Experimental report

09/02/2016

Proposal: 4-04-471 **Council:** 4/2015

Title: Cross-correlations between crystalfield excitations and phonons in CeAl2

Research area: Physics

This proposal is a new proposal

Main proposer: Koji KANEKO

Experimental team: Koji KANEKO

Local contacts: Mechthild ENDERLE

Samples: CeAl2

Instrument	Requested days	Allocated days	From	To
IN20	8	8	27/10/2015	05/11/2015

Abstract:

We would like to investigate inelastic neutron scattering spectra in CeAl2 in which strong coupling between a crystal-field excitation and phonons is realized. Using polarized neutrons, we want to solve discrepancy inelastic spectra between neutron and x-ray scattering, and search for nuclear-magnetic correlations. This study will deepen our understanding on spin-lattice coupling in f-electron systems and will be a first step toward the search of nuclear-magnetic mixed terms in CeAl2, a promising compound for this search due its the spin-phonon bound state.

Cross-correlations between crystalfield excitations and phonons in $CeAl_2$

Cross-correlations among multiple degrees of freedom give rise to emergent phenomena in condensed matter physics. In general coupling between spin and lattice is weak in f-electrons. In exceptional cases, such as the cubic Laves compound $CeAl_2$,[1] strong c-f hybridization results in large magnetoelastic coupling. In spite of lattice distortion, large magetoelastic coupling in $CeAl_2$ results in formation of a bound state between a crystal-field excitation and phonons, called 'vibronic state'. This formation results in splitting of both crystal-field excitations and phonons in the paramagnetic state.[2, 3, 4] In order to get insights into this unique vibronic state, we revisit revisit polarized neutron scattering experiment on $CeAl_2$ by taking advantage of recent progress on instrumentation in term of neutron flux and polarized neutron capabilities

Co-aligned single crystal rods of $CeAl_2$ shown in Fig. 1 was used in this measurements. The inelastic neutron scattering experiment was carried out on triple-axis spectrometer IN20 with a conventional longitudinal polarimetry setup. A fixed final energy with k_f=2.66 $Å^{-1}$ was employed in the present experiment . The sample was cooled down to 2 K using the standard cryostat.

A polarized inelastic neutron scattering experiment on IN20 succeeded to extract detailed evolution of crystal field-excitations as decreasing temperature. A splitting of the Γ_8 quartet around 14 meV is realized already at 150 K, and shifts to lower energy upon cooling. This in in clear contrast to the temperature variation of phonon spectra where the single phonon peak around 14 meV at room temperature is gradually divided into two peaks below 150 K.[5]

The present study successfully differentiates contrasting temperature variation of phonon and crystal-field excitation. This behavior is consistent with theoretical calculation in qualitative manner,[6, 7] and detailed analysis on both excitations are in progress.

References

[1] M. Loewenhaupt *et al.*, Phys. Rev. Lett. **25**, 1709 (1979).
[2] M. Loewenhaupt *et al.*, J. Magn. Magn. Mater. **63&64**, 73 (1987).
[3] W. Reichardt *et al.*, J. Phys. F: Met. Phys. **14**, L135 (1984).
[4] M. Loewenhaupt *et al.*, J. Phys.:Condens. Matter **15**, S519 (2003).
[5] S. Tsutsui *et al.*, to be published.
[6] P. Thalmeier *et al.*, Phys. Rev. Lett. **49**, 1588 (1982).
[7] P. Thalmeier, J. Phys. C: Solid State Phys. **17**, 4153 (1984).

Figure 1: Co-aligned single crystal rods of $CeAl_2$ used in the present experiment.