Experimental report

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Proposal: 4-02-470 **Council:** 4/2016

Title: Study of the spin resonance in Nd0.05Ce0.95CoIn5

Research area: Physics

This proposal is a continuation of 4-01-1134

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Samples: Nd0.05Ce0.95CoIn5

Instrument	Requested days	Allocated days	From	To
THALES	10	10	05/09/2016	15/09/2016

Abstract:

Nd0.05Ce0.95CoIn5 is a novel heavy-fermion superconductor where a spin-density wave can be tuned inside a superconducting phase by means of an external magnetic field. Our neutron diffraction results show that a low-field spin-density wave (SDW) is gradually suppressed with increasing fields at about 8 T. At higher fields, we observed a second magnetic phase with nearly identical propagation vector and same magnetic structure. The high-field SDW is coupled to superconductivity and exhibits similar properties as the Q-phase in CeCoIn5. The two phases are separated by a quantum critical point (QCP) raising the open question of its driving mechanism. One possibility involves the fluctuations of quasiparticle excitations. Theoretically it was predicted in the parent compound that a superconducting spin exciton condensates at the QCP and couples superconductivity and magnetism. We aim at searching for this spin resonance and study its temperature dependence at zero field with focus on its behaviour when entering the SDW phase. Because of the hypersensitivity of magnetism on small differences in the Nd concentration the experiment will be carried out one single crystalline sample only.

Experimental Report

Study of the spin resonance in Nd0.05Ce0.95CoIn5

Experimental team

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$Nd_{0.05}Ce_{0.95}CoIn_5$ displays a magnetic phase below T_N = 0.8 K inside the superconducting condensate, T_c = 1.8 K, at zero magnetic field [1]. Neutron diffraction has shown that the propagation vector of this magnetic phase resembles the one of the Q-phase in $CeCoIn_5$ [2-5]. Our neutron diffraction studies on D23 (5-41-776 and CRG-2105) and D10 (5-42-820) have shown that although the magnetic structure of this phase is similar to the one of the Q-phase, the field dependence reveals a distinct behavior [5]. In the reported experiment on ThALES we studied the low-energy excitation spectrum of $Nd_{0.05}Ce_{0.95}CoIn_5$ and searched for a spin resonance, such as found in the parent compound $CeCoIn_5$. For this task we used a silicium monochromator, Si (111), and the ThALES spectrometer in a *W* configuration with the horizontal and vertical focusing options. Neutrons were scattered from the sample consisting of one single crystal of m = 64 mg that was placed in a cryostat and oriented within the scattering plane perpendicular to [1, -1, 0]. The outgoing beam was diffracted on a double focusing pyrolitic graphite analyzer with a fixed k_f = 1.45 A^{-1} and collimated in front of the detector by means of a radial collimator.

The low-energy neutron excitation spectrum of $Nd_{0.05}Ce_{0.95}CoIn_5$ is displayed in Fig. 1 a. The spectrum was measured at Q_{AF} = (0.5, 0.5, 0.5) for temperatures T = 0.44, 1.2 and 2.5 K. The background was obtained from the average intensity measured at the reciprocal lattice positions (0.41, 0.41, 0.83) and (0.54, 0.54, 0.05). The spectrum reveals a Gaussian-like excitation for temperatures lower than the superconducting transition that is suppressed at T = 2.5 K. Rocking ω−scans at the peak maximum (ΔE = 0.4 meV) and T = 0.44 K result in a peak position ω = 42(1)° corresponding to a reciprocal wave-vector of Q_{AF} = (0.5, 0.5, 0.5) (data not shown here). The temperature dependence at ΔE = 0.4 meV and Q_{AF} = (0.5, 0.5, 0.5) is displayed in Fig. 1 b and over plottet with ΔE = 0 meV and Q_{IC} = (0.55, 0.55, 0.5) (taken from Ref. [2]). The data reveal a spin-resonance that is suppressed around the superconducting transition temperature T_c. Within the

resolution of our experiment it appears at the same wave-vector than the magnetic order but seems not to be disturbed by the onset of static magnetic order at T_N.

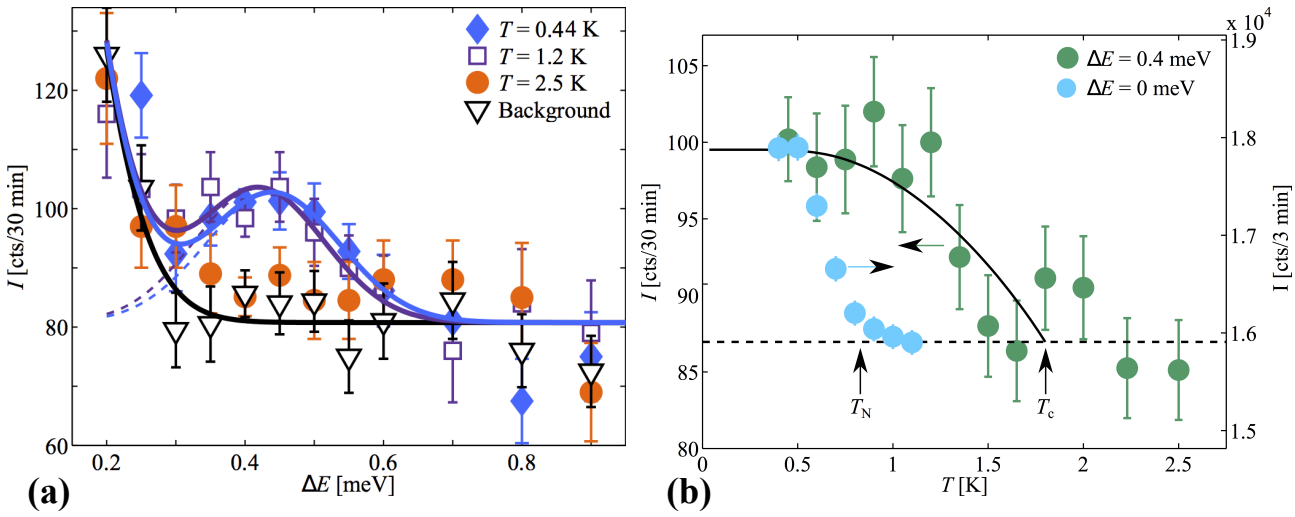

Fig. 1 (a) Neutron excitation spectrum measured at Q_{AF} = (0.5, 0.5, 0.5) and T = 0.44, 1.2 and 2.5 K. The background is measured as described in the text. (b) Temperature dependence of the excitation measured at ΔE = 0.4 meV measured at Q = (0.5, 0.5 0.5) and over plotted with ΔE = 0 meV at Q_{IC} = (0.55, 0.55, 0.5) (taken from [2]) The solid line represents a guideline to the eye, the dashed line shows the background.

[1] R. Hu *et. al.*, Phys. Rev. B **77**, 165129 (2008).

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[5] S. Gerber *et. al.*, Nature Physics **10**, 126 (2014).

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