Experimental Report

06/11/2013

Proposal:	**5-14-252**	**Council:**	10/2012	
Title:	Influence of frustration on the magnetic order in CePdAl			

This proposal is continuation of: 5-41-603

Researh Area: Physics

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Samples: CePdAl

Instrument	Req. Days	All. Days	From	To
D10	7	7	02/05/2013	09/05/2013

Abstract:

CePdAl is a geometrically frustrated heavy fermion compund that orders antiferromgnetically below TN = 2.7 K with an incommensurate structure with Q = (0.5 0 0.35)and is in the vicinity to a quantum cristical point (QCP). Only 2/3 of the Ce moments show long-range-order below TN, while the remaining 1/3 shows only short-range-ordering which is directly connected to the frustration in the system. While TN can be changed by pressure or concentration tuning, frustration is supposed to span a new axis in the parameterspace in tuning a QCP. We propose to study the influence of geometrical frustration on the magnetic order and TN in CePdAl. Therefore we want to apply uniaxial pressure along the ab-plane in order to decrease the symmetry of the Ce-triangles and therby lift the frustration.

Influence of frustration on the magnetic order in CePdAl

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The role of magnetic frustration for quantum critical points has been stressed in recent developments in theoretical physics [1] and triggered interest in potential model systems. A good candidate is CePdAl, a heavy-fermion compound with Néel temperature $T_N = 2.7$ K which can be gradually suppressed to zero by Ni substitution on the Pd site [2]. Its hexagonal lattice structure with a Kagomé-like basal plane leads to frustration of one third of the magnetic moments, as was observed in powder neutron diffraction (figure 1) [3]. In single crystal neutron studies we have recently found that frustration is manifest in short-range order below T_N [4].

A frustrated magnetic system should be much more sensitive to a small uniaxial pressure than other compounds. A minor change of the lattice constants can influence both the Néel temperature and the domain population (due to the hexagonal structure, three magnetic domains, rotated by 120°, are expected in the ab plane of CePdAl). For a reliable estimate of the magnitude of these effects, it is necessary to have zero-pressure data from exactly the same setup. Using the pressure cell shown in figure 1, we have applied a pressure of around 0.04 GPa along the [110] direction; later the pressure was released by loosening the screws and the relevant scans were repeated.

Experiments were peformed at the diffractometer D10 with a wavelength $\lambda = 2.36$ Å. The scattering plane is spanned by the [001] and the $[1\bar{1}0]$ direction to access the reciprocal $(h0l)$ plane (since $Q_{\mathrm{AFM}} = (0.5\ 0\ \tau)$, $\tau \approx 0.35$). Our CePdAl single crystal (m=0.32 g) was cooled to 1.9 K with a ^{4}He cryostat. First, omega scans across several nuclear and magnetic Bragg peaks were measured. Then, the temperature dependence of the (1.5 0 -0.35) reflection was studied by taking scans along l at temperatures between 1.9 K and 5 K.

Comparing results from p=0.04 GPa and p=0, we note a strong loss in intensity of the magnetic Bragg peaks under pressure (approximately a factor of 4 at 1.9 K), see figure 1. The peak position and width stay unchanged, as does the Néel temperature within the resolution of our data (from thermal expansion measurements, the effect of uniaxial pressure along the a axis on the Néel temperature was estimated to be 0.4 K/GPa, which corresponds to 16 mK in our measurement). Furthermore, position and intensity of the nuclear Bragg peaks remain the same with and without pressure. The drastic effect on the magnetic intensity, while the crystallographic and magnetic structure stay intact within the accuracy of the data, indicates significant changes in domain population.

Unfortunately, the pressure has induced twinning in the crystal, leading to a multi-peak structure in the scans that makes the interpretation of the data more difficult. In particular, it was not possible to fit the short-range order signal reliably.

For that reason, we have unmounted the pressure cell and exchanged the sample for a 1.8 g single crystal of CePdAl, glued to an aluminium sample holder. We have studied the anisotropy of the short-range order which we observed in our last D10 experiment [4]. Scans along h, k and l were taken at the (0.5 0 0.35) magnetic Bragg peak, at temperatures between 1.6 K and 5 K. As an example, a scan along l at 1.6 K is shown in figure 1. Short-range magnetic order is observed along all directions, with a mildly anisotropic correlation length ($\xi_h = 86$ Å, $\xi_k = 44$ Å, $\xi_l = 55$ Å at 1.6 K).

[1] P. Coleman and A. Nevidomskyy, J. Low Temp. Phys. 161 (2010), 182

[2] V. Fritsch *et al.*, arXiv:1301.6062 [cond-mat.str-el] (2013)

[3] A. Dönni *et al.*, J.Phys.: Condens. Matter 8 (1996), 11213

[4] S. Woitschach *et al.*, ILL experimental report to proposal 5-41-603

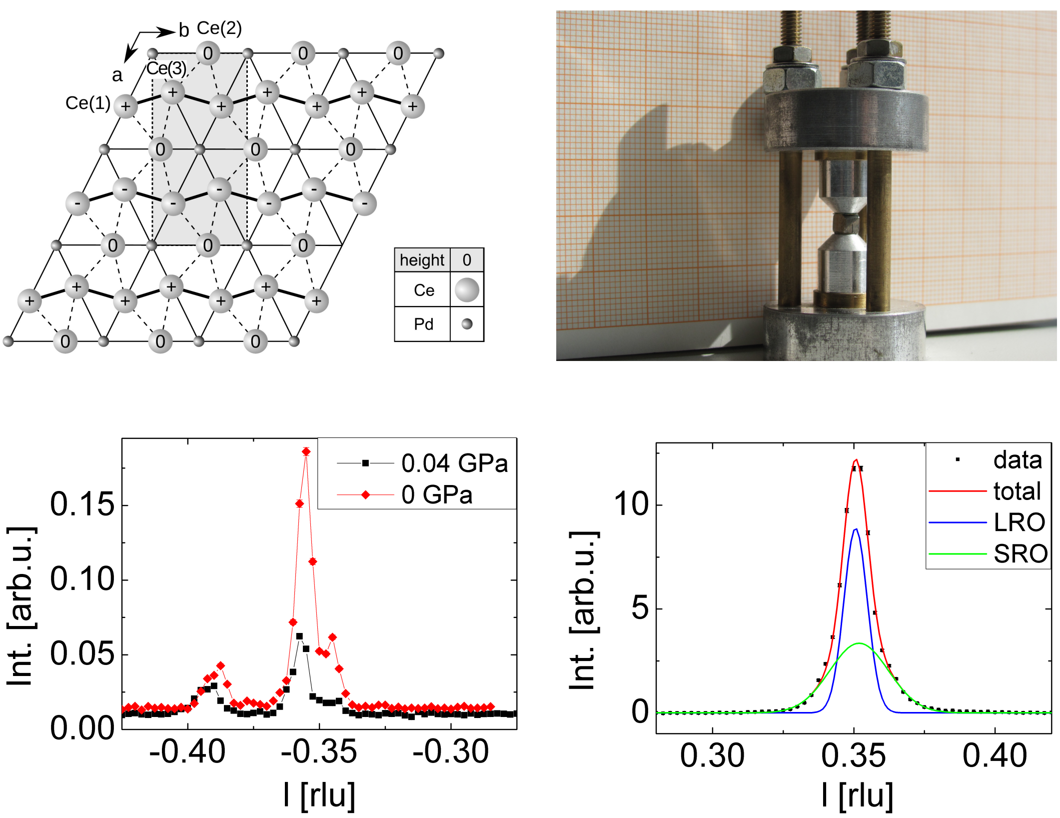

Figure 1: *Top left:* Model of the magnetic order in the basal plane of CePdAl [3]. *Top right:* Pressure cell with CePdAl single crystal. *Bottom left:* l-scan over the (1.5 0 -0.35) magnetic Bragg peak with and without uniaxial pressure (1.9 K). *Bottom right:* l-scan over the (0.5 0 0.35) magnetic Bragg peak without pressure cell, measured with a different crystal (1.6 K).