Experimental Report

13/02/2014

Proposal:	**4-01-1249**	**Council:**	10/2012	

Title: Spin dynamics in optimally doped (U0.965 / Th0.035) Be13

This proposal is resubmission of: 4-01-1057

Researh Area: Physics

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Samples: Th-doped UBe13

Instrument	Req. Days	All. Days	From	To
IN14	9	7	06/05/2013	13/05/2013

Abstract:

UBe13 is a ‘non-magnetic’ actinide-based superconductor in which the spin dynamics is composed of a quasi-elastic and an inelastic component. We here propose to investigate the spin dynamics of a 3.5% Th-doped sample, which corresponds to optimum doping. The experiment will help to relate the various contributions in the spin dynamics to the anomalies observed in specific heat.

Spin dynamics in optimally doped $U_{0.965}Th_{0.035}Be_{13}$

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Report for Experiment 57927

Abstract

UBe13 is a "non-magnetic" actinide-based superconductor in which the spin dynamics is composed of a quasi-elastic and an inelastic component. The spin dynamics of a 3.5% Th-doped sample, which corresponds to optimum doping were investigated. We found a weal signal at (0.5 0.5 2) around 0.2 meV as well as signs of a possible six fold symmetry.

I. Introduction

Most superconductors, for which magnetic fluctuations are discussed to be relevant for superconductivity, show a layered crystal structure. Contrary to those, UBe_{13} is a heavy fermion superconductor ($T_c = 0.85$K, $\gamma > 1$J/molK^2 [1]) with a cubic crystal structure (Fm3c space group) [2]. In undoped UBe_{13}, antiferromagnetic fluctuations are observed at low temperatures at (0.5 0.5 2) but not at (0.5 0.5 0) due to their longitudinal polarization. High-resolution inelastic neutron scattering revealed a shift of spectral weight from lower to higher energies upon entering the superconducting from normal state as observed in other heavy-fermion superconductors as well as in High-Tc- or iron-based superconductors. The measurement of this was hindered by a signal gapped at E = 0.5 meV occurring already at temperatures above T_c and related to a Schottky-like anomaly in the specific heat at T = 2 K. The temperature of this anomaly decreases with doping, which resembles the copper-based high-T_c-superconductors, where a "pseudogap" temperature decreases with doping and the anomaly vanishes at the concentration with highest T_c. In the underdoped region, an inelastic response is observed already above T_c.

II. Methods

At IN14, we performed triple axis (TAS) experiment in the standard TAS configuration as well as using a flatcone detector. The sample, consisting of three $U_{0.965}Th_{0.035}Be_{13}$ single crystals pinned on sticks on the edges of a equilateral triangle, were mounted in a dilution refrigerator to perform measurements at a constant temperatures of 80 mK (superconducting state) and 800 mK (normal state). At the end of the experiment, when the sample was heated, measurements were made at a temperature of roughly 20 K. In the TAS configuration, energy scans were made at (-0.5 -0.5 2) were an inelastic signal was expected, while (1 1 1.5) was used to determine the background, similar to our previous measurements on the undoped compound. Since the intensity had not a minimum at our background location, we searched for a more appropriate position to determine the background. In this process we noticed the intensity is distributed in a more sophisticated way in Q-space. Therefore we decided to change to the flatcone configuration to gather elastic and inelastic (energy transfer 0.6 meV) data in a large portion of Q-space.

III. Results

Figure 1 shows the results of the energy scans at (-0.5 -0.5 2). Since the energy scans at the background position did not show any temperature dependence, data measured at 80 mK as well 800 mK were combined in one common background. At (-0.5 -0.5 2), it appears a broad signal is present at 0.2 meV. Also, within the measurement precision, no difference between the superconducting and the normal state could be observed. The observation of a signal at such low energy transfer is hampered by the fact that it is located in the tail of the elastic incoherent scattering.

Data obtained using the flatcone configuration is depicted in Fig. 2. In the elastic data, broad clouds of intensity can be observed, which indicate a sixfold symmetry. This six fold symmetry is temperature independent up to at least 20 K. At the moment, it is not clear whether the six fold symmetry has a physical origin. One should keep in mind the sample consist of three single crystals pinned on sticks on the edges of a equilateral triangle. Hence shadowing effects can not be ruled out. On the other hand, the inelastic data, taken at an energy transfer of 0.6 meV do not show a six fold symmetry. One can see a broad signal around (0 0 1) as well a signal at (±0.5 ±0.5 2), which is similar but weaker as in pure UBe_{13}.

IV. Outlook

We achieved to find a weak, temperature independent signal at (0.5 0.5 2), even though the observation of this signal is hampered by the presence of the background from elastic incoherent scattering. At the moment we are considering the use of different neutron scattering methods with better energy resolution (spin-echo, backscattering). The origin of the six fold symmetry needs to be verified, probably by using a different sample with only one single crystal.

References

[1] Ott et al., Phys. Rev. Lett. 50, 1595 (1983)

[2] Goldman et al., Phys. Rev. B 31, 6042 (1985)

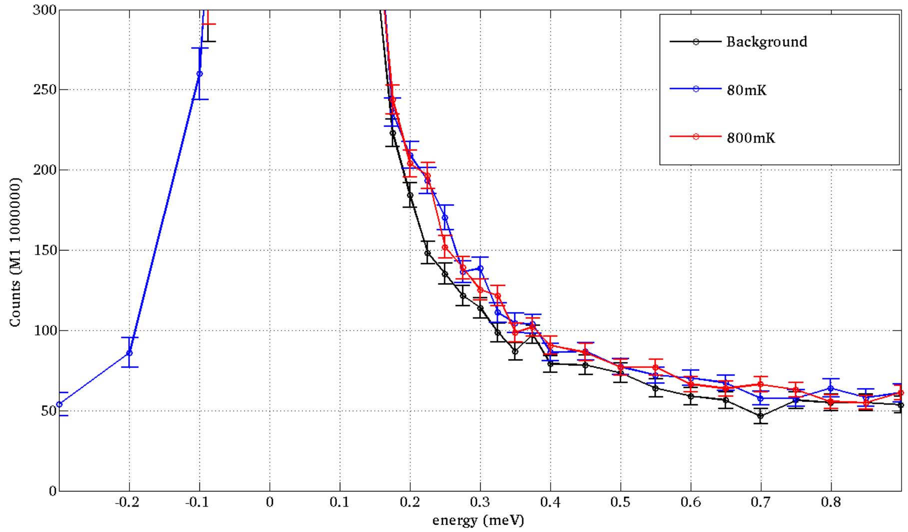

Figure 1: *Energy scans at (-0.5 -0.5 2). The background is from (1 1 1.5) and a combination of data measured at 80 mK as well 800 mK.*

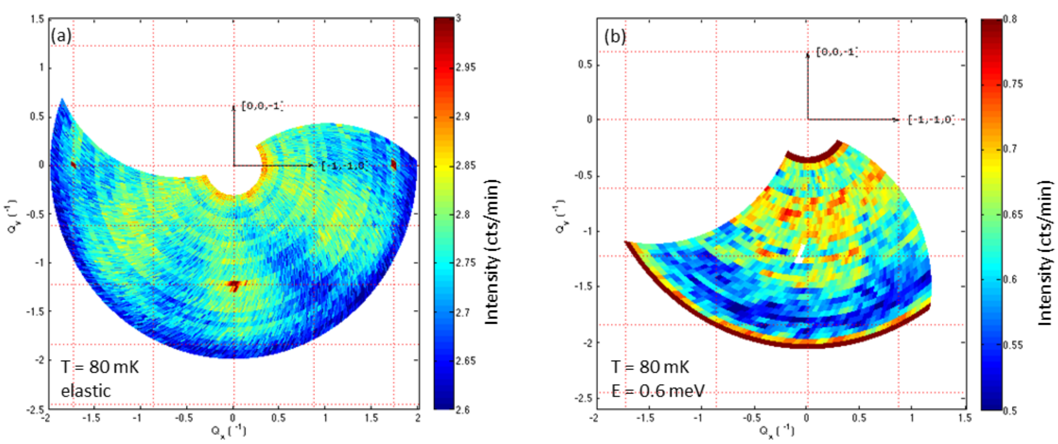

Figure 2: *Intensity in Q-space at T = 80 mK for (a) inelastic scattering and (b) with an energy transfer of 0.6 meV.*