Experimental report

16/09/2019

Proposal: 4-05-744 **Council:** 4/2019

Title: Search for metallic spin liquid state in the magnetically frustrated compound CePd1-xNixAl

Research area: Physics

This proposal is a new proposal

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Samples: CePd0.8Ni0.2Al

Instrument	Requested days	Allocated days	From	To
THALES	9	4	13/09/2019	17/09/2019
IN3	1	1	04/09/2019 11/09/2019	05/09/2019 12/09/2019

Abstract:

Magnetic frustration is predicted to be a tune parameter for unconventional quantum criticality with a Kondo breakdown and a spin-liquid phase of localized 4f moments being decoupled from conduction electrons.Such geometrical frustration in Kondo lattices has been found in hexagonal systems crystallizing in the ZrNiAl structure.Particularly in CePdAl, the Kondo coupling, magnetic frustration, and quantum criticality are closely intertwined in this correlated metallic system, which suggest a Kondo-destroying QCP can exist in a stoichiometric heavy-fermion metal far away from any kind of magnetic order. Moreover, with the chemical pressure from Ni dopings, the system can be also tuned to non-fermi-liquid behavior without any magnetic ground state but strong residual frustration. Here we propose to do neutron scattering experiments on the highly doped CePd1-xNixAl with x=0.2, to search the frustration-dominated spin liquid state in the metallic material.

Exp. Report: Search for metallic spin liquid state in the magnetically frustrated compound $CePd_{1-x}Ni_xAl$

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Magnetic frustration is predicted to be a tune parameter for unconventional quantum criticality with a Kondo breakdown and a spin-liquid phase of localized 4f moments being decoupled from conduction electrons. Such geometrical frustration in Kondo lattices has been found in hexagonal systems crystallizing in the ZrNiAl structure. Particularly in CePdAl, the Kondo coupling, magnetic frustration, and quantum criticality are closely intertwined in this correlated metallic system, which suggest a Kondo-destroying QCP can exist in a stoichiometric heavy-fermion metal far away from any kind of magnetic order. Moreover, with the chemical pressure from Ni dopings, the system can be also tuned to non-fermi-liquid behavior without any magnetic ground state but strong residual frustration. Thus $CePd_{1-x}Ni_xAl$ may intrinsically show a frustration-dominated spin liquid state as CePdAl. This state should further recover to metallic FL state under high field.

To search the metallic spin liquid state with frustration, we have proposed to do neutron scattering experiments on the highly doped $CePd_{1-x}Ni_xAl$ with x=0.2 at ThALES. A high quality single crystal with centimeter sizes and mass about 1.6 gram was aligned to [H, 0, L] scattering plane by hydrogen-free glue on a copper plate at IN3 triple-axis spectrometer (Fig.1). The sample mount have been put into a magnet (up to 10 T) with a dilution insert ($T_{min} \approx 60$ mK). We firstly check the magnetic order under zero field by measuring the possible Bragg peak at $Q_{AF} \approx$ (0.5, 0, 0.35) and (1.5, 0, 0.35) same as the undoped compound, to search the broad peak induced by frustration. We have searched the magnetic order throughout a large Brillouin zone, NO clear magnetic peak could be identified at 80 mK. The primary wavevector $Q_{AF} \approx$ (0.5, 0, 0.35) is very close to some ring-like signals from sample holder. We thus expected inelastic scattering around the second zone with $Q \approx (1.5, 0, 0.33 \pm \delta)$, where δ depends on the incommensurate propagation vector. We finally found a excitation mode at Q=(1.5, 0, 0.3) with E=0.4 meV. However, its behavior is very strange, there is no magnetic field effect on this mode. It slowly disperses to high Q by breaking into two branches, below 0.4 meV also shows two separate weak peaks, forming a "X" type crossing shape (Fig. 2). As beamtime was very limited, we only obtain some data along Q=[1.5, 0, L] direction at different energies with magnetic field B=10 T.

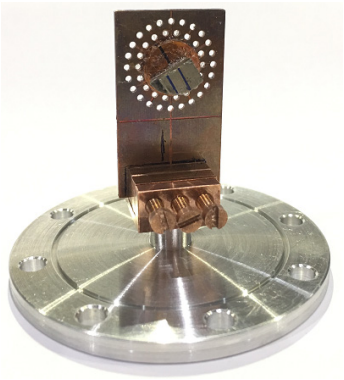

Fig.1 Aligned $CePd_{1-x}Ni_xAl$ crystal on copper plate.

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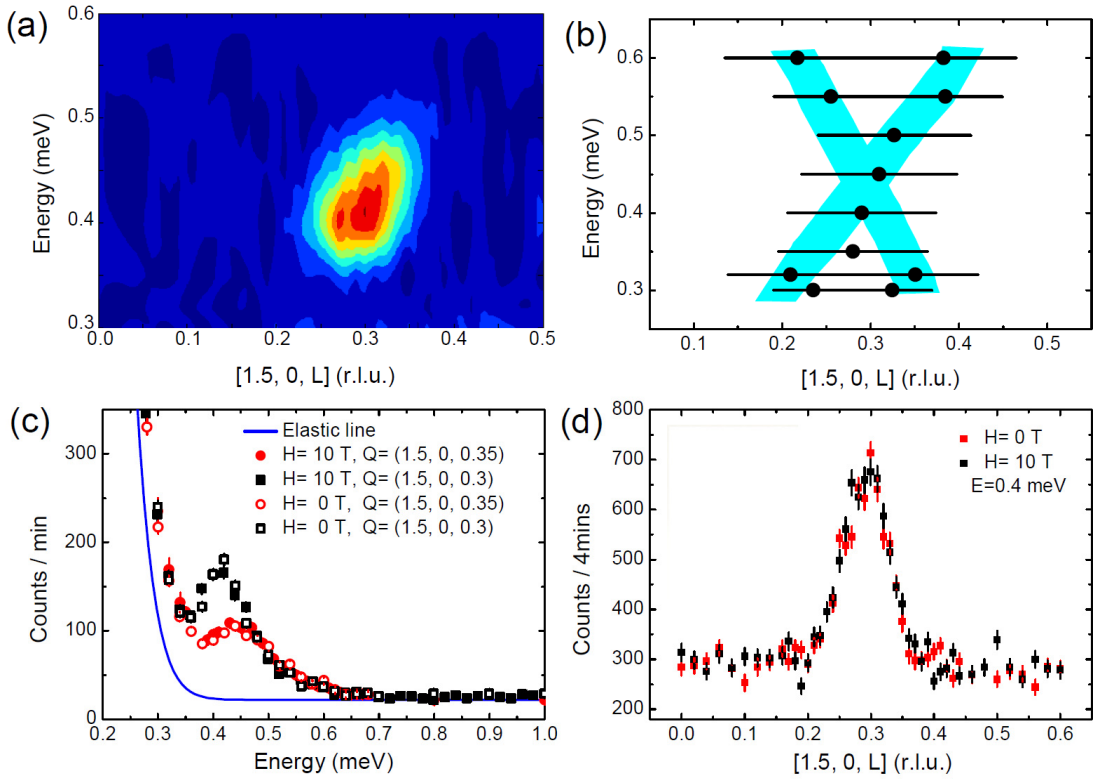

Fig. 2 Inelastic neutron scattering results of $CePd_{1-x}Ni_xAl$ (x=0.2) measured at ThALES.