ESRF	**Experiment title:** Lattice dynamics of Europium monoxide by grazing-incidence inelastic X-ray scattering and first principles theory	**Experiment number**: HC 1934
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Shifts: 15	Local contact(s) Alexei Bosak	

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The aim of this experiment was a systematic investigation of the lattice dynamics of bulk-like epitaxial EuO film in the temperature range 30 K – 300 K by inelastic X-ray scattering with a special attention near the Curie temperature (69 K).

Report

An epitaxial 100 nm thick EuO(001) film was grown on yttria stabilised zirconia (YSZ) according to the growth conditions described by Sutarto et al. [1]. Few monolayers of Eu metal were deposited on the substrate before the growth in the oxygen atmosphere to compensate for the oxygen diffusing from the substrate. The surface morphology was investigated by in-situ reflection high energy electron diffraction (RHEED) and the stoichiometry was confirmed with in-situ x-ray photoemission spectroscopy (XPS), fig. 1. After the characterisation the sample was capped with a 10nm thick Nb layer to prevent oxidation upon exposure to air. The crystal structure and quality of the film were investigated by x-ray diffraction prior the inelastic x-ray scattering experiment (IXS).

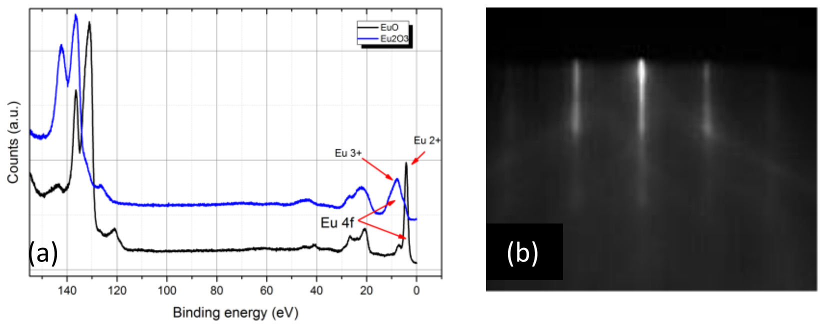

Figure 1. (a) X-ray photoelectron spectroscopy data measured on EuO/YSZ (lower line) and Eu_2O_3 (upper line). (b) RHEED image of EuO/YSZ along (110) direction.

The IXS experiment was performed in grazing incidence geometry at ID28 beamline of the ESRF using Si(999) reflection achieving an energy resolution of 3meV at full width half maximum. The phonon energies were measured along Γ-X and Γ-K-X directions at 40K and at room temperature. Additionally the transverse branch along Γ-X direction was measured at 90K. The experiment was guided by the first principle calculations. The calculated phonon dispersion relations along with the experimental points are shown in figure 2.

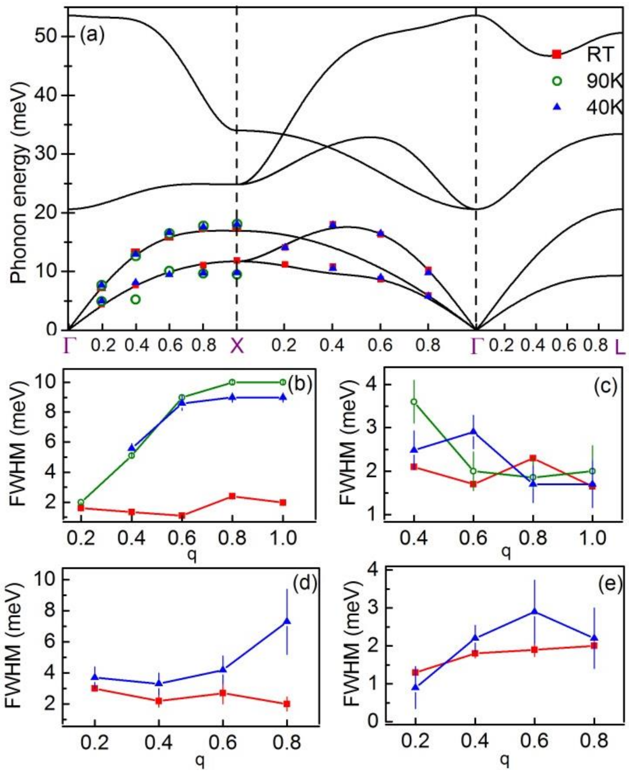

Figure 2. (a) The solid lines represent the calculated phonon dispersion relations and the points are the experimental data measured at various temperatures. Graphs (b) and (c) plot the FWHMs of transverse acoustic branch along Γ-X and Γ-K-X directions, respectively. (d) and (e) are the FWHMs of the longitudinal acoustic branches along Γ-X and Γ-K-X directions, respectively.

The experimental results showed good agreement with the calculated phonon dispersion relations. However, certain acoustic branches showed pronounced broadening (reduced phonon lifetimes) at lower temperatures. A q dependent and q independent broadening at low temperatures were observed for Γ-X transverse and Γ-K-X longitudinal branches, respectively. Our ab-initio calculations did not predict such effects. We speculate that the broadening at 40 K originates from magnon-phonon coupling as a result of the long range ferromagnetic ordering below the Curie temperature. However, the origin of the broad phonon spectrum at 90 K is still not clear. Previous magnetic studies on EuO report the presence of strong spin fluctuations at temperatures above the Curie temperature [2,3]. The possibility of phonon coupling to such spin fluctuation cannot be discarded. Further ab-initio calculations for EuO in the antiferromagnetic state are in progress. Due to the weak scattering from the oxygen atoms the optic branches were not measured.

References

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