Experimental report

16/09/2019

Proposal:	**4-03-1734**		**Council:**	4/2019
Title:	Quantum critical scaling in the quasi-1D heavy fermion CeCo2Ga8			
Research area:	Physics			

This proposal is a new proposal

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Samples: CeCo2Ga8 single crystals

Instrument	Requested days	Allocated days	From	To
IN5	8	4	09/09/2019	13/09/2019

Abstract:

Study of quantum critical point (QCP), which T=0 K quantm phase transition, is a great challenge in strong correlated materials, since it only emerges at zero temperature by tuning parameters like pressure, magnetic filed or chemical dopings. Many Ce- and Yb-based systems exhibit QCP and non-Fermi-liquid (NFL) behaviour. Theses systems are mainly 2D or 3D. There are not many examples for 1D systems exhibiting QCP and NFL behaviour without chemical doping/disordered, which creates disordered induced NFL and theoretical interpretation of QCP becomes more difficult. Very recently quasi-1D Kondo lattice system CeCo2Ga8 has been reported to exhibits NFL and QCP behavior without doping (also without disordered) and at ambient pressure. We therefore propose here to measure the energy and temperature dependence of spin excitations in single crystals of CeCo2Ga8 using the high neutron flux spectrometer IN5 to examine the quantum critical scaling (i.e. /T-scaling) behavior of the dynamical susceptibility. The present system is a model system to investigate both experimentally and theoretical to find out how the value of the critical exponent will change with the dimensionality.

Exp. Report: Quantum critical scaling in the quasi-1D heavy fermion $CeCo_2Ga_8$

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Study of quantum critical point (QCP), which T=0 K quantum phase transition, is a great challenge in strong correlated materials, since it only emerges at zero temperature by tuning parameters like pressure, magnetic field or chemical dopings [1-3]. However, the QCP also governs many novel dynamics at finite temperature with a quantum critical fluctuation region, giving results of many non-Fermi-liquid (NFL) behaviors, such as divergent Sommerfeld coefficient $\gamma(T)=C/T$ as the temperature goes to zero, and the nearly linear temperature dependence of resistivity [2,3]. Many Ce- and Yb-based heavy fermion materials systems exhibit QCP and non-Fermi-liquid (NFL) behavior [3,4]. These systems are mainly 2D or 3D. There are not many examples for 1D systems exhibiting QCP and NFL behavior without chemical doping/disordered, which creates disordered induced NFL and theoretical interpretation of QCP becomes more difficult [5, 6]. Very recently quasi-1D Kondo lattice system $CeCo_2Ga_8$ has been reported to exhibits NFL and QCP behavior without doping (also without disordered) and at ambient pressure [7]. We therefore have proposed to measure the energy and temperature dependence of spin excitations in single crystals of $CeCo_2Ga_8$, using the high neutron flux spectrometer IN5 to examine the quantum critical scaling (i.e. w/T-scaling) behavior of the dynamical susceptibility [8]. The aim of this study is to investigate both experimentally and theoretical to find out how the value of the critical exponent will change with the dimensionality.

We have grown about 10 grams $CeCo_2Ga_8$ single crystals. Since the shape of crystal is needle-like (quasi-1D) along c-axis, it is very difficult to distinguish the orientation in ab-plane, we then simply co-aligned them on copper plates with same orientation along c-axis to measure the spin excitations along L direction (c-axis ⊥ ki) and in the ab-plane (c-axis // ki) (Fig.1). With a dilution insert down to 60 mK and the incident neutron wavelength λ= 4.8 Å, spin excitations at a three temperatures T= 0.06, 1.5 and 10 K have been measured (Fig. 2). Here we simply define the ab-plane is along H direction. With a series rotation of sample around H and L axes from +15° to -15° with 1° /step, the excitation signals can be obtained up to 2. 5 meV. As shown in Fig.2, it should be noted that the horizontal bars probably from the instrument background, and the central shadow is due to the block effect from sample holder and inhomogeneous absorption of Co atoms. The magnetic scattering may exist around Q=(2, 0, 0.3), but it is very diffused. Since it is very hard to identify the spin excitations at dilution temperature, we further warm up the sample to 1.5 K and 10 K. The data at 1. 5 K show almost no difference between 0.06 K, but weak difference between 10 K(Fig. 3(a)(b)). As the energy loss and energy gain exhibit asymmetric temperature dependence, it is thus confirmed that the quasi-elastic signal is magnetic (Fig. 3(c)). Further experiments are required to give a proper w/T scaling.

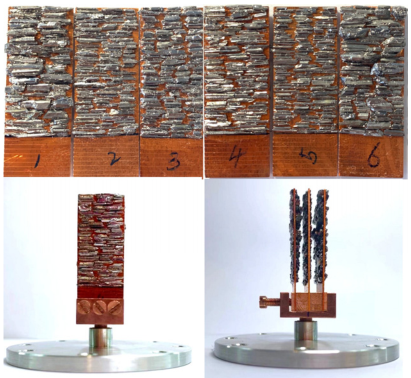

Fig.1 Co-aligned $CeCo_2Ga_8$ crystals in our inelastic neutron scattering experiment.

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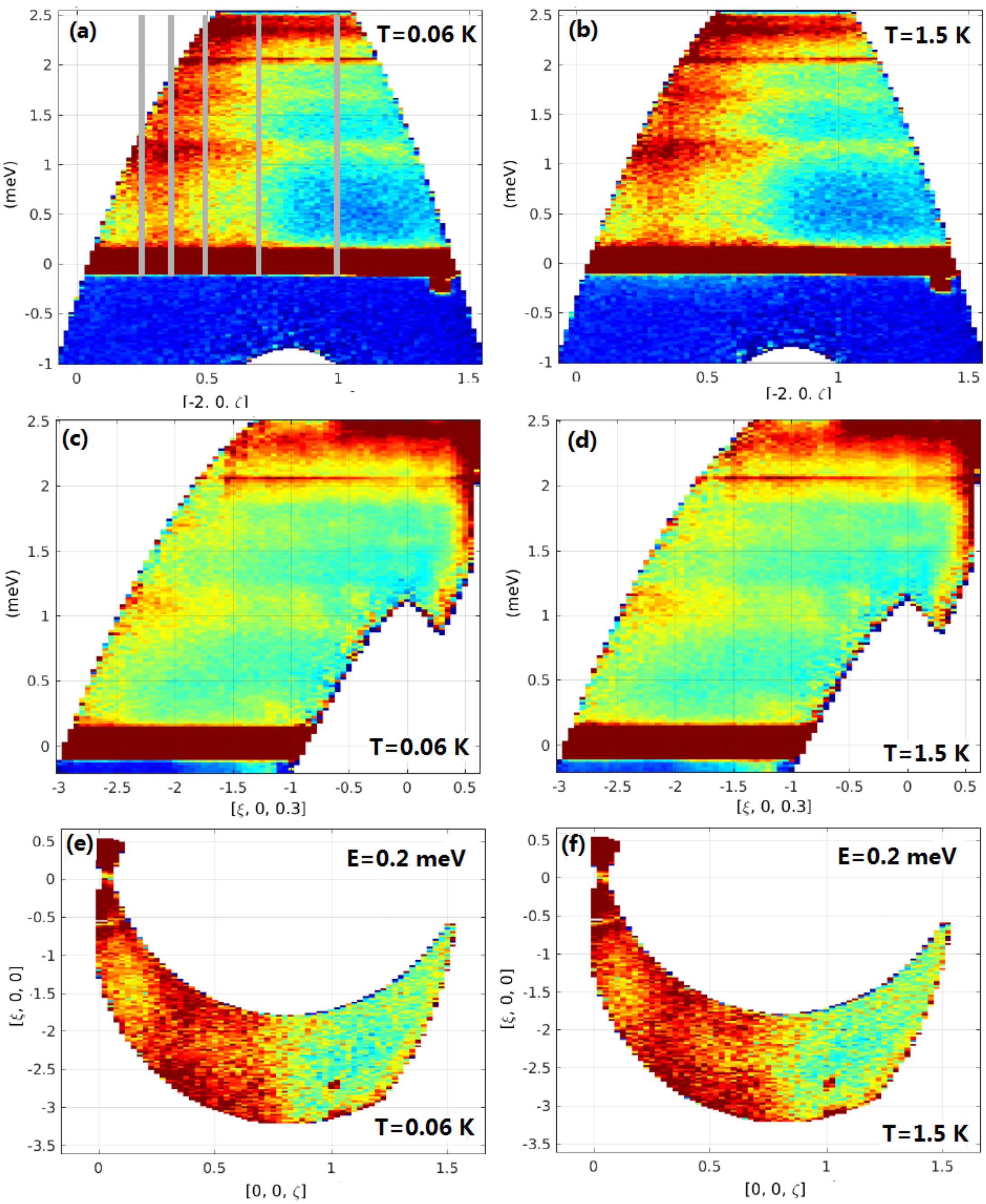

Fig. 2 Inelastic neutron scattering results of $CeCo_2Ga_8$ measured at IN5 with T=0.06 K and 1.5 K.

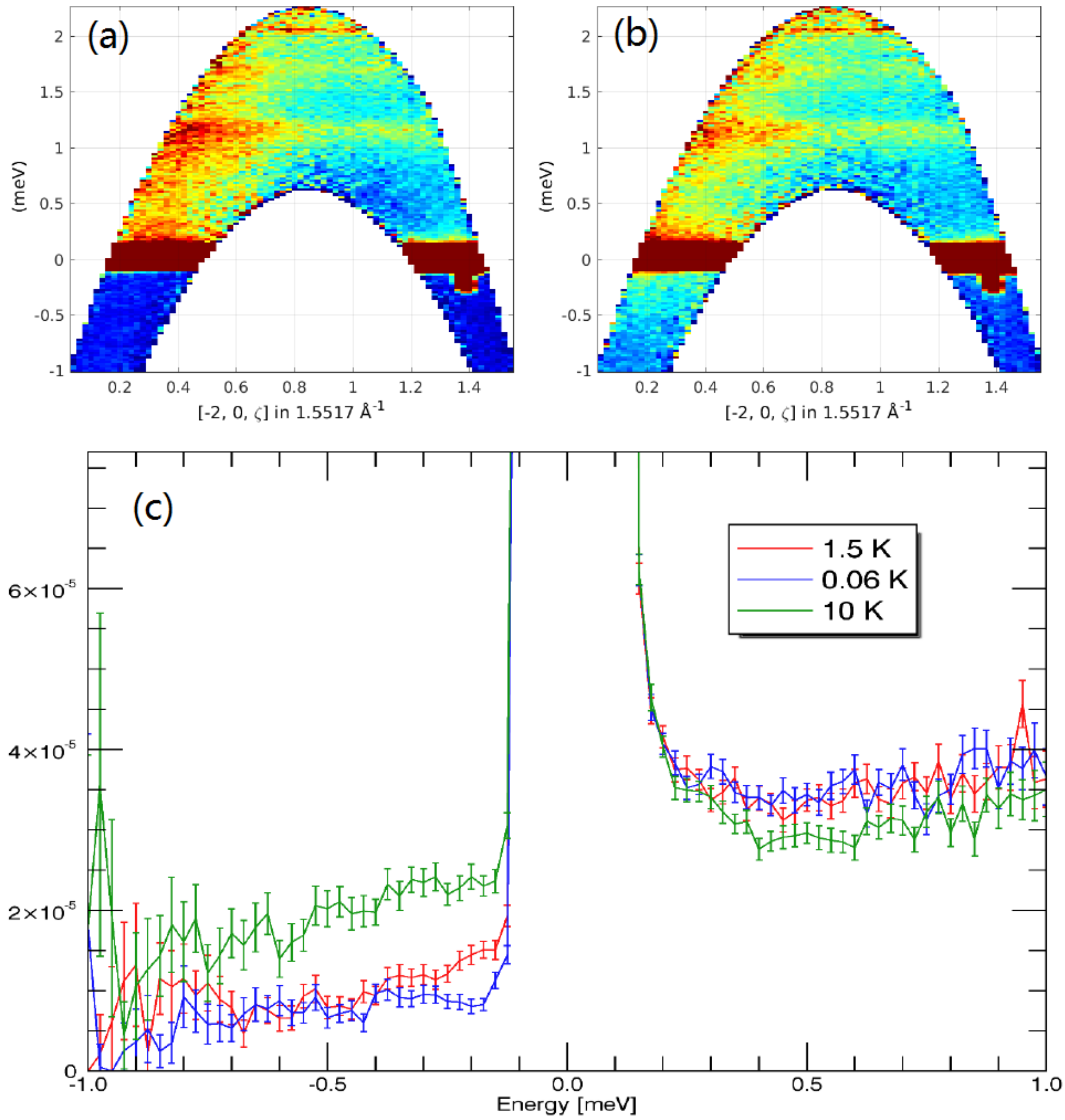

Fig. 3 Comparison of elastic neutron scattering spectrum of $CeCo_2Ga_8$ at T=0.06 K, 1.5 K and 10 K.