Experimental report

28/08/2017

Proposal: 4-01-1531 **Council:** 10/2016

Title: Spin excitations in CeCoSi

Research area: Physics

This proposal is a new proposal

Main proposer: Oliver STOCKERT

Experimental team: Diego Gaspar FRANCO
Stanislav NIKITIN

Local contacts: Michael Marek KOZA

Samples: LaCoSi
CeCoSi

Instrument	Requested days	Allocated days	From	To
IN6	3	3	13/02/2017	16/02/2017
IN4	4	4	09/02/2017	13/02/2017

Abstract:

CeCoSi is a 4f based intermetallic compound where under pressure a meta-orbital transition from an antiferromagnetic ground state with a Neel temperature of 8.8 K to a magnetically ordered state with a quite high ordering temperature of 38 K might occur. This transition takes place around 1.5 GPa. Within such a scenario of a meta-orbital transition crystalline electric field (CEF) excitations should decrease in energy quite drastically under pressure and the Kondo effect should become more pronounced. In order to check the scenario of a meta-orbital transition we want to characterize in a first step the magnetic excitation spectrum of CeCoSi at ambient pressure. Hence, the CEF excitations and the quasielastic response will be studied.

Experimental report for proposal No. 4-01-1531

So far, in strongly correlated electron systems only Kondo effect and RKKY interaction are considered to determine the ground state properties, while it is assumed that there is a large splitting to the first excited crystalline electric field (CEF) levels. The effect of CEF excitations on the ground state properties has therefore largely been ignored in the past. However, in the case of low-lying CEF levels and a stronger hybridization of the conduction electrons with excited CEF states than with the CEF ground state, these excitations to higher CEF levels might influence the ground state properties of the system and a so-called meta-orbital transition to a new ground state might occurs [1]. As a result of DMFT calculations such a meta-orbital transition is e.g. discussed in the heavy-fermion compound $CeCu_2Si_2$ [2].However, so far the concept of meta-orbital transitions is only a theoretical one and an experimental confirmation is lacking. The 4f-based intermetallic compound CeCoSi might be a system where a meta-orbital transition is realized as a function of hydrostatic pressure.

We proposed to study the magnetic excitations of the CeCoSi which crystallizes in the tetragonal CeFeSi structure (space group P4/nmm) and the

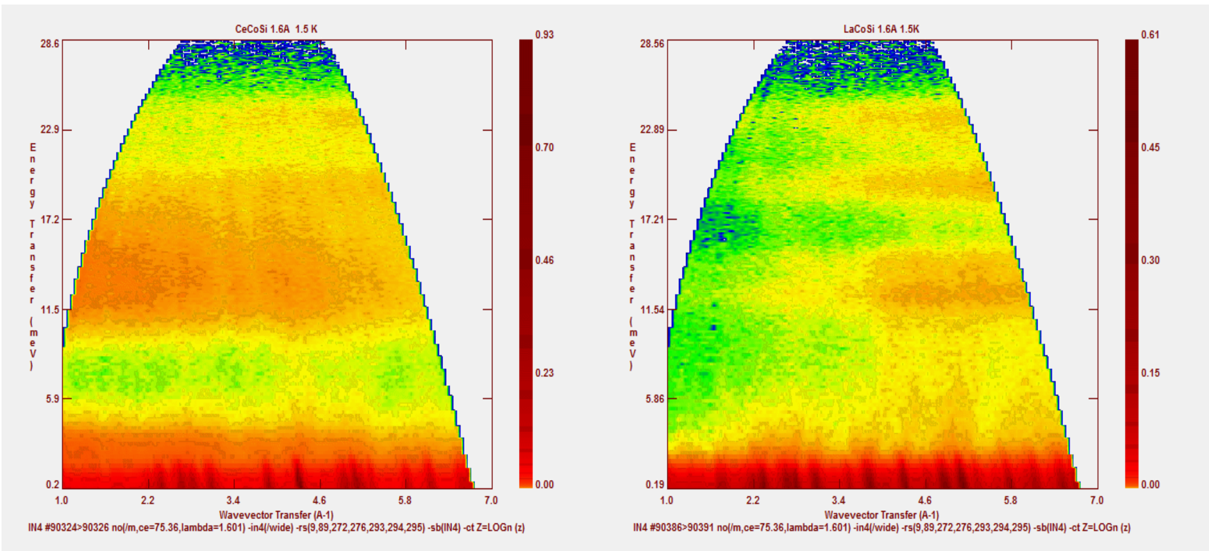

Figure 1 Dynamic structure factors S(q,ω) at T=1.7K and λ=1.6 Å of CeCoSi (left) and LaCoSi (right)

cerium moments order antiferromagnetically below T_N=8.8K at ambient pressure. For measurements, we used powders of CeCoSi and LaCoSi with ~15g of each sample, which were mounted in flat aluminum sample holders. The temperature evolution of CEF excitations was measured on the IN4 TOF spectrometer. We used standard orange cryostat in order to achieve temperature range 1.5-300K and neutron wavelength λ=1.1,1.6 and 3.2Å. In order to separate magnetic contribution and phonons the powder of LaCoSi were measured at T=1.5 and 100K for each wavelength. In addition, we collected spectra for an empty sample can, and a vanadium filled can.

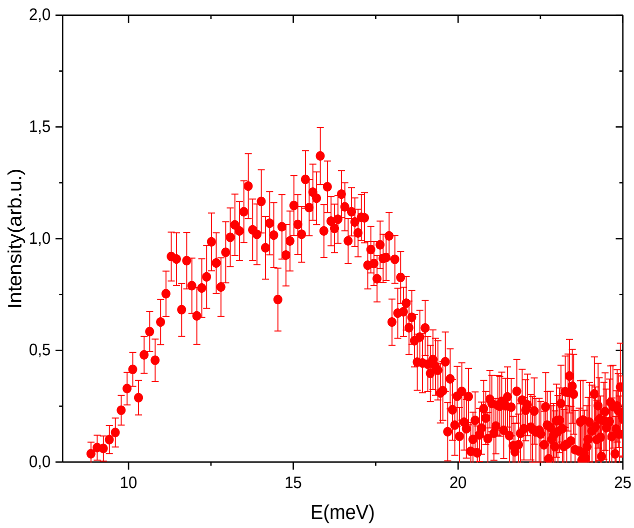

Figure 2 CEF excitations of CeCoSi at T=1.5K after subtraction of the phonon contribution.

For a cerium atom in a tetragonal crystal field, the six fold degenerate J = 5/2 states are split into three doublets. Therefore, two crystal field (CEF) excitations would be expected to be observed. Fig1. represents dynamical structure factors of CeCoSi and LaCoSi measured at T=1.5K and the phonon contributions at high Q are looked very similar. We performed scaling of the phonons scattering intensity of between LaCoSi and CeCoSi following [3], made a subtraction and got a clear magnetic CEF signal, as shown on a fig.2. We followed the temperature dependence of the CEF excitations up to 200K.

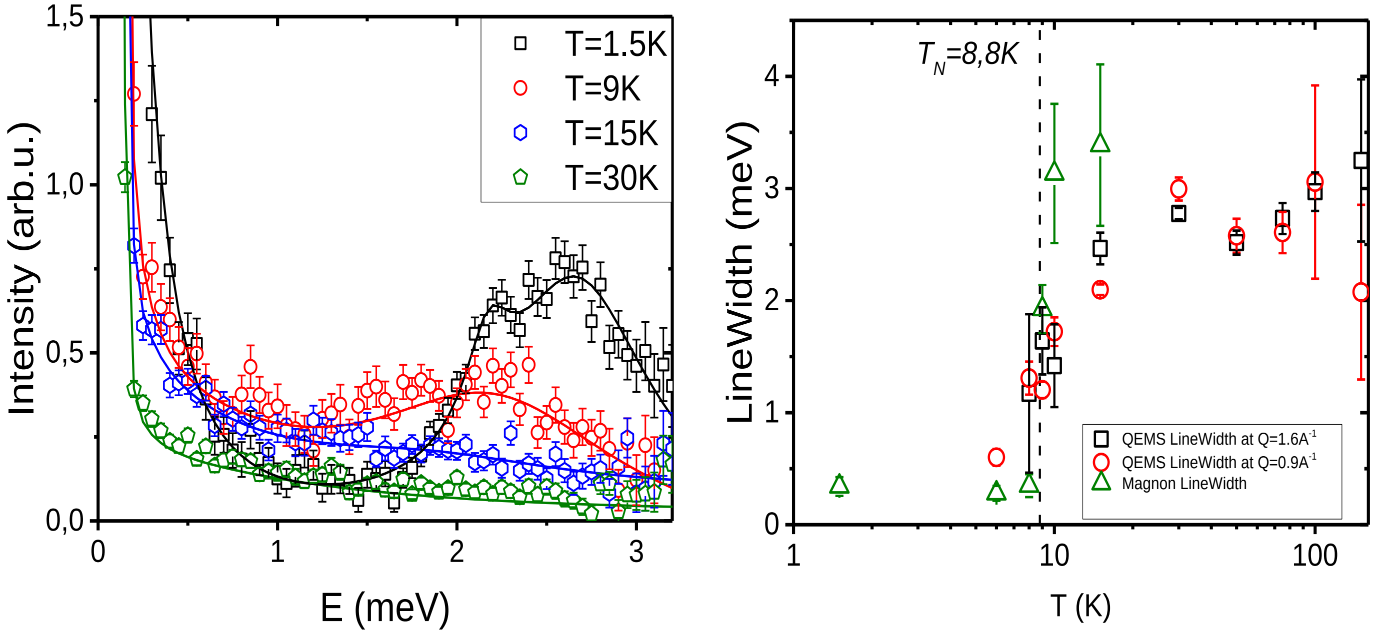

Figure 3 (left) Low energy excitation spectra of CeCoSi measured on IN6 with λ=4.6A. (right) Temperature dependence of magnon and QEMS linewidth of CeCoSi measured on IN6 with λ=4.6 and 5.1A^{-1}. Vertical dotted line at T_N separate AFM and PM phases.

As second step, we investigated quasielastic magnetic scattering (QEMS) and spin wave excitations on IN6 TOF spectrometer. We used the same samples and collected spectra with λ=5.1 and 4.6Å. Below T_N we found well define spin waves peaks which can be described with two lorentzian lines fig.3(left). At transition temperature, spin waves are softening and the spectral weight passes to a QEMS. We follow the temperature dependence of QEMS linewidth and found that it saturated at E~2.5meV fig.2(right) in contrast with classical Kondo systems, with $\Gamma \sim \Gamma_0 + A\sqrt{T}$

References:

[1] Hattori JPSJ 79, 114707 (2010)

[2] Pourovski PRL 122, 106407 (2014)

[3] T. Willers et al., PHYSICAL REVIEW B 85, 035117 (2012)