Experimental report

12/09/2023

Proposal:	**DIR-295**	**Council:**	4/2023
Title:	Magnetic controlled topological states in Euagas		
Research area:			

This proposal is a new proposal

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Samples: EuAgAs

Instrument	Requested days	Allocated days	From	To
D3	4	5	28/08/2023	01/09/2023
ORIENTEXPRESS	1	1	24/08/2023	25/08/2023

Abstract:

One area of current interest in the field of topological materials is nodal semimetals in which Weyl fermions are induced by magnetic order. Such systems offer the possibility to use magnetic fields to control topological transport phenomena. So far there are few good examples, but recently EuAgAs was found to be a promising candidate [1]. According to *ab initio* electronic structure calculations, EuAgAs has a band inversion very close to the Fermi level, and a variety of different topological phases are predicted depending on the details of the magnetic structure adopted by the Eu spins [1,2]. The objective of the experiment was to determine the magnetic structure of EuAgAs, and hence to identify the topological phase that forms in the magnetically ordered phase.

The hexagonal unit cell of EuAgAs is described by space group $P6_3/mmc$, with two formula units per unit cell, see Fig. 1. Magnetic order occurs below T_N = 12 K [1]. The Eu atoms have a localized spin S = 7/2, and the Ag and As atoms do not carry a magnetic moment. In previous measurements at the BESSY synchrotron using X-ray resonant magnetic scattering at the Eu M_5 edge we found magnetic Bragg peaks corresponding to Eu magnetic order with an incommensurate propagation vector $\mathbf{q} = (0, 0, q)$ with $q = 0.52$ to 0.55 depending on temperature. We also observed weak 2**q** satellites, whose origin could be either magnetic or structural.

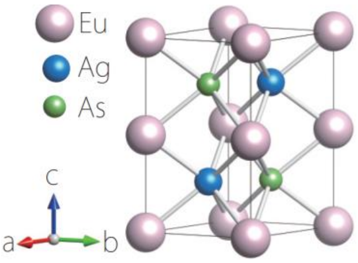

Figure 1. Unit cell of EuAgAs.

The measurements were performed on D3 with the CryoPAD neutron polarimeter. Spherical neutron polarimetry (SNP) is advantageous for highly absorbing samples such as EuAgAs because the technique is based on intensity ratios, which means that the absorption in the sample cancels out. Therefore, the only effect of absorption is to reduce the signal strength. The intensity reduction is partly mitigated by the use of hot neutrons with wavelength λ = 0.84 Å.

Two crystals were used for the experiments, one oriented with (100)-(001) as the horizontal scattering plane, and the other with (110)-(001) as the scattering plane. Measurements of the polarization matrix P_{ij} (9 elements) were made at four inequivalent nuclear reflections together with some equivalent Friedel pairs, and at eight inequivalent magnetic reflections: 002+q, 003+q, 11q, 10q, 101+q, 102+q, 103+q and 20q, plus some Friedel pairs. The counting time was 4.5 h per reflection. The nuclear reflections were used to check the polarisation and to determine the time decay of the He-3 spin filter, In most cases, measurements of P_{ij} were made with positive incident neutron polarization (9 components of P_{ij}), but a few reflections were measured with both positive and negative incident polarization (18 components of P_{ij}).

Before the beam time it had been found that the incident polarisation was lower than usual, and early on in the experiment we noticed significant systematic errors in the polarisation matrices for the nuclear reflections. The effect is illustrated for the 004 reflection in Fig. 2(a). The diagonal elements of P_{ij} are significantly less than 1, and the off-diagonal elements are not zero, as they should be. Tests after the experiments revealed that this effect was due to an incorrect guide field polarity.

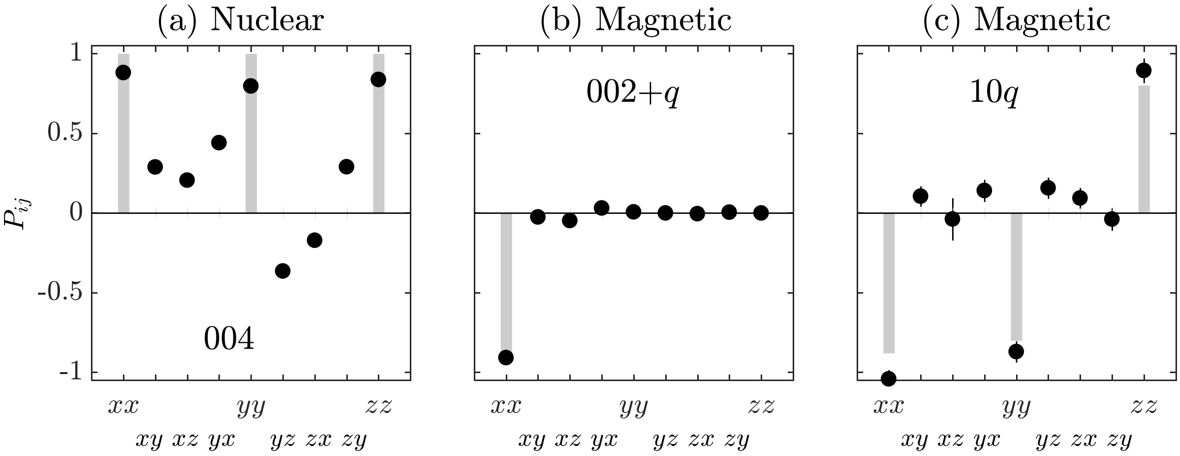

Figure 2. Graphical representation of polarization matrices for EuAgAs measured on D3 (CryoPAD). Filled symbols are measured P_{ij} values; vertical bars are theoretical values. The matrix components are indicated on the horizontal axis. (a) Nuclear 004 reflection — note the large systematic errors. (b) and (c) Magnetic 002+q and 10q reflections, with $q \approx 0.5$. Data were recorded at T = 7 K.

This instrument malfunction will also affect the magnetic P_{ij}, but we have nevertheless tested a number of possible magnetic structure models and found that a transverse helix describes the data quite well. The model fits the 002+q reflection the best, Fig. 2(b), while for other reflections such as 10q, Fig. 2(c), there remain discrepancies which may be systematic errors caused by the misaligned neutron polarisation.

In order to confirm the model, we will submit a continuation proposal to re-measure some of the magnetic reflections and also to investigate the 2$\mathbf{q}$ peaks.

References

[1] A. Laha *et al*, Phys. Rev. B **104**, L241112 (2021)
[2] Y. Jin *et al*, Phys. Rev. B **104**, 165424 (2021)