Experimental report

26/09/2023

Proposal: 4-02-618 **Council:** 10/2022

Title: Studying the TC-coupled Spin Excitations in Spin-Triplet Superconductor Candidate UTe2 with Polarized Neutron

Research area: Physics

This proposal is a new proposal

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Samples: UTe2

Instrument	Requested days	Allocated days	From	To
THALES	6	6	11/05/2023	17/05/2023

Abstract:

UTe2 has drawn a lot of attention among the superconductivity community recently for the promising secondary evidences of spin-triplet Cooper pairing shown in this system through temperature-independent NMR Knight shift, the highly anisotropic and unusually large upper critical field, power-law behavior of the specific heat. Inelastic neutron scattering can provide information on the pairing mechanism by probing the low energy excitation spin fluctuations. A spin resonance has been reported in UTe2 around 1 meV. We propose to perform cold neutron inelastic scattering on UTe with polarized analyis, to determine the anisotropy in spin space of the spin resonance. We ask 6 for days on THALES with CRYOPAD and dilution fridge.

In this experiment we sought to carry out polarization analysis of a magnetic excitation (resonance) near 1 meV that appears only within the superconducting phase and near antiferromagnetic (AFM) order in the heavy fermion compound UTe2. It is believed that this may indicate antiferromagnetic fluctuations induce spin-triplet pairing [1]. The reduced intensity from both the inelastic configuration and polarization setup severely limited our ability to resolve the excitation at 1 meV despite a large sample mass (~1.4 g) [Fig 1]. Additionally, we encountered an issue with the polarization setup in which we observed different flipping ratios at different Bragg peaks, leaving some data contaminated. After the experiment, the instrument scientists investigated the issue. The following is their stated solution to the problem:

“Wednesday, after removing the sample, we have performed a few tests with the Cryopad, to investigate why the polarisation has been lower in the x-channel on the 022 reflections.

We find that this effect is not related to the sample. In fact, after removing the dilution insert we realized that at this particular a4-value, and for kf=ki=1.5, there is an effect of double scattering from the aluminium 111 powder line, involving some aluminium of the Cryopad near the precession coils (which might possibly explain its polarization dependence). The presence of this extra intensity explains what we have seen.

So, the data on this Bragg peak are not clean. However, the good news is that this effect is very localized and strongly k-dependent, which means that it is absent from all other data which we have taken, and we don't have to worry about strange depolarization effects or stray fields.
On the quartz, the polarization is normal.

Also, Eric has measured the remnant field in the Cryopad before and after the experiment to be below about one milligauss, which is a good value and excludes problems from that side.”

Another complicating matter was the large incoherent scattering tail at the elastic line that is uncharacteristic of cold TAS. To summarize, due to a number of factors we were unable to resolve the resonance at 1 meV. Therefore, the polarization analysis was inconclusive.

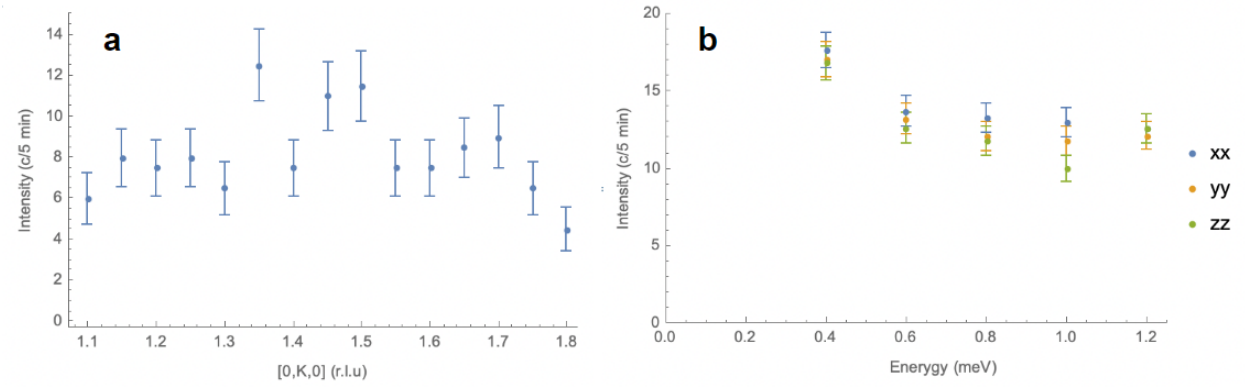

Figure 1. **a** Q-scan at 1meV across the resonance using the spin-flip x-polarized channel in the second Brillouin zone. **b** Energy dependent scan with all three spin-flip polarization channels. Counting times at the resonance (1meV) exceeded 3 hours.

Reference

[1] C. Duan, et al. Nature 600, 636–640 (2021)