Experimental report

18/09/2024

Proposal: 4-04-512 **Council:** 4/2021

Title: Crystal filed excitations of a honeycomb Kondo lattice CePt6Al3 with Pd-doping and reference compound NdPt6Al3

Research area: Physics

This proposal is a new proposal

Main proposer: Devashibhai T. ADROJA

Experimental team: Michael Marek KOZA

Local contacts: Michael Marek KOZA

Samples: Ce(Pt1-xPdx)6Al3 (x=0.1 and 0.2
NdPt6Al3 an YPt6Al3

Instrument	Requested days	Allocated days	From	To
PANTHER	4	3	12/05/2021	15/05/2021

Abstract:

Recently the honeycomb lattice has attracted considerable attraction due to the bond dependent exchange interactions according to the Kitaev model, resulting in a quantum spin-liquid ground state. We have synthesised a new Ce-based honeycomb lattice compound CePt6Al3, which exhibits heavy Fermion behaviour and long-range magnetic ordering at 0.75 K as evident from a peak in the ac-susceptibility and heat capacity. The magnetic entropy indicates a doublet ground state and a quasi-quartet excited state under the crystal electric field (CEF). Our inelastic neutron scattering study of CePt6Al3 reveals a CEF excitation near 15 meV at 5 K that exhibits unusual temperature dependence, the peak goes down to 10 meV at 170 K. Considering the honeycomb lattice of CePt6Al3, one would expect a presence of unconventional magnetic excitations. We therefore propose to investigate the CEF excitations in Ce(Pt1-x)6Al3 (x=0.1 and 0.2), which exhibit magnetic ordering at around 3 K and the magnetic reference NdPt6Al3, which exhibits magnetic ordering at 1.25 K, using PANTHER to understand the unusual temperature dependence of the CEF excitations in CePt6Al3.

Title: Crystal filed excitations of a honeycomb Kondo lattice $CePt_6Al_3$ with Pd-doping and reference compound $NdPt_6Al_3$

Proposal No: 4-04-512, PANTHER

Aim of the proposal: Recently the honeycomb lattice has attracted considerable attraction due to the bond dependent exchange interactions according to the Kitaev model, resulting in a quantum spin-liquid ground state. We have synthesised a new Ce-based honeycomb lattice compound CePt6Al3, which exhibits heavy Fermion behaviour and long-range magnetic ordering at 0.75 K as evident from a peak in the ac-susceptibility and heat capacity. The magnetic entropy indicates a doublet ground state and a quasi-quartet excited state under the crystal electric field (CEF). Our inelastic neutron scattering study of CePt6Al3 reveals a CEF excitation near 15 meV at 5 K that exhibits unusual temperature dependence, the peak goes down to 10 meV at 170 K. Considering the honeycomb lattice of CePt6Al3, one would expect a presence of unconventional magnetic excitations. We therefore propose to investigate the CEF excitations in Ce(Pt1-x)6Al3 (x=0.1 and 0.2), which exhibit magnetic ordering at around 3 K and the magnetic reference NdPt6Al3, which exhibits magnetic ordering at 1.25 K, using PANTHER to understand the unusual temperature dependence of the CEF excitations in CePt6Al3.

Experimental results from PANTHER:

I. **CEF excitations in $NdPt_6Al_3$**:

The inelastic excitations from $NdPt_6Al_3$ and non-magnetic phonon reference compound YPt_6Al_3 are shown in Fig.1 (a-d). We also show the fitting of the CEF excitations based on the CEF model in Fig.1 (e-f). Fig.2 shows the fitting of the single crystal susceptibility of $NdPt_6Al_3$ based on the CEF model obtained from the inelastic data analysis.

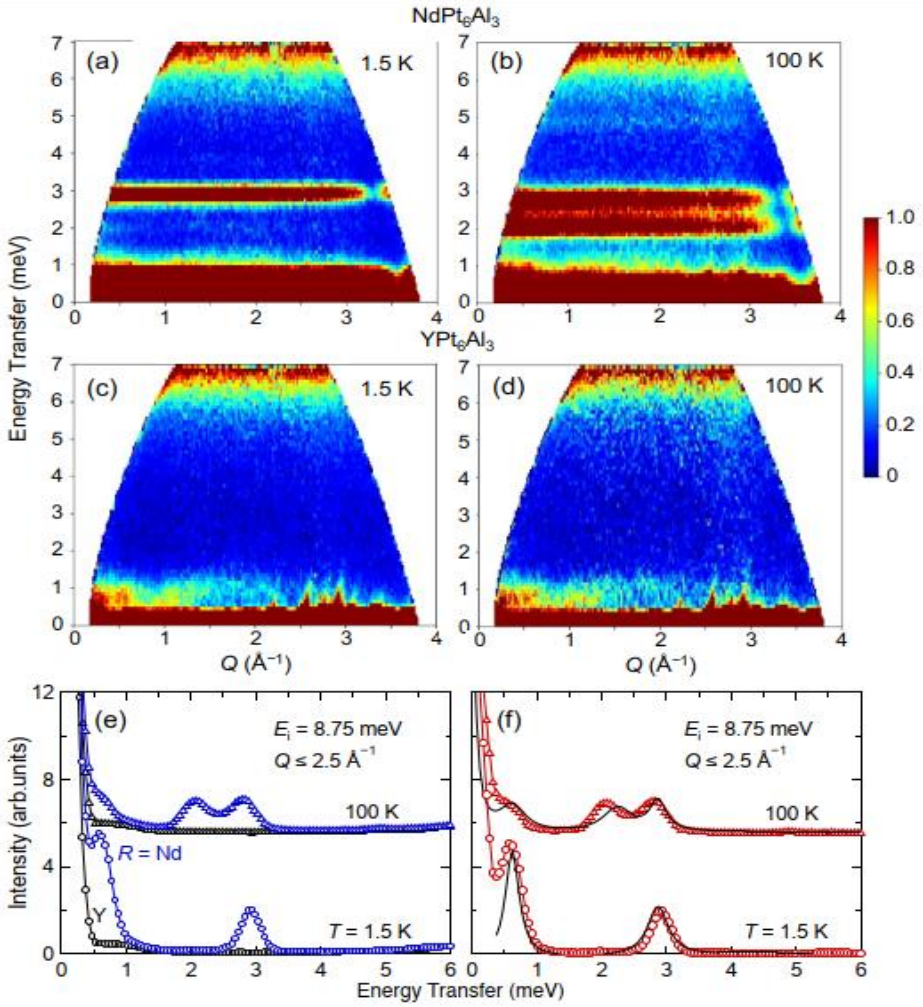

FIG. 1. (Color online) Color-coded plots of the inelastic neutron scattering intensity for $NdPt_6Al_3$ (a, b) and YPt_6Al_3 (c, d) as a function of energy transfer and momentum transfer with an incident energy Ei = 8.75 meV at 1.5 K (a, c) and 100 K (b, d). (e) Neutron scattering intensity as a function of energy transfer obtained by integrating the data in a |Q| range 0–2.5 $Å^{-1}$ for $NdPt_6Al_3$ (blue) and YPt_6Al_3 (black) at 1.5 and 100 K. The data at 100 K are offset for comparison. (f) The differential spectra (i.e. magnetic scattering) calculated by subtracting the intensity for YPt_6Al_3 from that for $NdPt_6Al3$. The solid lines (black) show the fits based on the CEF model for the Nd^{3+} ion.

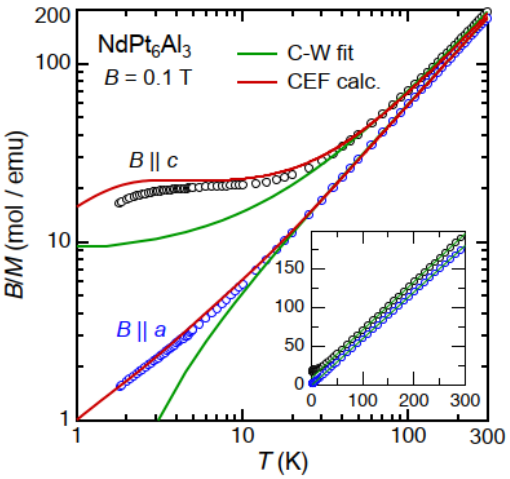

FIG. 2. (Color online) Temperature dependence of the inverse magnetic susceptibility B/M(T) of $NdPt_6Al_3$ single crystal for the magnetic fields B || a and B || c. The fits to the data for T > 100 K with a Curie-Weiss form are shown by the solid lines (green). The solid lines (red) represent the calculated B/M(T) data by using the CEF model for the Nd^{3+} ion (see text).

II. CEF study on $Ce(Pt_{1-x}Pd_x)_6Al_3$ x=0, 0.2 and 0.3

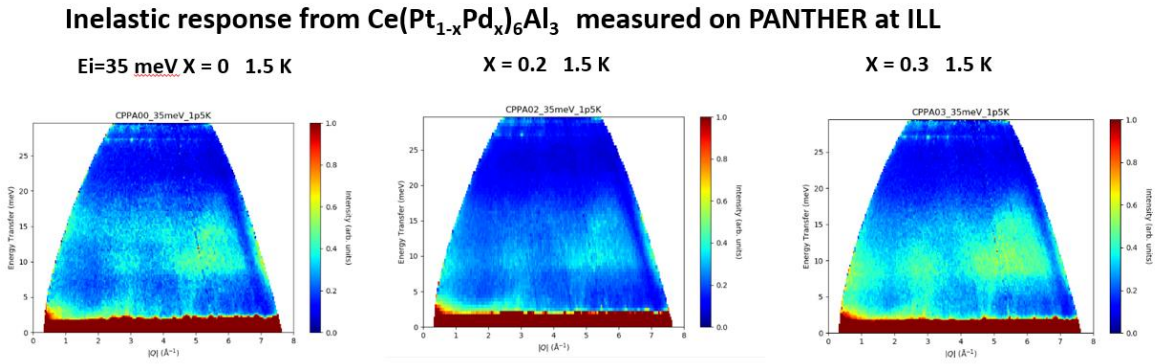

Fig.3 Shows the magnetic excitations in $Ce(Pt_{1-x}Pd_x)_6Al_3$ x=0, 0.2 and 0.3 at 1.5 K. The broad CEF excitations are see below 15 meV.

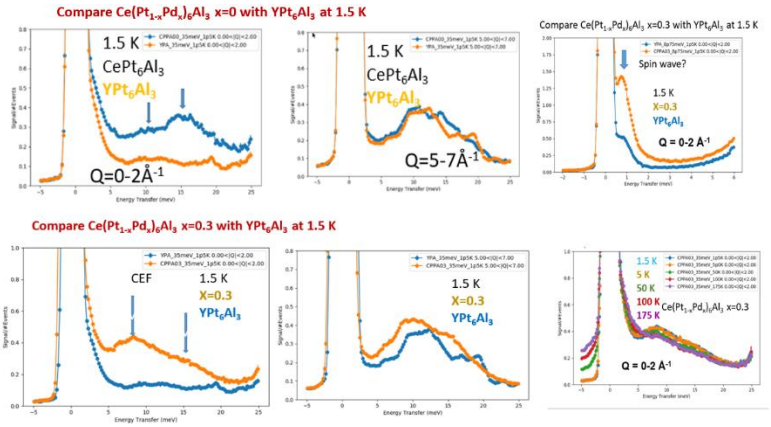

Fig.4 Shows the inelastic excitations from $Ce(Pt_{1-x}Pd_x)_6Al_3$ x=0 and 0.3 along with non-magnetic reference compound YPt_6Al_3 at 1.5 K Two CEF excitations observed are marked with an arrow in x=0 and 0.3. The bottom right figure shows the temperature dependence of CEF excitations in x=0.3. The top right figure shows the possible spin wave excitations in x=0.3.

A detail analysis of the CEF excitations in x=0, 0.2 and 0.3 is under progress.