ESRF	**Experiment title:** Magnetic order in the antiferromagnetic ground state of single crystalline $EuRh_2Si_2$ probed by X-ray resonant magnetic scattering	**Experiment number**: HE 3862
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Report:

The aim of the experiment was to determine the magnetic order in the antiferromagnetic (AFM) ground state of single crystal $EuRh_2Si_2$. To this end, the resonant magnetic scattering of the Eu ions was studied as a function of temperature, incident photon energy and scattering geometry. From the data we expected to find an explanation for the complex and strongly anisotropic magnetism in $EuRh_2Si_2$ which is very unexpected for a pure spin system, i.e. in the absence of an orbital moment.

After aligning the sample in the diffractometer, we found the intense magnetic scattering peak at around (0, 0, 0.79) as expected from the previous hard x-ray experiment. Due to the strong resonant enhancement at the Eu M_5 edge and the excellent quality of the single crystals, we were able to observe a very sharp and strong magnetic peak. This peak was followed as a function of temperature and showed a clear evolution through three different stages, reminiscent of the three AFM phases, expected below T_N = 24.5 K (Fig.1). The lowest possible sample temperature of the diffractometer was higher than expected, 16 K instead of 12 K, which is why we could enter the low-T phase completely, but nonetheless clearly saw it coexisting with the medium-T phase at the phase transition.

Having confirmed the hard X-ray data, we started to measure the azimuth dependence of the magnetic scattering in the different phases, which gives detailed information about the magnetic order in each phase. Unfortunately, the translational motions of the in-vacuum goniometer didn't working reliably and the y motion got completely stuck. It was therefore not possible to center the sample properly in the diffractometer. As a consequence, the beam moved across the sample and even partly onto the sample holder during the azimuth

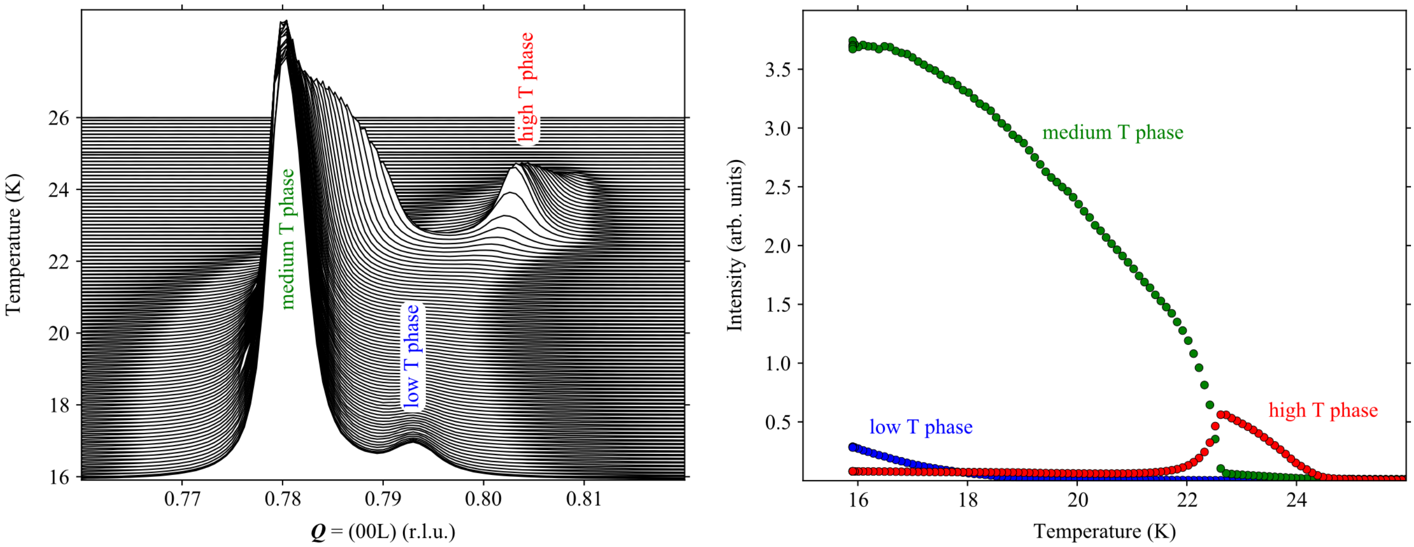

***Figure 1:** Temperature dependence of the resonant magnetic scattering peak around ~(0, 0, 0.79) showing the existence of three different AFM phases below T_N = 24.5 K.*

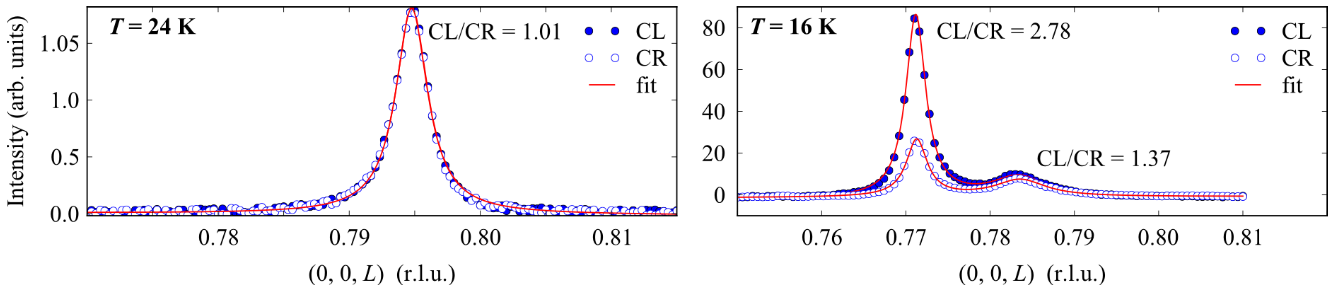

Figure 2: Circular dichroism in the magnetic diffraction peak of the low- and medium-T phase reveals the chiral character of the magnetic order in both phases. No chirality is present in the high-T phase.

scans which prevents a meaningful analysis of the scattered intensity as a function of azimuth angle. This problem couldn't be fixed during the time of the experiment.

We therefore decided to concentrate on the dependence of the scattered intensity on the incident light polarisation in the different phases. Because the E vector of the linearly polarized light at ID08 can only be set to an angle between 0 and $\pi/2$ with respect to the storage ring plane the obtainable information was very limited. However, we found that in the medium-T phase the magnetic order possesses a strong chirality while the order in the high-T order must be a non-chiral structure (Fig.2). The low-T phase shows a weak, but clear chirality. The circular dichroism caused by the chiral orders increased when we decreased the beam size which confirmed the existence of magnetic domains which in the medium-T phase must be of the order of ~100×100 μm^2, and probably much smaller in the low-T phase.

In summary, we couldn't study the azimuth dependence of the magnetic scattering in $EuRh_2Si_2$ due to technical problems of the ID08 soft X-ray diffractometer. Without these data we cannot determine the magnetic ordering in the three AFM phases, which would have helped to understand the reason behind the complex and strongly anisotropic. Nonetheless, important information on the possible types of magnetic order was obtained by the X-ray polarisation dependent measurements. This data is currently analysed together with our new magnetisation. Because of the current mechanical problems of the ID08 diffractometer we currently regard a different approach by means of XMLD measurements more promising for understanding the reasons behind strong magnetic anisotropy. A second attempt to determine the magnetic order in the three AFM phases of $EuRh_2Si_2$ might be undertaken when the mechanical problems of the ID08 diffractometer have been overcome.