Experimental report

27/08/2022

Proposal: **4-01-1730** **Council:** 4/2021

Title: Magnon spectrum of Weyl semimetal EuCuAs

Research area: Physics

This proposal is a new proposal

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Samples: EuCuAs

Instrument	Requested days	Allocated days	From	To
IN12	8	0		
THALES	8	7	08/09/2021	16/09/2021

Abstract:

The magnon dispersion will be measured in all high symmetry directions. Measurements will be made in reflection geometry. Spin wave theory will be used to determine the principle exchange interactions

One area of current interest in the field of topological materials is nodal semimetals in which Weyl fermions are induced by magnetic order. Topological transport phenomena can then be controlled by an external magnetic field. There are few good examples, but recently EuCuAs was proposed as a candidate [1]. The hexagonal unit cell of EuCuAs is described by space group $P6_3/mmc$, and magnetic order occurs below T_N = 14 K [2]. The Eu atoms carry spin S = 7/2, and the Cu atoms do not have a magnetic moment, Our previous measurements on Wish@ISIS and D9@ILL have shown that the Eu magnetic order has a propagation vector **q** = (0, 0, τ) with $\tau \approx 0.5$, and that the Eu spins are ordered ferromagnetically in the hexagonal *ab* plane [3]. The measurements on D9 in a magnetic field are consistent with a transverse helix with a period of $2/\tau \approx 4$ layers.

The objective of the experiment on Thales reported here was to measure the spin-wave (helimagnon) dispersion in the magnetically ordered phase, and to use the results to develop a spin Hamiltonian for EuCuAs by determining the exchange couplings between nearest and next-nearest neighbour Eu spins.

We prepared a mosaic sample from 10 flux-grown single crystals. The total mass of the crystals was around 1 g, and when co-aligned on an aluminium plate they covered an area of approximately 15 x 15 mm^2 with a mosaic spread of about 2 deg. The majority of measurements were made at the base temperature of an orange cryostat, with some further measurements made in the paramagnetic phase at 40 K.

Because of the very severe neutron absorption of Eu, measurements needed to be made in reflection from the plate-like sample. Initial constant-**Q** measurements were made at various wave vectors **Q** of the form (0, 0, *L*) covering a range energies up to around 1 meV. No clear magnetic peaks were observed, but we observed an excess of scattering at 2 K relative to 40 K at several values of L. An example is shown in Fig. 1(a). Figure 1(b) shows the difference between the measurements at 2 K and 40 K. The signal is suggestive of a magnetic excitation at this Q value with an energy of around 0.25 meV. The low energy of this feature suggests that the inter-layer helimagnon dispersion is very small.

The in-plane magnon dispersion was probed in scans with an in-plane component of **Q**. An example is shown in Fig. 2, which presents a constant-energy scan at an energy of E = 0.7 meV parallel to the (H, H, 0) high symmetry direction. In this scan there is a well resolved peak at T = 2 K which disappears at T = 40 K. This is strong evidence for a magnon excitation.

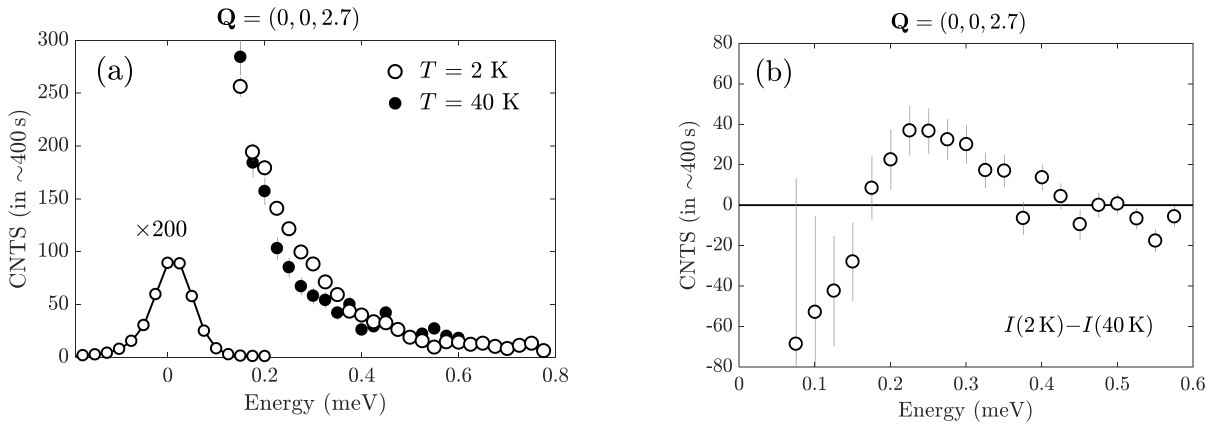

Figure 1. (a) Constant-**Q** scan at **Q** = (0, 0, 2.7). Data are shown for temperatures in the magnetically ordered phase at 2 K, and in the paramagnetic phase at 40 K. (b) Difference between the 2 K and 40 K data. Measurements were made at a fixed final energy E_F = 3.5 meV

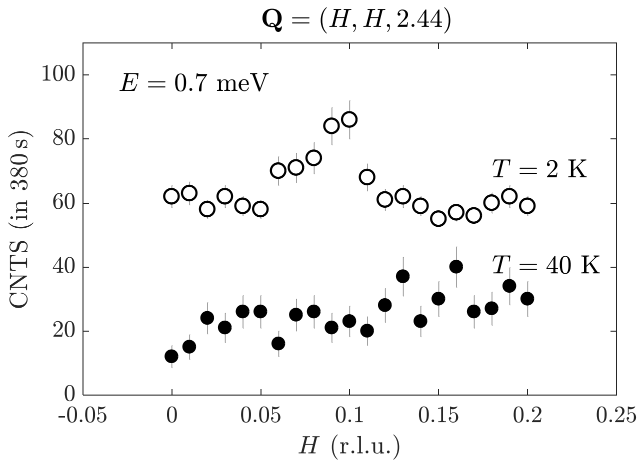

Figure 2. Constant-energy scans at E = 0.7 meV along the high symmetry line (H, H, 2.44). A fixed final energy of E_F = 3.5 meV was used. Data are shown for temperatures in the magnetically ordered phase at 2 K, and in the paramagnetic phase at 40 K. The 2 K data has been shifted vertically by 50 counts for clarity. The peak in the 2 K scan at H = 0.1 is due to magnon scattering.

There was not sufficient time during the experiment to explore the magnon dispersion further, but the measurements indicate that the magnetic interactions are quasi-two-dimensional, consistent with the layered crystal structure. They also show that more detailed measurements are feasible since the counting time per point is around 6 minutes.

References

[1] Y.-P. Du, *et al.*, Sci. Rep. **5** 14423 (2015)
[2] J. Tong, *et al.*, J. Alloys Compounds **602**, 26 (2014)
[3] ILL Experimental Report on 5-41-1048