Experimental report

15/04/2019

Proposal: **4-02-520**

Council: 4/2017

Title: Towards the understanding of the SDW-phase in Nd0.05Ce0.95CoIn5

Research area: Physics

This proposal is a continuation of 4-02-470

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Samples: Nd0.05Ce0.95CoIn5

Instrument	Requested days	Allocated days	From	To
THALES	8	8	16/04/2018	18/04/2018
			20/04/2018	26/04/2018

Abstract:

Nd0.05Ce0.95CoIn5 is a novel heavy-fermion superconductor where a spin-density wave can be field-tuned over a quantum phase transition inside its superconducting condensate. Resent inelastic neutron scattering results from our group have resolved a spin-resonance in Nd0.05Ce0.95CoIn5 that scales with the superconducting properties of CeCoIn5. Intriguingly our data hint for a scenario that this low-energy excitation is not affected by the onset of static magnetic order at 0.8 K = TN < Tc = 1.8 K. We plan to extent our successful experiment to a careful investigation of its temperature dependence and determine its transversal and longitudinal correlation lengths.

Experimental Report

Investigation of the SDW phase in $Nd_{0.1}Ce_{0.9}CoIn_5$

Experimental team

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The series $Nd_{1-x}Ce_xCoIn_5$ is a good model system to study the interplay between magnetism and superconductivity. It features a coexistence of itinerant magnetism and superconductivity for x > 80% [1]. The superconducting state for $CeCoIn_5$ is unconventional, as it presents a d_{x2-y2} gap symmetry below Tc = 2.3 K [2]. A spin resonance has been observed with the wave vector $\mathbf{Q_{SR}}$ = (0.5, 0.5, 0.5) and with an energy of ΔE = 0.6 meV within the superconducting condensate [3]. The presence of spin resonance peak indicates strong coupling between the spin fluctuations and superconductivity. Our group further carried out neutron inelastic scattering measurements on $Nd_{0.05}Ce_{0.95}CoIn_5$, which features a static SDW magnetic order (with $\mathbf{Q_{IC}}$ = (0.448, 0.448, 0.5)) below T_N = 0.8 K inside the superconducting phase below Tc = 1.8 K [4]. The magnetic low-energy excitation spectrum shows a spin resonance with an energy ΔE = 0.432 meV below Tc, which is unaffected by the static magnetic order below T_N, and detailed temperature dependence and discussions have been reported in Ref 4. Therefore, in this beam time we decided to investigate the spin resonance in higher Nd-doped $Nd_{0.1}Ce_{0.9}CoIn_5$, which is superconducting below Tc ~ 1.58 K and presents a incommensurate SDW phase with ordering vector $\mathbf{Q_{IC}}$ and T_N ~ 1.25 K that persists to magnetic fields beyond H_{c2} according to our other beam time allocated at SINQ/PSI.

Measurements were carried out on 14 co-aligned single crystals of $Nd_{0.1}Ce_{0.9}CoIn_5$ with a total mass as 115 mg, spanning the scattering plane by (1, 1, 0) and (0, 0, 1). We chose a fixed outgoing wave vector $\mathbf{k_f}$ = 1.55 $Å^{-1}$ on the peak (0.5, 0.5, 0.5) to measure the excitation spectrum at temperatures below and above Tc (at 58 mK and 3.38 K), separately. The spectrum can be seen in Figure 1 (a), where no clear feature of spin resonance peak is observed. We further measured both the temperature dependence of the peak intensity on peak (0.5, 0.5, 0.5), with inelastic energy transfer 0.35 meV and also elastic modes. For the former, no signal above the background can be found within entire temperature range (see Figure 1 (b), where the two green points were measured above T_N but presents much higher intensity that which were taken below T_N), while the latter displays an enhanced peak intensity below ~1.3 K (close to T_N), see Figure 1 (c). To check the incommensurate magnetic structure of these samples, a (H, H, 0.5) scan has been measured at 59 mK. A sharp peak at (0.476, 0.476, 0.5) and a weaker peak at (0.524, 0.524, 0.5) can be clearly identified (see Figure 1 (d)). From this beam time, we could not observe the possible spin resonance peak in this Nd doping level. Therefore we can only speculate about the absence. The higher Nd doping concentrations may have induced more disorder to the system which could have led to a broadening of the spin resonance peak. Alternatively, the co-alignment of more than ten samples, could have led to a broadening due to either small misalignment or of small variations of the doping concentrations for the individual crystals. Therefore, further attempts would ideally require a large single crystal.

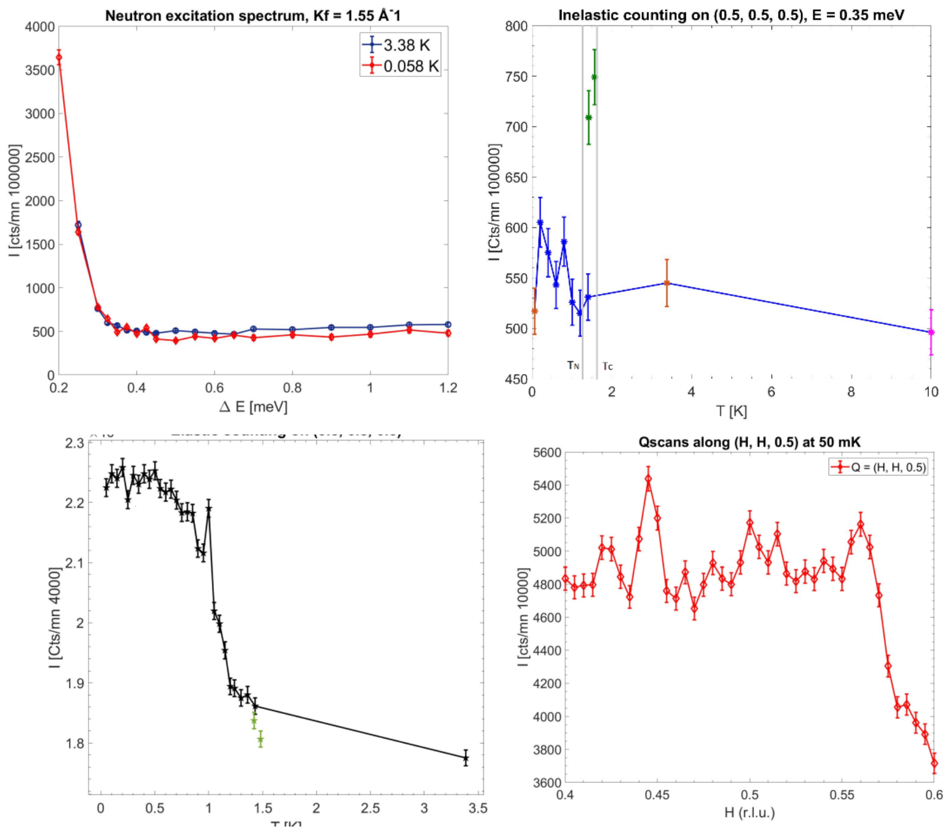

Figure 1 (a), the excitation spectrum on peak (0.5, 0.5, 0.5), (b), (c), the inelastic and elastic peak intensity againt temperature at peak (0.5, 0.5, 0.5), and (d), the (H, H, 0.5) scan at 50 mK.

Reference:

[1] R. Hu, Y. Lee, J. Hudis, V. F. Mitrovic, and C. Petrovic, Composition and field-tuned magnetism and superconductivity in $Nd_{1-x}Ce_xCoIn_5$, Phys. Rev. B 77, 165129 (2008).

[2] C. Petrovic, P. G. Pagliuso, M. F. Hundley, R. Movshovich, J. L. Sarrao, J. D. Thompson, Z. Fisk, and P. Monthoux, Heavy-fermion superconductivity in $CeCoIn_5$ at 2.3 K, J. Phys. Condens. Matter 13, L337 (2001). M. P. Allan, F. Massee, D. K. Morr, J. Van Dyke, A.W. Rost, A. P. Mackenzie, C. Petrovic, and J. C. Davis, Imaging Cooper pairing of heavy fermions in $CeCoIn_5$, Nat. Phys. 9, 468 (2013).

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