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Distorted helix in Eu-based magnetic semimetal EuZnGe

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1 Introduction

The search for new magnetic quantum materials with emergent electrodynamic responses is essential for future applications in spintronic technologies. Europium-based semimetals are a group of materials attracting growing interest due to the strong interplay between the conduction electrons and the underlying magnetic moments of Eu^{2+}. Recent material searches along these lines have led to a rich series of discoveries highlighted by the giant magnetoresistance in a Zintl-compound $Eu_5In_2Sb_6$ [1], and anomalous transport properties due to possible topological electronic bands in $EuCd_2Pn_2$ (*Pn* = As, Sb) [2].

In this study, we first report the magnetic properties of Eu-based semimetal EuZnGe, and clarify a distorted spiral spin structure [3].

2 Experiment

We performed the resonant x-ray scattering experiment of EuZnGe using a single crystal grown by Eu-Zn flux. The measurement was carried out at BL-3A by using the horizontally polarized x-ray in resonance with Eu L_2 absorption edge (7.615 keV). The scattering plane was set to be (*H*, 0, *L*). The sample was loaded into a vertical-field superconducting magnet with the *b* axis parallel to the field direction.

3 Results and Discussion

We observe magnetic Bragg scattering in the (0, 0, *L*) scan as shown in Fig. 1(a). The scattering shows up around L = 7.5 – 7.6 with a double-peak feature indicating unconventional incommensurate spin structure. We find that the magnetic scattering shows a resonant feature in the energy dependence of the intensity (Fig. 1(b)), and disappears above the magnetic transition temperature.

The simple helical spin modulation with the modulation wavenumber q would show a single peak at (0, 0, $2n\pm q$), where n is integers. The double-peak feature with diffuse intensity in-between suggests that the random mixture of the distorted spin configurations for q = 0.5 and 0.4. To clarify the possible spin structure in EuZnGe, we simulate the diffraction intensity profile by the 5- and 4-sublattice spin configurations as shown in Fig. 2(a). We successfully reproduce the intensity profile (Fig. 2(b)).

We measure the magnetic field dependence of the scattering intensity profile, and observed nonmonotonic q-change at the spin-flop-like magnetic transition. This is hard to be reconciled with the multidomain scenario for the nearly degenerate two spin configurations, and support our mixed model.

Underlying mechanism to stabilize such an unconventional spin structure is unclear at the moment. Possible candidate would be a competition between the RKKY interaction and the hexagonal in-plane anisotropy. Recently, related spin structures have been reported in several Eu-based materials [4-5]. The future study is necessary to deepen the understanding of the unusual spin spiral structure in Eu-based magnetic semimetals.

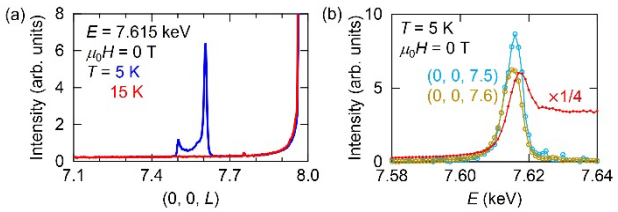

Fig. 1: (a) Intensity profile along (0, 0, *L*). (b) Energy dependence of magnetic Bragg scatterings (cyan and yellow) and fluorescence (red).

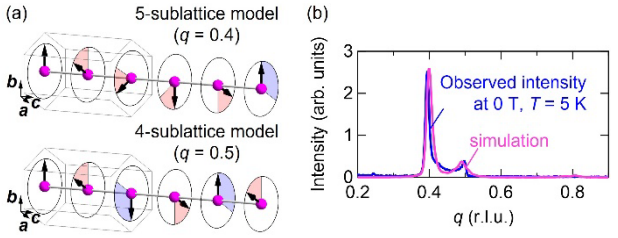

Fig. 2: (a) Model of spin configuration for 5 and 4 sublattice structures. (b) Simulated and observed intensity profiles for the distorted spiral spin structure in EuZnGe.

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References

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