Experimental report

16/02/2020

Proposal: 4-02-519 **Council:** 4/2017

Title: Search for a magnetosuperconducting domain dependence of the Zeeman splitting in the unconventional superconductor CeCoIn5

Research area: Physics

This proposal is a resubmission of 4-02-499

Main proposer: **Stephane RAYMOND**

Experimental team: Stephane RAYMOND
Gerard LAPERTOT

Local contacts: Jacques OLLIVIER

Samples: CeCoIn5

Instrument	Requested days	Allocated days	From	To
IN5	5	5	14/03/2018	19/03/2018

Abstract:

The aim of the proposal is to investigate the link between the spin resonance of the unconventional superconductor CeCoIn5 and the field induced magnetic ordering occurring within the superconducting phase. For certain directions of the magnetic field, the ordering occurs only within a single magnetic K-domain selected by superconducting properties, namelly the topology of the superconducting gap. We would like to investigate if a similar selection occurs for the Zeeman splitting of the spin resonance. This would give strong support to the theoretical scenario of a condensation of the spin resonance into a static magnetic order under magnetic field.

Aim of the experiment

The aim of the proposal was to investigate the link between the spin resonance of the unconventional superconductor $CeCoIn_5$ (Tc=2.3 K) [1] and the field induced magnetic ordering occurring within the superconducting phase [2]. For certain directions of the magnetic field, the ordering occurs only within a single magnetic k-domain selected by superconducting properties, namely the topology of the superconducting gap [3]. We wanted to investigate if a similar selection occurs for the Zeeman splitting of the spin resonance. The same sample as in previous TAS studies [4] was mounted on a dilution stick in the 2.5 T vertical field magnet with [1, 1, 0] and [0, 0, 1] in the horizontal plane and the field was applied along [1, -1, 0]. Near $\mathbf{Q_{AF}}$=(1/2,1/2,1/2), the two satellites known from TAS measurement, are located at $\mathbf{Q_{AF}}$+(δ, δ, 0) and $\mathbf{Q_{AF}}$+(-δ, -δ, 0) with δ≈0.05. They belong to the $\mathbf{k}^+$ domain. The other two satellites are located at $\mathbf{Q_{AF}}$+(δ, -δ, 0) and $\mathbf{Q_{AF}}$+(-δ, δ, 0). They belong to the $\mathbf{k}^-$ domain and they are (slightly) out of the horizontal plane. This makes the use of an instrument with vertical detectors like IN5 crucial. IN5 was used at λ=6 Å (resolution 0.04 meV). All the data were collected at 50 mK.

Results

The sample is an assembly of about 80 co-aligned single crystal samples of thickness of about 0.1-0.3 mm with a total volume of 250 mm^3. This assembly was used in previous TAS studies and a good in-plane mosaïcity was found (about 1 degree) [4]. However, the characterization of the Bragg peaks on IN5 indicates that the moisaïcity was much more spread out in the vertical direction. This point was not known from the previous TAS study since the vertical resolution is quite poor on such instruments and therefore the corresponding vertical integration masks the degraded vertical moisaïcity of the sample. However, this turned out to be a severe problem on IN5 and this precludes to answer the questions raised in the proposal's scientific case. This is illustrated in Fig.1 which shows the dispersion of the resonance mode in the [h , h, 0.5]-[h, -h, 0.5] plane around $\mathbf{Q_{AF}}$. While the resonance is clearly observed (as well as its dispersion) in the horizontal plane, the fourfold symmetry of the signal between $\mathbf{k}^+$ and $\mathbf{k}^-$ (horizontal/vertical) is not observed since the signal is too weak in the vertical direction in relation to the poor moisaïcity. This unexpected situation (the mechanical mount being itself quite symmetric !) precludes to study the effect of the field. The magnetic field was nonetheless applied and a redistribution of the spectral weight can be seen at the resonance energy of 0.5 meV (See Fig.2 for E=0.5 meV at H=0 and 2.5 T). These preliminary data indicate the feasibility of the experiment provided the sample co-alignement is optimized in the vertical direction.

[1] C. Stock et al., Phys. Rev. Lett. 100, 087001 (2008).

[2] M. Kenzelmann et al., Science 321, 1652-1654 (2008).

[3] S. Gerber at al., Nature Physics 10, 126 (2014).

[4] S. Raymond and G. Lapertot, Phys. Rev. Lett. 115, 037001 (2015).

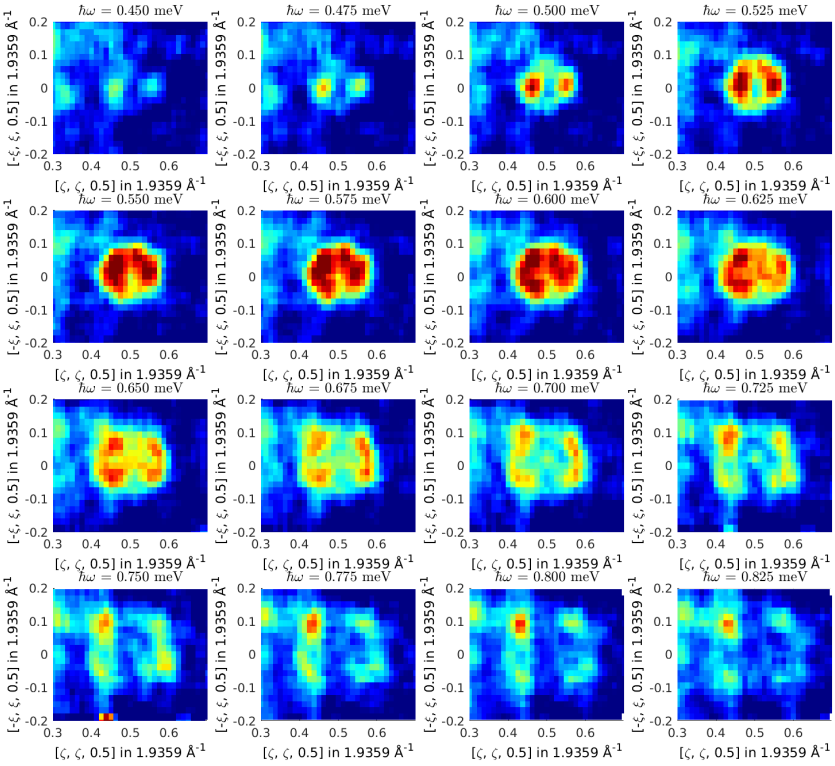

Fig.1 : Dispersion of the resonance of $CeCoIn_5$ from 0.45 to 0.825 meV. The gap is around 0.5 meV. The center of the map is $\mathbf{Q_{AF}}$=(1/2, 1/2, 1/2).

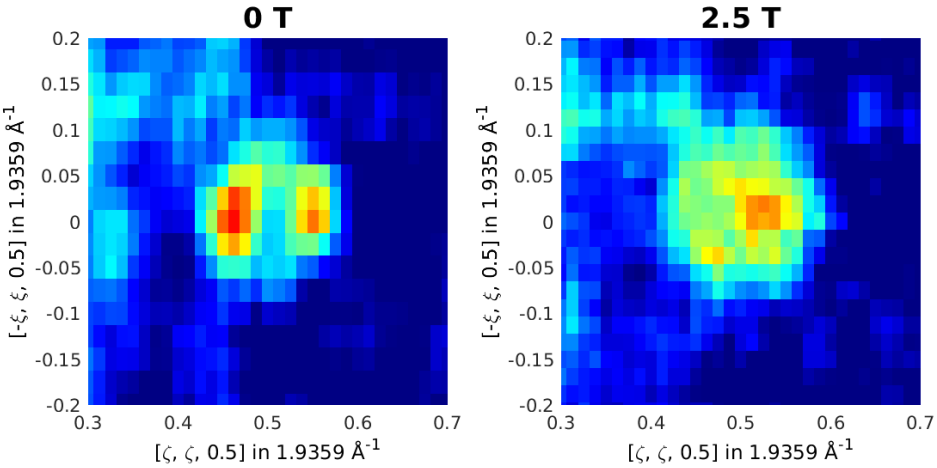

Fig. 2 : The resonance at 0.5 meV at H=0 and H=2.5 T.