# POLARISED GRAZING INCIDENCE DIFFRACTION AS AN OPTION ON EROS FOR THE STUDY OF THIN MAGNETIC FILMS

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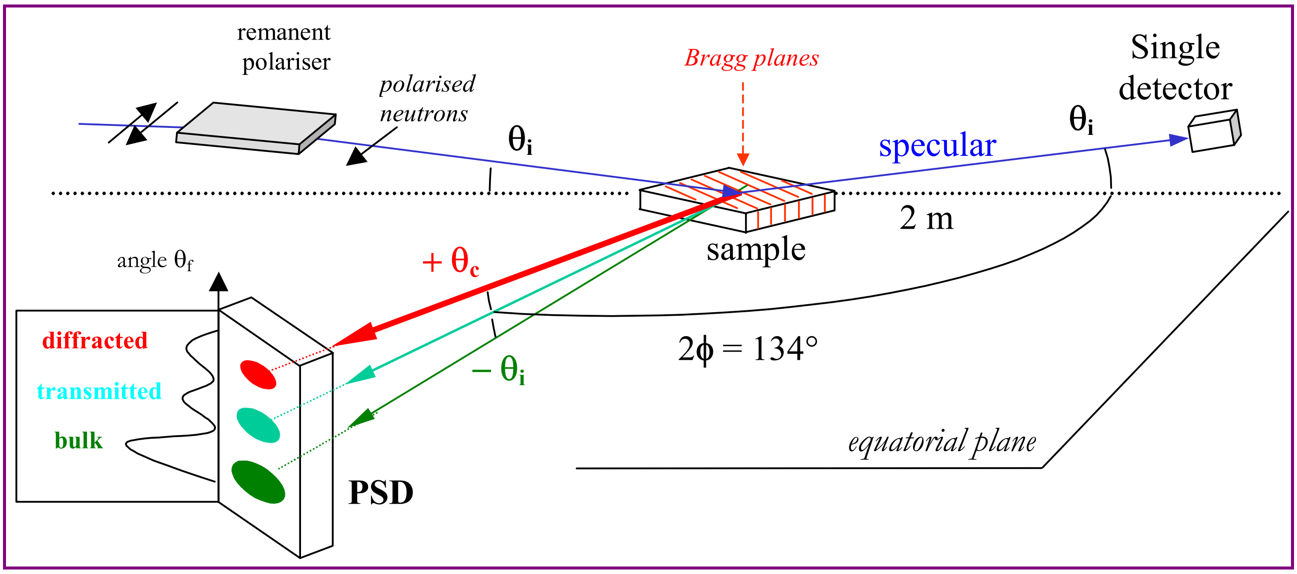


Figure 1. Experimental setup for polarised GID

A surface diffractometer has been recently installed as an option at the LLB on the reflectometer EROS. This new instrument is dedicated to the study of the surface crystallographic and magnetic structure of thin films.
The diffractometer can work in three modes i) in full guide spectrum (Laue-type configuration), ii) in Time of Flight and iii) in monochromatic beam. This configuration are unique and permits an easy sample alignement procedure.
Compared to the reflectometry setup several add-ons were developed for the grazing inicidence diffractomer. The add-ons include a compact goniometric table, a remanent polarizer, a monochromatic mirror, a sample horizontal slit (varying from 20 µm to 1 mm), a sample holder with a permanent magnetic field applied in various in-plane directions and a linear PSD.
Electronics were also added to control the different setup elements. The whole experimental is sketched in Figure 1.

Hence the instrument is designed to provide a polarised beam neutron. The sample in mounted horizontally on a goniometric table
The diffraction signals are detected by a PSD placed in the equatorial plane at a fixed angle $2\phi$.
According to the Bragg's law: $\lambda = 2d_{hkl}\sin\phi$ (as the angle $\phi$ is fixed) the useful wavelength is selected by the in-plane cell parameters of the sample ($d_{hkl}$).
First experiments were applied to a epitaxial thin film of $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) deposited on $SrTiO_3$. The sample is 20nm thick and its surface is $1cm^2$. The LSMO compound is ferromagnetic at room temperature and the thin film magnetic moment was measured by reflectivity at 1 µB per unit cell.
The alignment of the sample is performed using the Laue configuration and then the diffracted wavelengths are identified in a Time of Flight measurement. In our case the diffraction signals of the LSMO compound are expected at $d_{200}$=0.39nm which corresponds to a diffraction wavelength of 0.7nm.

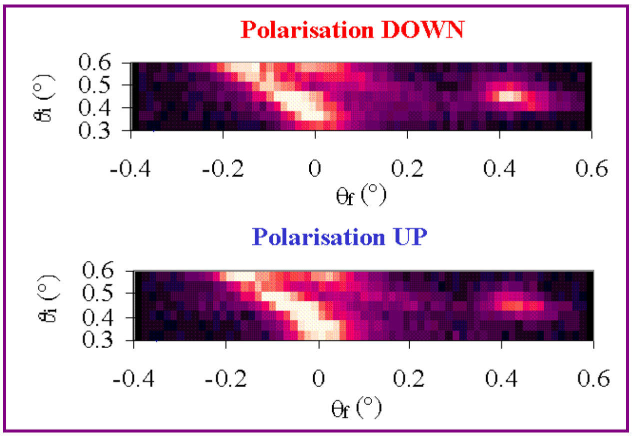


Figure 2. Intensity observed in a linear scale on the PSD as a function of the incident angle ($\theta_i$) and the output angle ($\theta_f$).

Figure 2 shows the signals observed on the PSD for up and down neutron polarizations in linear scale at l=0.7nm in the $\theta_i$-$\theta_f$ plane.

At the starting incident angle $\theta_i$=0.3° one can observe the diffraction due to the substrate, this signal is observed for all $\theta_i$ values. As the incident angle is increased the diffraction signal from the film (noted Reflected) arises ($\theta_f \sim 0.41°$) which is in a good agreement with the expected value for the critical angle ($\theta_c$). The film diffraction signal is maximum at the critical angle and as the incident angle increases its intensity is strongly decreased. For $\theta_i > \theta_c$ a third feature is observed and it corresponds to the transmitted signal (noted Transmitted). Its angular position is narrowing the substrate signal as the incident angle increases.

A cut at $\theta_i$=0.4° (~$\theta_c$) is shown in Figure 3 to explicit the magnetic contrast. A clear difference in intensity is observed as function of the neutron polarization. The magnetic contrast defined as the ratio $I_{(DO)}/I_{(UP)}$ ~1.7.

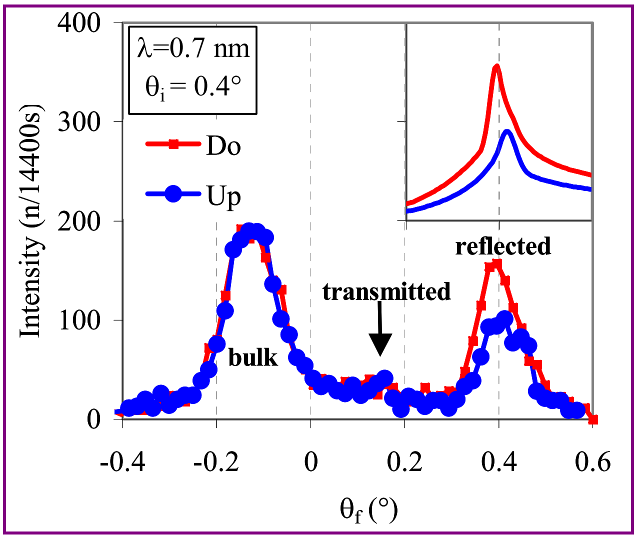


Figure 3. Measured intensity as function of the neutron polarization for $\theta_i$=0.4°. Inset shows the calculations for the magnetic contrast (see text).

Numerical simulations were developed under Delphi in order to calculate the theoretical intensity expected for the reflected signal. The result of these calculations is shown as an insert in Figure 3. The magnetic contrast is well reproduced. One can note that the measured signal width is larger than the simulated one. This feature is under investigation but could not be explained by instrumental or sample divergences.

As a conclusion the grazing incidence neutron diffractometer has shown the feasibility of this technique applied to the study of thin magnetic films. This is the first result of such a measurement on very thin magnetic oxide film. Further improvements of the instrument will include a monochromatic polarizer and 2D PSD. The instrument is included in the further intrumental development plan of the LLB (CAP2010).