ESRF	**Experiment title:** XRMR investigation of the magnetic contribution to the dispersive part of susceptibility by shifts of Kiessig oscillations near the critical angle	**Experiment number**: MI - 925
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Report:

Magneto-Optical constant determination for X-rays in vicinity of the absorption edges remains one of the important experimental challenges in materials science. XMCD measurements give only the imaginary part of the magnetic contribution to the refractive index (after proper but not reliable normalization). In soft X-ray region Faraday rotation and the shift of the Bragg peaks are successfully used for the absolute determination of the refractive part of this term.

The aim of our experiment, performed at ID12 beamline at the ESRF [1], was to test the sensitivity of the reflectivity method, and in particular the Kiessig oscillation displacement, for the direct determination of the dichroic (magnetic) contributions to the dispersive and absorptive part of the optical constants in the resonant region for hard X-rays. The different positions of the Kiessig oscillations for the right and left circular polarized radiation is obviously a consequence of the different phase shifts for the multiple reflected waves in a magnetized thin film.

The sample Nb(4 nm)/YFe_2(40 nm <110>)/Fe(1.5 nm)/Nb(50 nm) has been epitaxially grown on a sapphire substrate at the LPM, University of Nancy. YFe_2 is known to be a soft ferrimagnet [2], in which Y atoms acquire an induced magnetic moment of *ca.* 0.4 μ_B . The energy and angular dependencies of reflectivity curves and corresponding polarization asymmetry ratio have been measured at different energies near the Y $L_{2,3}$ edges (L_3: 2071 – 2095 eV, L_2: 2145 – 2185 eV, energy resolution 0.2 eV) for the right and left circular polarized radiation (polarisation rate was ~ 0.85-0.75%) in L-MOKE geometry with an external magnetic field 0.45 T applied parallel/antiparalel of the wave vector of the incident beam. Results for the L_3 are presented in Fig.1 and 4. XAS and XMCD spectra for the investigated sample were measured at the glancing angle of 25^o using the total fluorescence yield. For normalization of the data the susceptibility of YFe_2 were calculated with atomic scattering amplitudes for Y and Fe from [3] and atomic density of Fe and Y taken for the cubic elementary cell corresponding to the Laves phases C15 with the lattice parameter a= 0.737 nm [4]. The properly normalized XAS and XMCD data and their Kramers-Kronig (KK) transforms for the refractive part of susceptibility were used as the starting point for the fit. For the other layers we used XOP [5] data for the refractive index. For data analysis we have developed the software package ASYM that is based on the general theory of reflectivity [6].

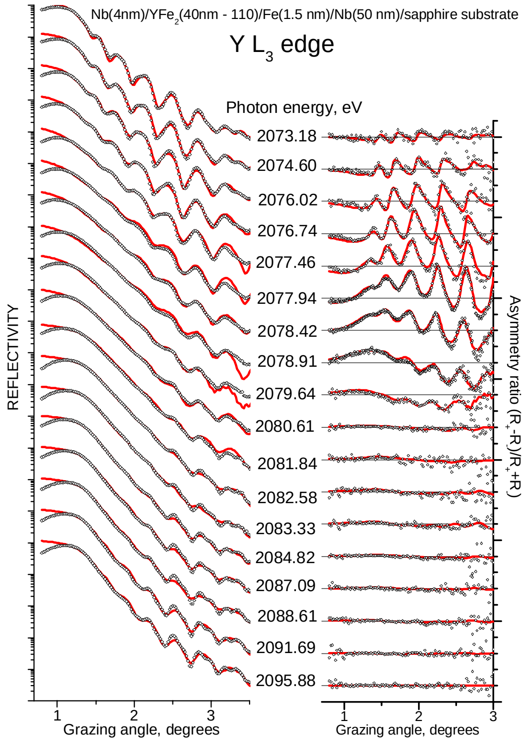

Fig.1.

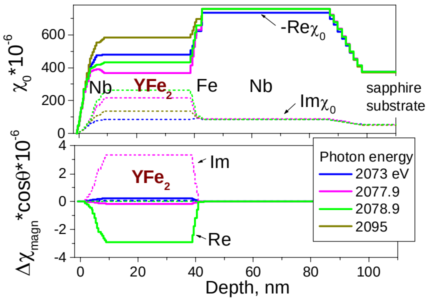

Fig.2. Depth profiles of susceptibility components, obtained from the data fit for some energies.

Fit of the data provides us with the exact structure of our film (Fig. 2) and the complex susceptibility χ_o and $\Delta\chi_{magn}$ in YFe_2 layer as a function of energy (symbols in Fig. 3). These dependences are compared with properly normalized XAS, XMCD spectra and their KK transforms (blue lines in Fig. 3). Excellent agreement of the results is observed though there is a difference of the absolute values for Re χ.

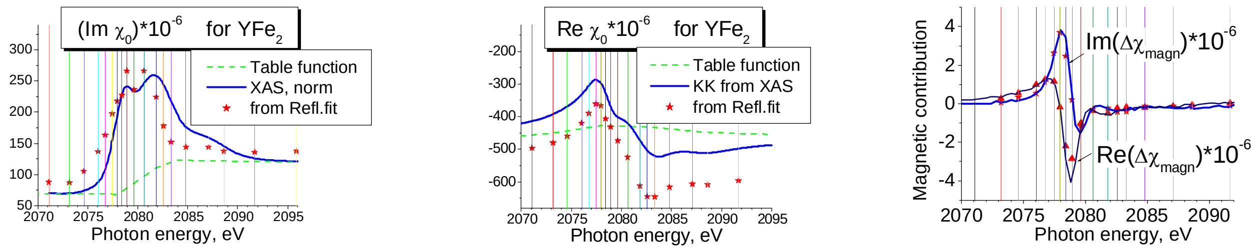

Fig. 3. Results of reflectivity and asymmetry fit.

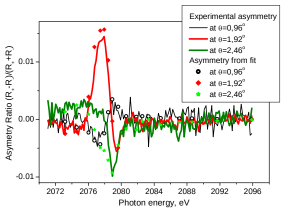

Fig.4

The energy spectra of reflectivity and their asymmetry ratio in vicinity of the L_2 and L_3 absorption edges of Y were measured at several grazing angles (Fig.4). They show the remarkable change of the line shape with the angle variation. The asymmetries, calculated with the obtained susceptibility functions, agree reasonably well with experimental spectra.

In conclusion, we have shown that the absolute values of magnetic terms of the susceptibility tensor in vicinity of the absorption edges can be extracted from the reflectivity measurements near the critical angle for the right and left circular polarized radiation by means of the joint fit of the reflectivity curves and asymmetry ratio

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