooled down to the lowest temperature under a specific magnetic field and the patterns were recorded by increasing temperature.
3. Slow Field Cooling: a magnetic field was applied well above T_C and the SANS patterns were recorded by gradually cooling down the sample to the lowest temperature

Fig. 1 shows the temperature dependence of the total neutron intensity recorded by the detector as well as characteristic scattering patterns obtained under a magnetic field of 53 mT following the three protocols, after correction of the background. The magnetic field and temperature dependence of the intensity is given by Fig.2 and 3, on the basis of which it is possible to sketch a phase diagram, which is strongly dependent on the magnetic history of the sample, similarly to the reported results for $Fe_{0.8}Co_{0.2}Si$ [6].

References

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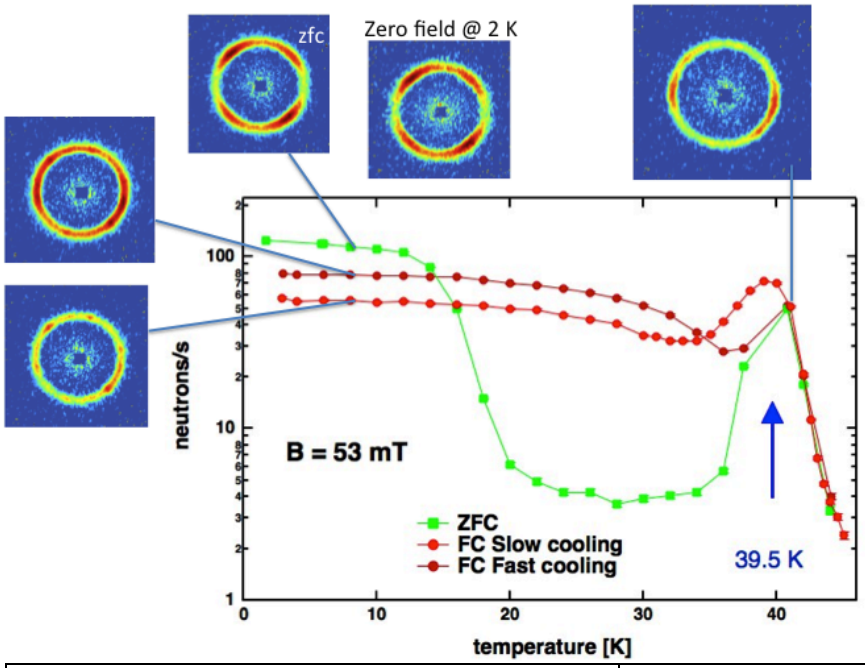

Figure 1:

Typical SANS patterns recorded at 53 mT with the magnetic field along the neutron beam and temperature dependence of the total scattered intensity recorded for different measuring protocols (see text). A distinct peak in the intensity is seen at 39.5K.

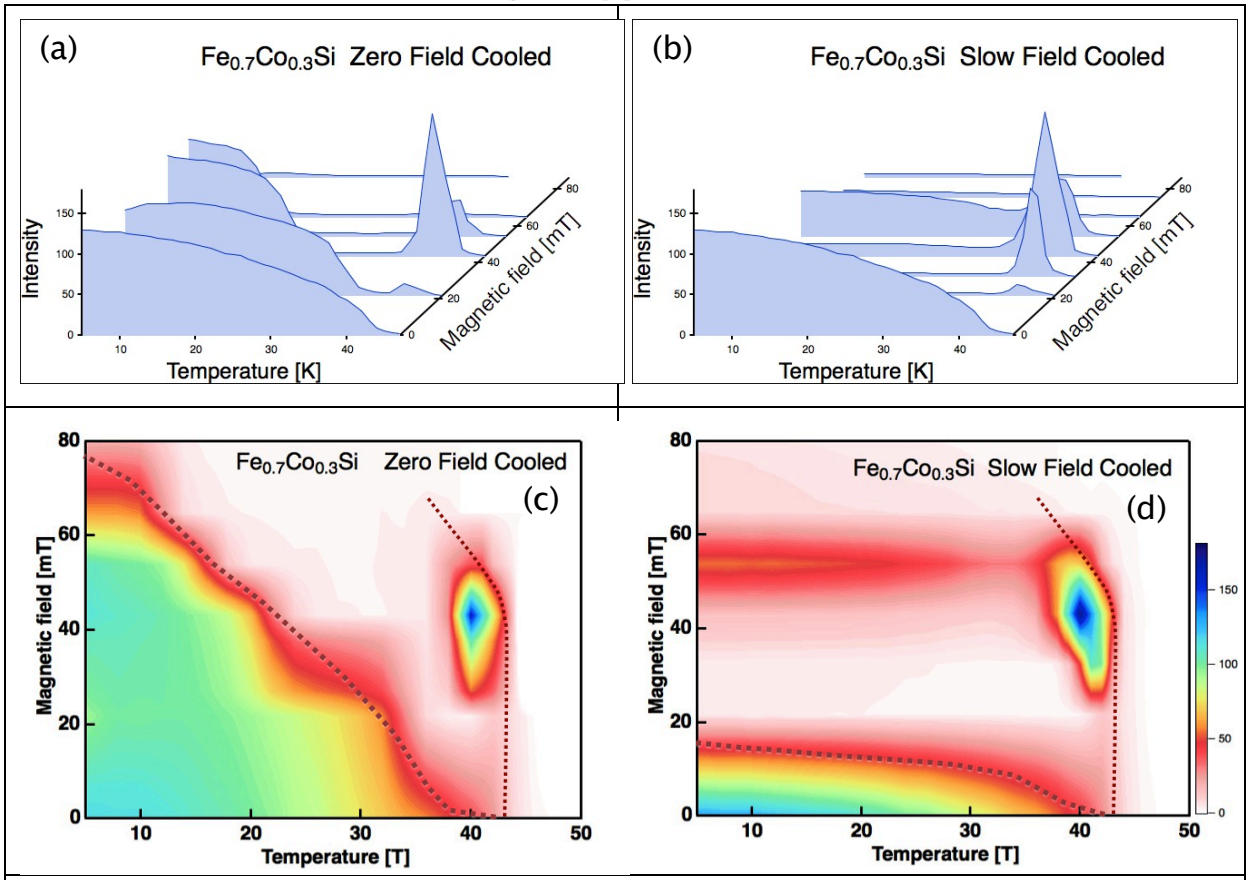

Figure 2: Magnetic field and temperature dependence of the total scattered intensity recorded by the detector for the zero field cooled (a and c) and the slow field cooled (b and d) procedures. The pocket of the skyrmion lattice phase is clearly visible close to T_C and from 20 to 60 mT, which extends down to the lowest temperatures only for the slow field cooled case. The zero field cooled curves on the other side, reveal an extended range of the helical phase.