# Experimental report

09/11/2016

**Proposal:** **TEST-2677**

**Council:** 4/2016

**Title:** Magnetic excitations in CePdIn

**Research area:**

**This proposal is a new proposal**

**Main proposer:** **Milan KLICPERA**

**Experimental team:** Milan KLICPERA

**Local contacts:** Hannu MUTKA

**Samples:** CePdIn

| Instrument | Requested days | Allocated days | From | To |
| --- | --- | --- | --- | --- |
| IN6 | 1 | 1 | 04/11/2016 | 07/11/2016 |

**Abstract:**

# Experimental report

Experimental title: **Magnetic excitations in CePdIn**

Proposal number: **TEST-2677**

Instrument: **IN6**

Date of experiment: 4. – 7.11. 2016

Local contact: Hannu Mutka


Experimental team: Milan Klicpera[1,2]

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Abstract: CePdIn crystallizes in the hexagonal ZrNiAl-type structure (space group *P-62m*, 189). CePdIn orders antiferromagnetically with the Néel temperature $T_N$ = 1.7 K and a further magnetic phase transition is indicated by an additional anomaly in the specific heat data around 0.9 K. This transition is most probably connected with changes of the magnetic structure in CePdIn, but no microscopic experiments clarifying the details of this change have so far been reported. The study of CePdIn belongs to our broader research of Ce*T*In compounds with *T* = Ni, Pd, Pt. These compounds display very interesting behavior, varying between a magnetic ground state, Kondo lattice or valence fluctuating state, depending on the degree of mixing of f-electrons with conduction electrons near the Fermi surface. Despite the fact, that the substitution of d-elements in these compounds is isostructural and isoelectronic, it demonstrates a dramatic change of their electronic properties. The aim of proposed work is to study the energy spectra of CePdIn in order to obtain a first overall picture of magnetic excitations in this compound. This includes crystal-field excitations and possibly also some magnetic excitations at low temperatures.

Scientific background:

The hexagonal Ce*T*In compounds, where *T* = Ni, Pd, Pt, display very interesting properties varying between magnetic ground state, Kondo lattice or valence fluctuating state depending on the degree of mixing of f-electrons with conduction electrons near Fermi surface. The substitution of d-element in these compounds is isostructural and isoelectronic, nevertheless it demonstrates dramatic change from valence fluctuating state (*T* = Ni) to antiferromagnetic (*T* = Pd) or paramagnetic (*T* = Pt) state [1-3]. The physical properties are influenced by the change of the character of d-electrons but also by the change of lattice parameters with the substitution. These compounds exhibit a significant anisotropy in magnetic and transport properties which is considered to originate in the anisotropic hybridization effects of the f-electrons with the band electron states in addition to the bare crystal field effect [1,4].

CePdIn crystallizes in the ZrNiAl-type hexagonal structure. The previous measurements on polycrystalline samples suggested the antiferromagnetic order below $T_N$ = 1.7 K and a further magnetic phase transition around 0.9 K [3,5,6]. This transition is most probably connected with changes of the magnetic structure in CePdIn, but no microscopic experiments clarifying the details of this change have so far been reported.

Our recent investigation on Ce(Ni,Pd)In series showed dramatic change of physical properties with Ni-Pd substitution [7]. The isoelectronic substitution of Pd by smaller Ni atoms causes not only a change in the lattice parameters but also a significant change in the electronic properties in this series. $CeNi_{0.2}Pd_{0.8}In$ orders antiferromagnetically at $T_N$ = 1.3 K, and its Kondo temperature was estimated to $T_K$ = 3.8 K. Compared to CePdIn, we observe a decrease of $T_N$ and an increase of $T_K$. At the second end of the series, $CeNi_{0.8}Pd_{0.2}In$ behaves almost like the CeNiIn compound, so the valence fluctuating state takes place in this compound. The transition between antiferromagnetic order and the valence fluctuating state is intermediated by the anomalous non-Fermi-liquid state observed in compounds with 40% and 60% of Ni [7].

Aim of the experiment:

Aim of proposed work was to study the energy spectra of CePdIn in order to obtain a first overall picture of magnetic excitations in this compound. This includes crystal-field excitations and possibly also some magnetic excitations at low temperatures. The results will be discussed with our magnetization and specific heat data to obtain thorough information about electronic properties of CePdIn.

Results:

Inelastic neutron scattering experiments were performed on CePdIn powder sample. IN6 spectrometer and neutron wavelengths 4.14 Å and 5.12 Å were employed for the measurement of low-energy part of the spectrum. The measurement was done at several different temperatures (1.5, 5, 15, 25, 50 and 100 K) allowing to map a temperature evolution of observed spectra. The example of measured spectra is shown in Fig.1.

IN6 measurement did show no clear magnetic peak in the low-energy region. However, a pronounced, presumably magnetic, signal is observed on the system energy gain part of spectra (see Figs. 1 and 2). With increasing temperature (up to 25 K) this broad feature slightly loses intensity. Data measured at higher temperature are then influenced by temperature factor strongly. Further analysis of measured data will be done.

The elastic part of spectra measured at 1.5 K and 5 K, i.e. below and above antiferromagnetic phase transition, showed only minor differences. Weak magnetic peaks were found at $Q = 0.72$, 1.20, 1.34 and 1.48 $Å^{-1}$. These peaks represent the only information on magnetic structure so far. We were not able to determine the propagation vector of magnetic structure. Nevertheless, the magnetic structure in temperature interval (0.9, 1.7) K is incommensurate as no commensurate propagation vector was found for description of observed magnetic peaks. All found propagation vectors (describing observed peaks) have non-zero all three components.

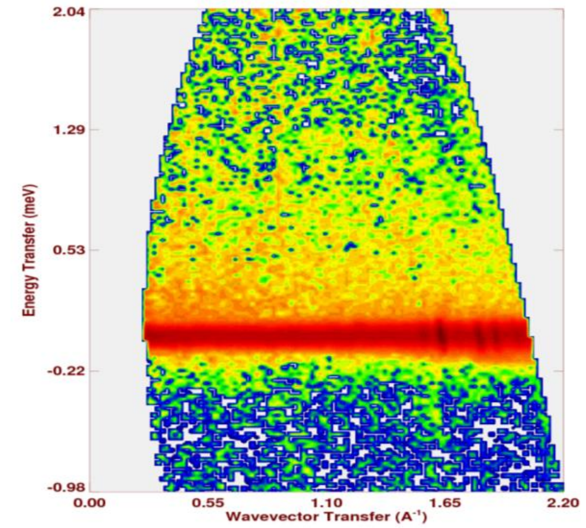


Fig.1 – *E*-*Q* map measured employing IN6 spectrometer and 5.12 Å wavelengths at 1.5 K on CePdIn powder sample.

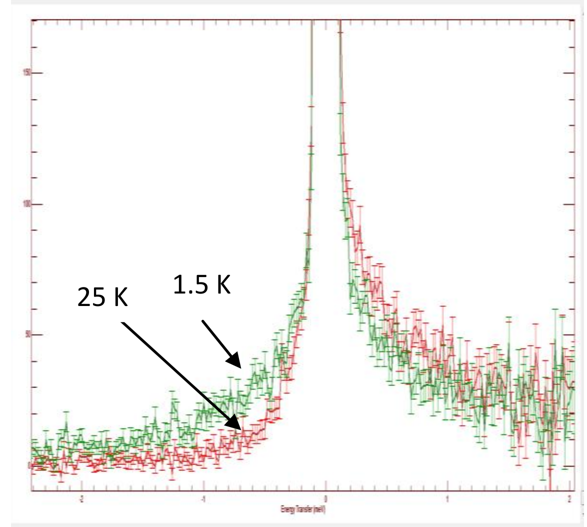


Fig.2 – Constant *Q*-cuts (at $Q = 1.2$ $Å^{-1}$) of data measured at 1.5 K and 25 K. Broad feture on system energy gain side of spectra slightly decreases with heating.

<u>References:</u>

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