Experimental Report

Proposal: **5-41-745** **Council:** 10/2012

Title: Magnetic structure of the non-centrosymmetric heavy fermion compound CeCoGe3

This proposal is a new proposal

Researh Area: Physics

Main proposer: **ADROJA Devashibhai T.**

Experimental Team: ADROJA Devashibhai T.
SMIDMAN Michael

Local Contact: CHAPON Laurent

Samples: CeCoGe3

Instrument	Req. Days	All. Days	From	To
D10	7	7	02/04/2013	09/04/2013

Abstract:

The non-centrosymmetric CeCoGe3 compound exhibits interesting physical properties. It orders antiferromagnetically with three ordering temperatures TN1=21K, TN2=12K and TN3=8K. The magnetization isotherm reveals the field induced metamagnetic transitions at 2K for H // c-axis. More interestingly it exhibits pressure-induced superconductivity (SC) with TC=0.7K at 5.5GPa. It would be interesting to correlate the role of the magnetic structure to SC in the CeTX3 (T=transition metals and x=Si and Ge) family of compounds. Despite the single crystal and polycrystalline neutron diffraction studies on CeCoGe3, the uniquesolution of the magnetic structure is not known. We therefore proposehere to use the high flux single crystal diffractometer D10 to investigate the magnetic structure in detailin zero-field at 2K, 10K and 16K as well as in applied field of 5T at 2K.

There has been considerable recent interest in heavy fermion (HF) compounds exhibiting a coexistence of superconductivity (SC) and magnetism. There are several examples of magnetic HF compounds displaying unconventional superconductivity close to a quantum critical point [1]. Compounds with the formula $CeTX_3$ (T = transition metals, X = Si, Ge, Al) have been extensively studied, since $CeCoGe_3$, $CeRhSi_3$ and $CeIrSi_3$ all order antiferromagnetically but display unconventional superconductivity under the application of pressure [2]. These materials crystallize in the non-centrosymmetric tetragonal $BaNiSn_3$ type structure (space group I4mm). $CeCoGe_3$ orders antiferromagnetically at T_{N1} = 21 K, which is the highest reported ordering temperature of the CeTX_3 compounds. $CeCoGe_3$ undergoes two further transitions at T_{N2} = 12 and T_{N3} = 8 K [3]. Previous single crystal neutron diffraction measurements at 2 K indicate the presence of two propagation vectors of $\mathbf{k_1}$ = (0,0,1/2) and $\mathbf{k_2}$ = (0,0,3/4) [4].

Plate like single crystals were grown using the flux method as outlined in Ref. [3]. One crystal was cooled in a helium-flow cryostat and measured on the D10 instrument with an energy analyzer. Figure 1 shows scans across (10*l*) at four temperatures, one above T_{N1} and one in each magnetic phase.

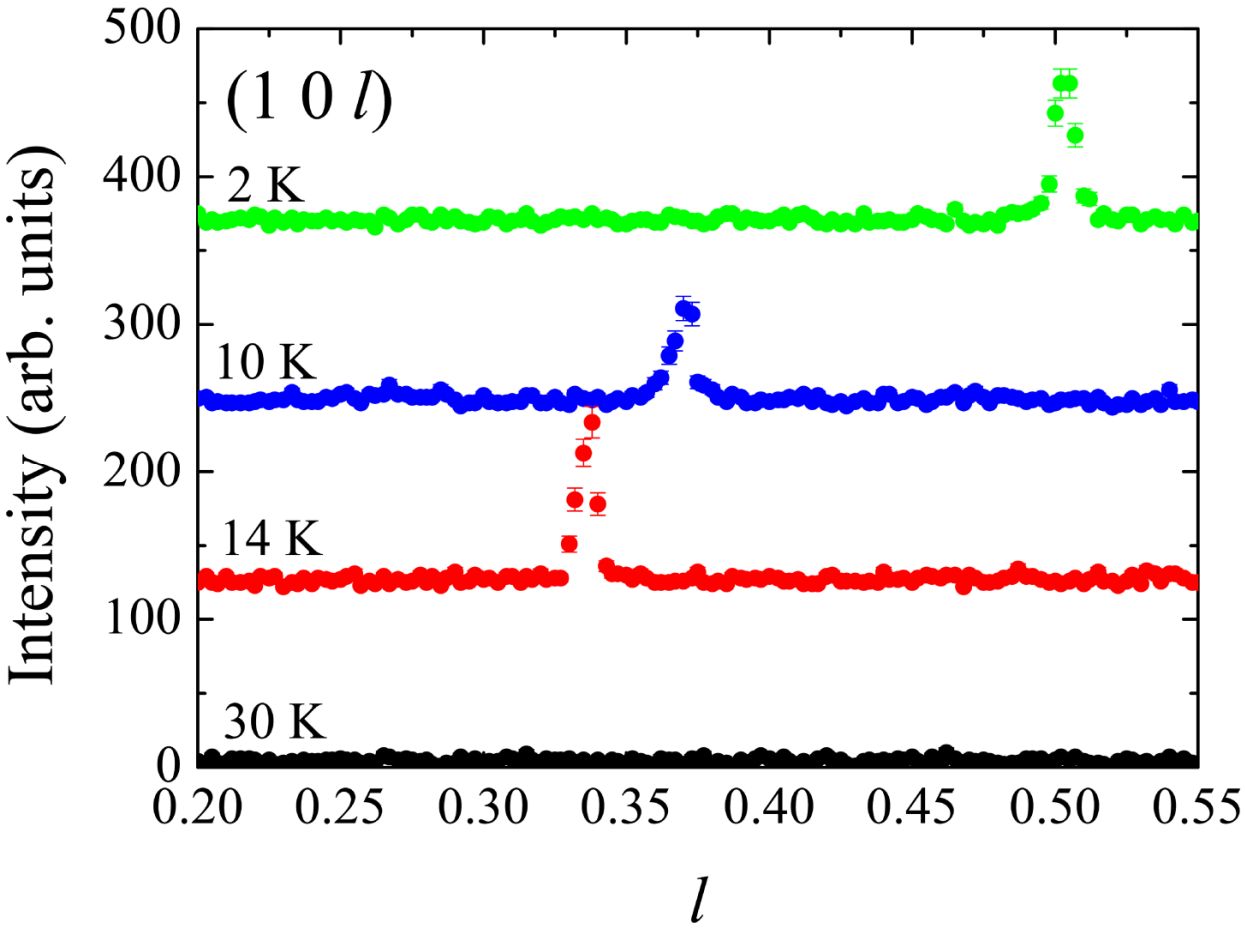

Figure 1. Elastic scans made across (10l) at four temperatures.

Only one peak is observed in each phase between (100) and (101). At 2 K there is a peak at *l* = 1/2 which shifts to *l* = 3/8 at 10 K and *l* = 1/3 at 14 K. This indicates the propagation vectors are **k** = (0,0,1/2) below T_{N3}, **k** = (0,0,5/8) between T_{N3} and T_{N2}, and , **k** = (0,0,2/3) between T_{N2} and T_{N1}. The propagation vector at 2 K agrees with $\mathbf{k_1}$ in Ref. [4] but no evidence for $\mathbf{k_2}$ is observed.

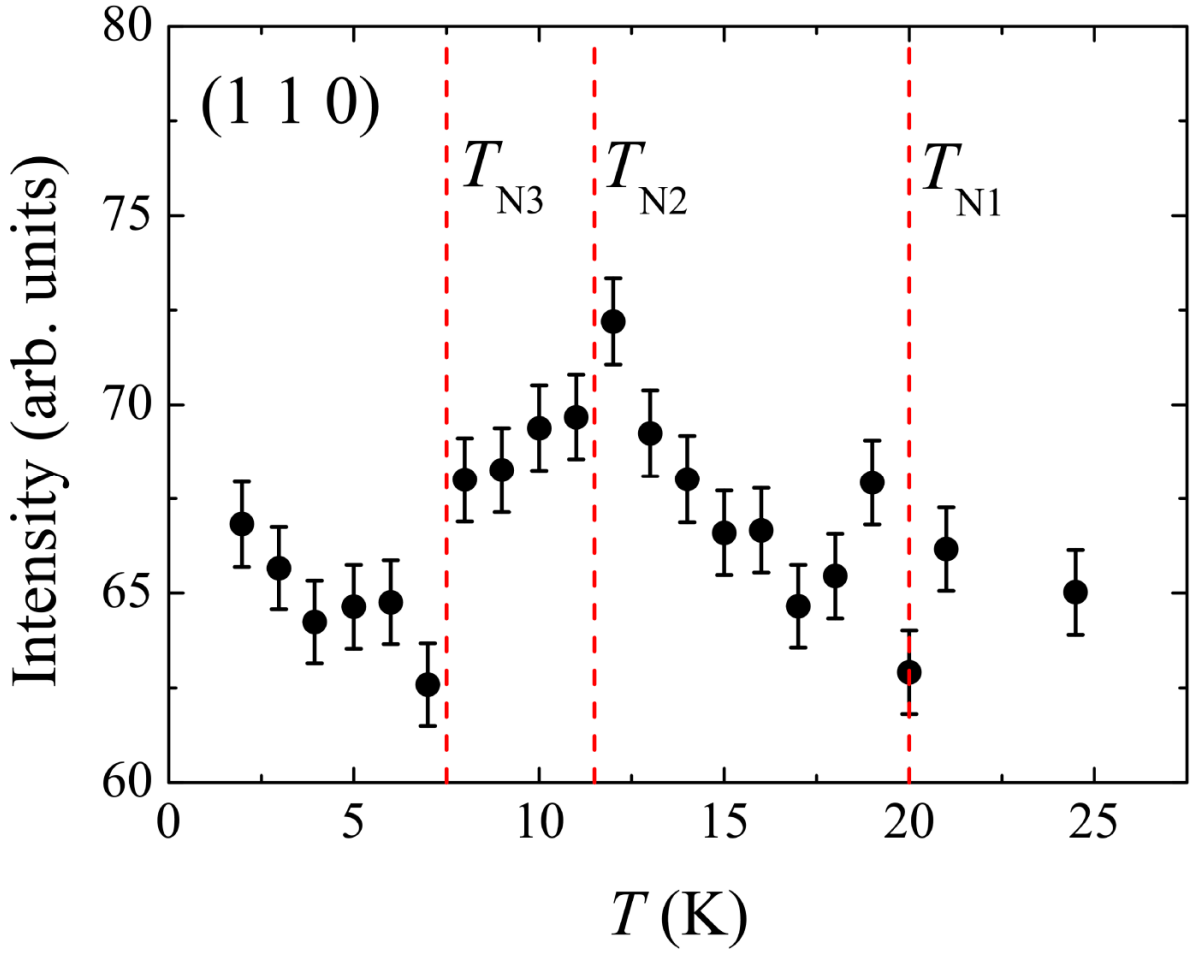

Figure 2. Temperature dependence of the integrated intensity of the (110) reflection.

Figure 2 shows the temperature dependence of the integrated intensity of the (110) reflection. The increased intensity between T_{N1} and T_{N3} indicates a ferromagnetic component in the two higher temperature magnetic phases.

At 35 K, the intensities of all accessible reflections (*hkl*) were collected. In each magnetic phase, the intensities of the magnetic reflections were collected at (*hkl*) ± **k**. 104 reflections were measured at 2 and 14 K while 57 were collected at 10 K. Magnetic peaks were not observed at (00*l*), indicating the ordered moments align along the *c* axis. The crystal and magnetic phases were fitted using FullProf. An *R* factor of 10.9 was obtained for the crystal structure at 35 K, while for the magnetic phases 21.5 was obtained at 2 K, 24.3 at 10 K and 22 at 14 K. Plots of F_{calc} against F_{obs} are shown in Fig. 3.

With a global phase of π/4, the structure at 2 K is compatible with an equal moment two-up, two down structure with an ordered moment of 0.405(5) μ_B/Ce. With a global phase of zero and the addition of a ferromagnetic component of -0.125 μ_B/Ce, an equal moment two-up, one down structure is obtained at 14 K. Further discussion of the experiment and results are given in Ref. [5].

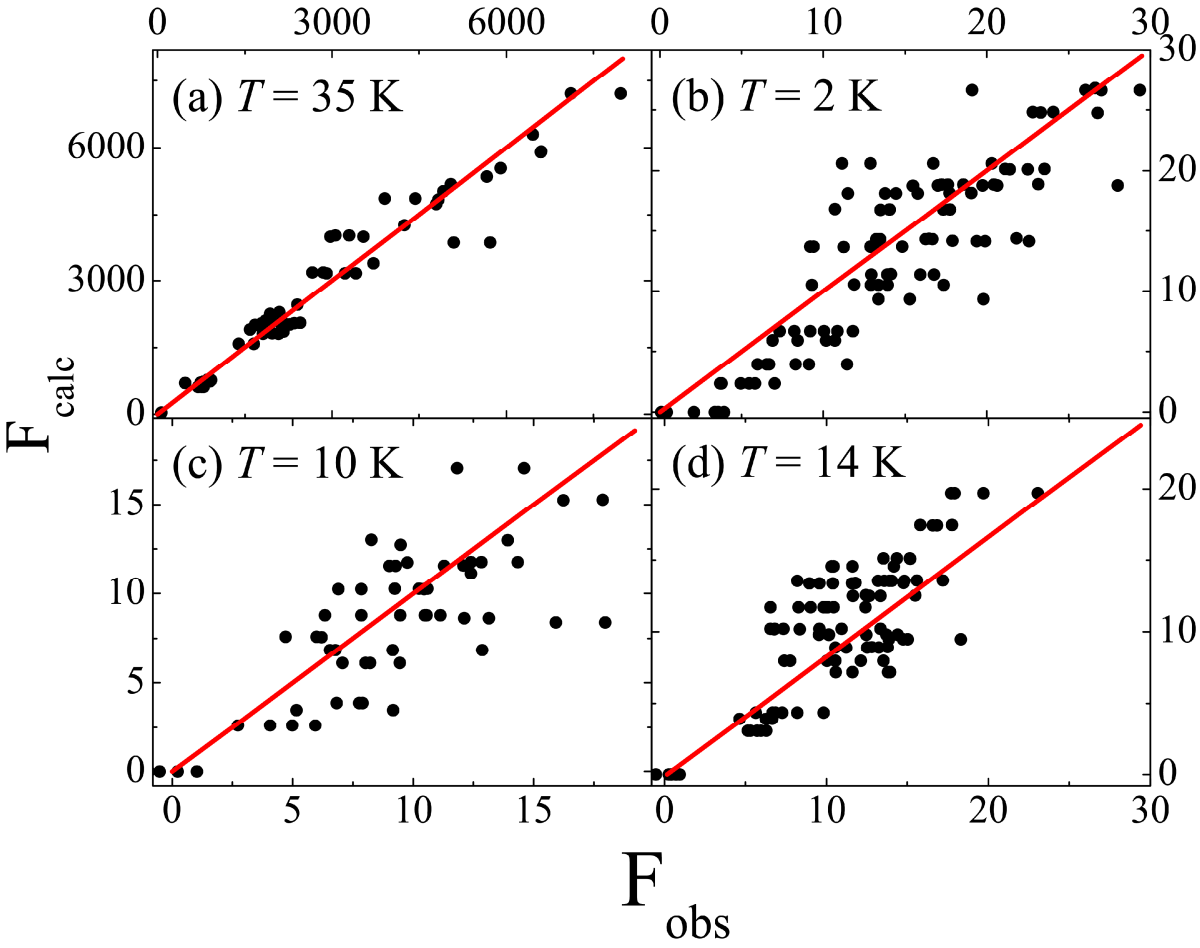

Figure 3. Plots of F_{calc} against F_{obs} for fitting (a) the crystal structure, (b)-(d) the magnetic structures of $CeCoGe_3$.

[1] N. D. Mathur et al., Nature **394**, 39 - 43 (1998).

[2] C. Pfleiderer, Rev. Mod. Phys. **81**, 1551 (2009).

[3] A. Thamizhavel et al., J. Phys. Soc. Jpn. **74**, 1858 (2005).

[4] K. Kaneko et al., J. Phys.: Conf. Ser. **150**, 042082 (2009).

[5] M. Smidman et al., Phys. Rev. B. **88**, 134416 (2013).