ESRF	**Experiment title:** XMCD in X-ray anomalous transmission (the Borrmann effect) in YIG single crystal	**Experiment number**: HC-2973
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Report

Scientific Background

We have proposed to measure the X-ray circular dichroism in anomalous transmission for different temperatures near the K-edge of Fe (7,112 KeV) to reveal the details of iron magnetic states in YIG. Recently [1,2] a very strong relative enhancement of quadrupole absorption was revealed in gadolinium gallium garnet with similar crystal structure as yttrium iron garnet (YIG) near the absorption edges of Gd. But no polarization analysis was made. In YIG iron atoms occupy two crystallographically non-equivalent Wyckoff positions 24(d) with $\bar{4}$ symmetry and 16(a) with $\bar{3}$ symmetry. Near the iron absorption edge each position provides the forbidden Bragg reflections: hh0 (h=2n+1)-type induced by iron atoms in 16(a) sites and h00 (h=4n+2) corresponding to the 24(d) sites [3]. Similar reflections were observed experimentally in YAG (yttrium aluminium garnet) near the yttrium K-edge [4], but never at the iron K-edge. We have high quality YIG single crystal with surface orientation 002 and a single crystal of gadolinium iron garnet with surface orientation 110. So that it was possible to study the forbidden reflections corresponding to the different iron sites. This demonstrates a site selectivity of the resonant X-ray diffraction.

Experimental details

While the YIG sample of a good quality with 002 surface was prepared, the experimental setup was not flexible enough for a perfect alignment of the crystal in Laue diffraction geometry. It would be desirable to equip this diffractometer with 2D in vacuum detector. So we have used the Bragg geometry and have measured the forbidden reflections 200 at the incident radiation energy close to the iron K-edge (7100 eV??) and 110 reflection in gadolinium iron garnet at the gadolinium L3 edge (eV). We have used the first harmonic of an APPLE-II helical undulator spectrum for the measurements at Gd L_3-edge and the second harmonic for the experiments at the Fe K-edge. X-ray absorption spectrum was recorded using total X-ray fluorescence yield detection mode. The azimuthal dependence of the 200 reflection in YIG was measured both near the maximum of absorption and in the pre-edge region. It allows to align the sample and to find the maximum of the integrated intensity. The energy dependencies of both reflection was studied at the suitable azimuthal angles. All measurements revealed a strong contributions of the Renninger reflections, which made the experiments highly complicated.

Results

We have measured the azimuthal dependence of the 200 reflection in the vicinity of the Fe K-edge (fig.1a). Sharp peaks on the experimental curve are the strong Renninger reflections excited by the multiple scattering of X-rays. In spite of a great number of such reflections corresponding to a large lattice parameter of YIG (12,6 A) the azimuthal dependence is explicit and corresponds to the theoretical predictions. It reveals the dipole-dipole resonant scattering by iron atoms in 16(a) Wyckoff position. The energy spectrum of the 200 reflection is represented in the fig. 2.

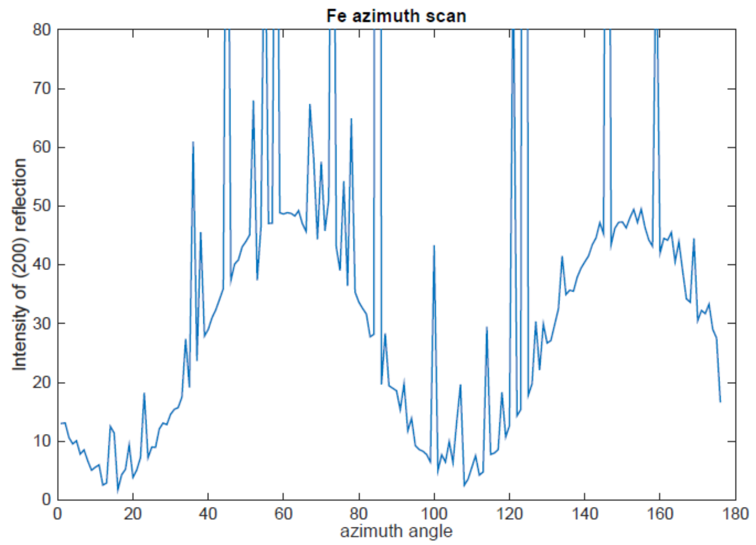

Fig.1. Azimuthal dependence of the 200 forbidden reflection at the energy 7120 eV (near the Fe K-edge).

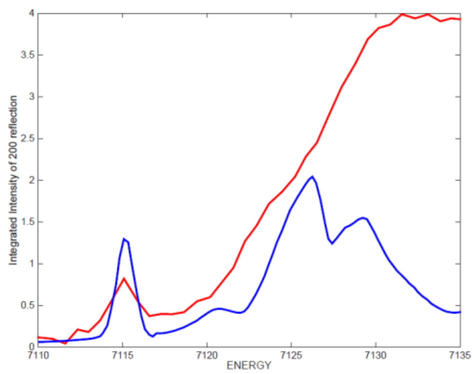

Fig. 2. Energy spectrum of the 200 forbidden reflection (blue line, at the azimuthal angle 60^{o}) and XANES spectrum near the K-edge of Fe (red line, scaled).

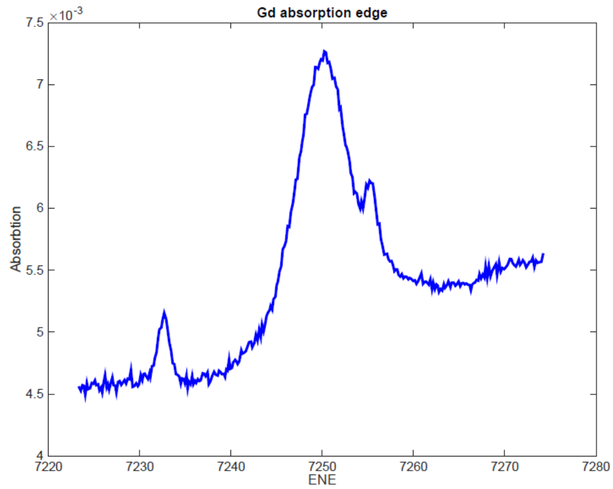

Fig. 3. Near edge structure of the gadolinium L_3 absorption edge.

The results obtained for the 110 reflection near the gadolinium L3 edge (fig.3) are too strongly affected by the Renninger reflections and very complicated analysis is necessary to separate them from the resonant scattering by gadolinium atoms.

References

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Report Summary

We have measured two forbidden reflections: 200 in yttrium iron garnet near the Fe K-edge and 110 in gadolinium iron garnet near the L3 gadolinium edge. The 200 reflection in YIG is induced by the iron atoms occupying the 24(d) Wyckoff sites with -4 local symmetry and demonstrates a selectivity of a method. Azimuthal and energy dependencies of the 200 reflection is in agreement with theoretical calculations. But the great number of Renninger reflections made the measurements for the 110 reflections unreliable, so very delicate calculations are necessary to separate them from the resonant contribution.