Experimental report

08/07/2016

Proposal: **TEST-2629**

Council: 4/2016

Title: Test experiment - crystal field excitations in CePtIn

Research area:

This proposal is a new proposal

Main proposer: **Milan KLICPERA**

Experimental team: Milan KLICPERA

Local contacts: Hannu MUTKA

Samples: CePtIn

Instrument	Requested days	Allocated days	From	To
IN4	2	2	29/06/2016	01/07/2016

Abstract:

Experimental report

Experimental title: **Test experiment – crystal field excitations in CePtIn**

Proposal number: **TEST-2629; TEST-2616**

Instrument: **IN4; IN6**

Date of experiment: 29.6. – 1.7. 2016; 8.6. – 9.6. 2016

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Abstract: CePtIn crystallizes in the ZrNiAl-type hexagonal structure (space group P-62m, 189). The previous measurements suggest that the RKKY interaction is dominant in compound but the absence of magnetic phase transition down to 60 mK implies also the strong influence of Kondo interaction in CePtIn. Moreover, non-Fermi-liquid behavior is observed in CePtIn. The value of c/T at 60 mK is ≈ 1 J.mol−1.K−2 which classifies CePtIn as heavy-fermion system. Specific heat shows strong increase with decreasing temperature which is, to some extent, suppressed by applied magnetic field. The low-temperature electrical resistivity also deviates from the T^2 dependence. The aim of proposed work is to study the energy spectra of CePtIn 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].

CePtIn crystallizes in the ZrNiAl-type hexagonal structure. The previous measurements on polycrystalline samples suggested that the RKKY interaction is dominant but the absence of magnetic phase transition down to 60 mK [3] implies also the strong influence of Kondo interaction in CePtIn. Moreover, non-Fermi-liquid (nFL) behavior is observed in CePtIn or rather in $Ce_{0.7}La_{0.3}PtIn$ [5]. The value of c/T at 60 mK is ≈ 1 $J.mol^{-1}.K^{-2}$ which classifies CePtIn as heavy-fermion system [3].

We have grown a single crystal of CePtIn and investigated it thoroughly by means of magnetization, specific heat and electrical resistivity measurements [6]. In agreement with previous results on polycrystalline samples [5], we observe signs of nFL behavior. Specific heat of CePtIn shows strong increase with decreasing temperature which is, to some extent, suppressed by applied magnetic field. The low-temperature electrical resistivity also deviates from the T^2 dependence [6]. The *H/M(T)* dependencies along both directions follow the Curie-Weiss law with effective moment close to the Ce^{3+} ion value and a large negative paramagnetic Curie temperature (~ −65 K) above 50 K and deviates from C-W law at lower *T* with a strong increase of magnetization. Magnetization easy-axis is the c-axis.

Aim of the experiment:

Aim of proposed work was to study the energy spectra of CePtIn 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 CePtIn and can be followed by single crystal neutron scattering experiments on existing single crystal.

Results:

Inelastic neutron scattering experiments were performed on CePtIn powder sample. IN6 and IN4 spectrometers were employed for the measurement of low-energy and high-energy part of the spectrum, respectively. The measurement was done with several incident wavelengths (4.14, 2.2, 1.68 and 0.84 A) and at several different temperatures (1.5, 30 and 80 K) allowing to map both large part of *E*-*Q* space and the temperature evolution of observed excitations.

IN6 measurement did show no excitation in the low-energy region. We were able to identify several phonon excitations – both acoustic and optic branches in the *E*-*Q* maps measured employing IN4 spectrometer, but did not observe any magnetic signal. According to the magnetic specific heat data presented in Ref. [6], we expected crystal field excitation at around 10 meV in CePtIn. We are really able to observe a peak at this energy; however this excitation is not of magnetic origin, which is demonstrated in Fig. 1. Both temperature dependence and *E*-*Q* map (low *Q*) point out to the phonon origin of observed excitation. We performed measurement on IN4 in several incident energies going up to 100 meV and observe no magnetic excitation.

To explain the absentce of crystal field excitations in the energy spectrum of CePtIn, one can suppose that this compound is valence fluctuator similarly to CeNiIn [1]. One can suppose that the valence of Ce ions is not 3+ but higher and thus these ions are non-magnetic. However, we observe some magnetic contribution to the specific heat [6]. To explain this discrepancy is highly desirable and we expect to find the answer in further investigation of measured date – mainly specific heat data.

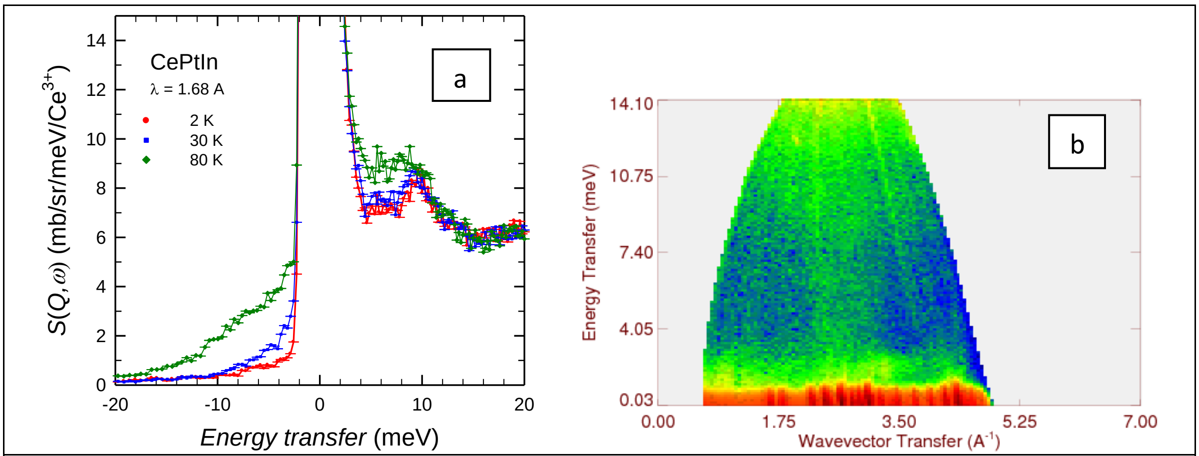

Fig.1 – INS data measured employing IN4 spectrometer on CePtIn powder sample. Panel a) shows the temperature dependence of *Q*-cuts measured with incident wavelength 1.68 A. Panel b) displays the *E*-*Q* map measured with incident wavelength 2.2 A showing no magnetic signal in the data. Only phonon contribution to the spectra is observed.

<u>References:</u>

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