Experimental Report

26/02/2014

Proposal:	**5-31-2283**	**Council:**	10/2012		
Title:	Magnetic structure of the non-centrosymmetric heavy-fermion compound CePdSi3				
This proposal is a new proposal					
Research Area:	Physics				

Main proposer: **SMIDMAN Michael**

Experimental Team: SMIDMAN Michael

Local Contact: RITTER Clemens

Samples: CePdSi3
CeCuAl3
Nd2PdSi3

Instrument	Req. Days	All. Days	From	To
D20	2	2	25/02/2013	27/02/2013

Abstract:

There has been considerable recent interest in non-centrosymmetric heavy fermion superconductors which have been reported to exhibit unconventional behaviour, where the pairing wavefunctions are a mixture of singlet and triplet states. For example, at ambient pressure CeRhSi3 and CeIrSi3 show antiferromagnetic (AFM) ordering at 1.5 K and 5 K, respectively and exhibit superconductivity at 0.45-1.1 K and at 0.5-1.6 K, respectively, when subjected to an applied pressure. We propose to investigate the magnetic structure of the isostructural compound CePdSi3 on D20. This exhibits two AFM transitions at 5.2 K and 3 K. We will measure the magnetic structure, moment size, moment direction and the temperature dependence of the order parameter from 1.5 K to 7 K. We will compare these results to those predicted from fitting a crystalline electric field model to inelastic neutron scattering data. This will allow us to explore the changes in magnetic behaviour across the CeTSi3 system and help to understand the role of magnetism in the superconductivity of these compounds.

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). No superconductivity under pressure has been observed in $CeCuAl_3$ but the compound displays a vibron quasibound state due to magnetoelastic coupling between the crystal field and phonon excitations [3].

After discussions with the instrument scientist it was realised that due to problems with sample purity, it would be difficult to unambiguously determine the magnetic Bragg peaks of the $CePdSi_3$ phase, so a replacement $CeCuAl_3$ sample was measured on D20 with an incident wavelength of 2.41 Å. The nuclear refinement for the 50 K run is shown in Fig. 1. The lattice parameters are a = 4.24160 Å and c = 10.60743 Å. Although two small unindexed peaks are observed at 65.8 and 67.6°, the sample is very nearly single phase.

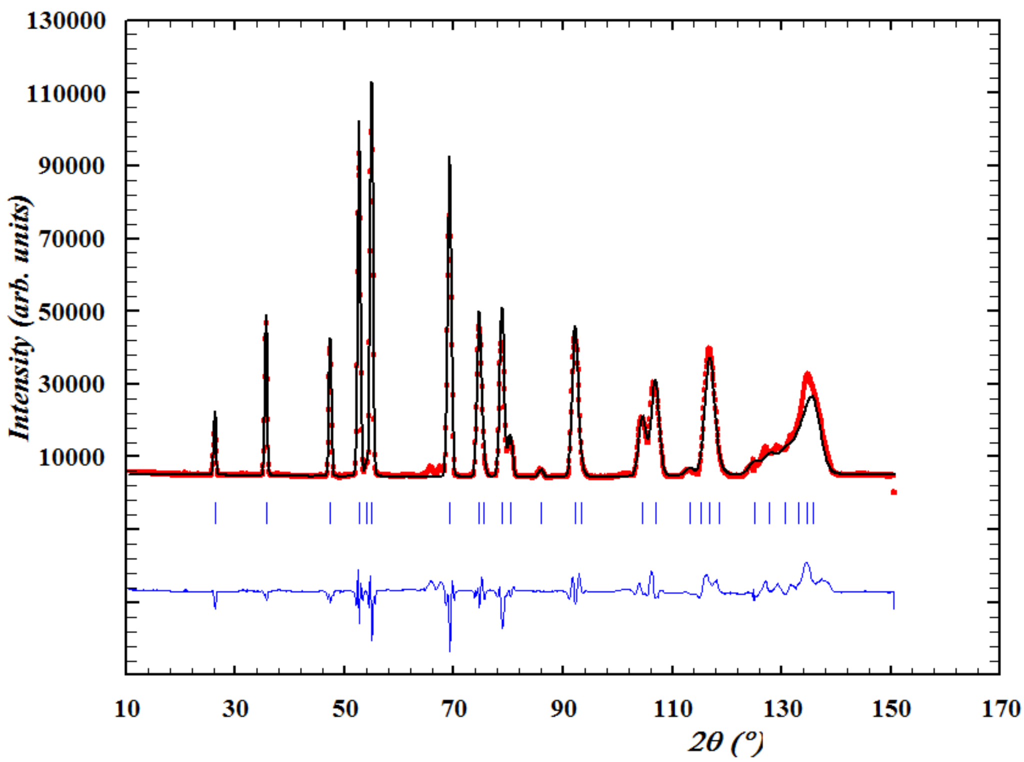

Figure 1. Diffraction pattern of $CeCuAl_3$ measured on D20 at 50 K with an incident wavelength of 2.41 Å. The solid lines show a structural refinement to the data.

$CeCuAl_3$ magnetically orders at T_N = 2.8 K and at 1.8 K additional Bragg peaks are observed, as shown in the top of Fig.2. These can be seen more clearly in bottom plot where the data at 10 K has been subtracted from that at 1.8 K. Several antiferromagnetic Bragg peaks can be identified, the most intense of which is at 23.7°.

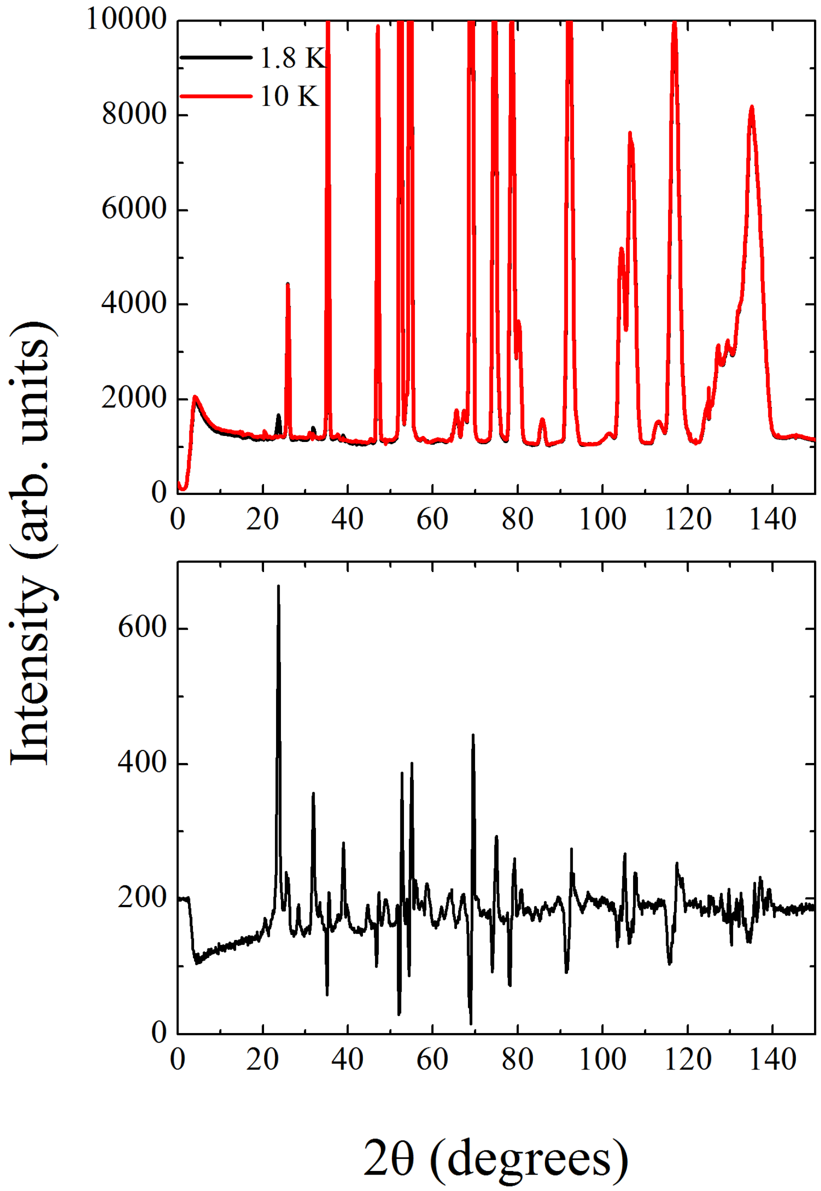

Figure 2. The top shows the diffraction pattern of $CeCuAl_3$ at 10 and 1.8 K. The bottom shows the 1.8 K data with the 10 K data subtracted and the addition of a constant background.

Diffraction patterns above the ordering temperature also show broad diffuse peaks in the magnetic Bragg peak positions. The top of Fig. 3 shows the diffraction pattern at 5 K with 50 K data subtracted. Instead of a magnetic Bragg peak at 23.7°, a broad diffuse peak is observed. The integrated intensity of one of the magnetic peaks is shown at the bottom of Fig. 3. The peak intensity decreases with temperature and there is a sharp change in gradient at around T_N. However, the integrated intensity remains finite up to at least 5 K, which indicates the presence of diffuse scattering over a relatively broad temperature range.

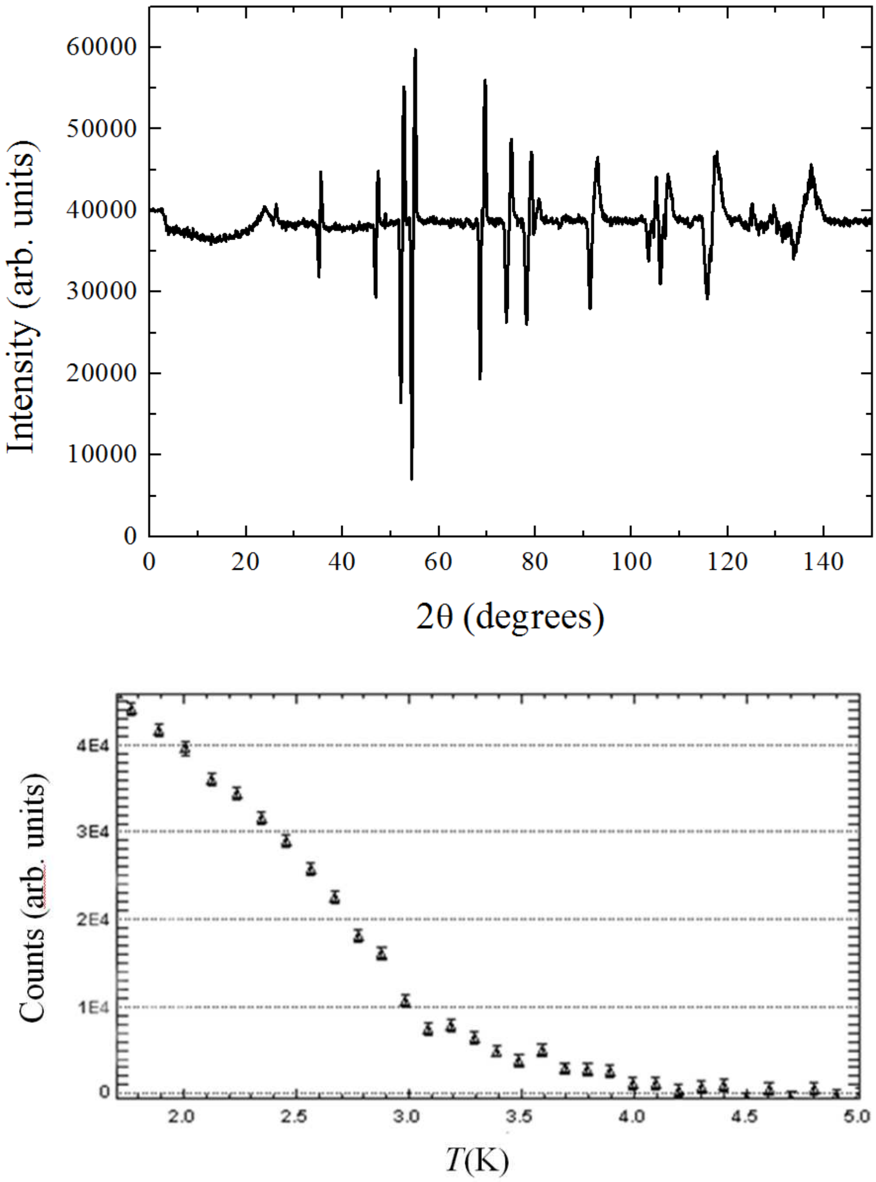

Figure 3. The top shows the diffraction pattern at 5 K with the 50 K data subtracted and a constant background added. The bottom shows the integrated intensity of a magnetic Bragg peak as a function of temperature.

[1] N. D. Mathur et al., Nature **394**, 39 - 43 (1998).
[2] C. Pfleiderer, Rev. Mod. Phys. **81**, 1551 (2009).
[3] D. T. Adroja et al., Phys. Rev. Lett. **108**, 216402 (2012).