ESRF	**Experiment title:** X-ray resonant magnetic scattering during a spin-reorientation transition	**Experiment number**: HE1312
Beamline:	**Date of experiment**: from: 5/02/03 to: 11/02/03	**Date of report**: 21/3/03
Shifts:	**Local contact(s)**: P. Bencok	*Received at ESRF:*

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Report:

This report concerns the use of beamtime allocated for the experiment number HE1312. Unfortunately, the proposed experiments could not be carried out using the new ID08 uhv-diffractometer because the uhv-goniometer was delivered almost one year late by the manufacturers. In October 2002 beamtime had to be used to install the diffractometer on ID08 since the uhv-goniometer was delivered one day before the start of the commissioning beamtime. This involved installing the detectors, installing the motor controls, verifying the goniometer motions, aligning the instrument and attaining good vacuum conditions. This approach ensured that the diffractometer was suitable for planned user experiments HE1318 and HE1330 which did not require uhv conditions, low temperatures and all goniometer motions. It should be noted here that the collaborators of experiment numbers HE1318 and HE1330 also contributed in many ways to an improved functioning of the uhv-diffractometer.

In January 2003 the sample preparation chamber was installed on the uhv-diffractometer along with the sample transfer, sample cooling and sample magnetization facilities. The majority of the time allocated for HE1312 involved debugging the diffractometer to perform uhv experiments that were more complicated than those already performed. Several issues, including resolution testing and controls problems made this process slower than anticipated. Due to the efforts of the present proposers (using beamtime allocated under HE1312), it is fair to say that a world class facility now exists on ID08 for soft x-ray scattering. The base pressure of the 5 circle uhv-diffractometer is $<4x10^{-10}$ mbar, sample transfer from air is straight forward, sample preparation facilities are available and low temperature (~100K) and magnetic fields (200Oe) have been tested. In this report we describe some results which demonstrate the versatility and functionality of the ID08 uhv-diffractometer. We hope that we will be given the opportunity to continue the work proposed in HE1312 since it will allow soft x-ray scattering to continue to contribute to our understanding of spin-reorientation transitions in thin films. [1,2].

In the first example, a high quality W/B multilayer was used to verify the operational capabilities of the goniometer. Fig. 1 shows the ϑ–2ϑ scans recorded from an aligned W/B multilayer using a photon energy of 650eV. The first five orders of Bragg diffraction are superimposed on a background of highly-resolved Kiessig fringes. These fringes arise from diffraction from the top and bottom of the multilayer and increase in intensity as the diffraction condition moves closer to the complete back-scattering geometry. The scan is taken from grazing incidence (ϑ=5°) to near normal incidence (ϑ=83°). In the hard x-ray range such rod scans need to be performed over ~10º whereas in the soft x-ray range accurate rod scans are required over nearly 80º. It is evident from Fig. 1 that the diffractometer is able to perform such rod scans.

The second example involves soft x-ray resonant magnetic scattering (SXRMS) from FeGd alloys. The stripe domains arise

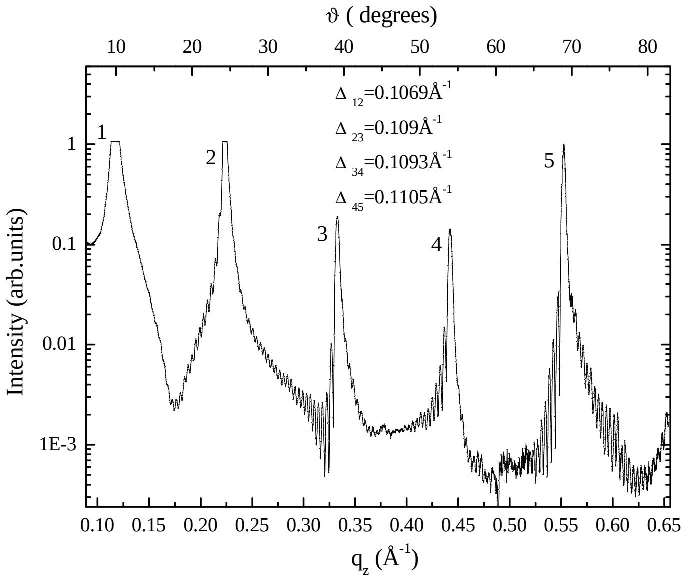

Figure 1 Soft x-ray rod scan from a W/B multilayer

from a competition between the magnetostatic anisotropy, which favours in-plane magnetization, and the magnetocrystalline anisotropy which favours an out-of-plane magnetization direction. These competing anisotropies result in a periodic array of up-and down domains (stripe domains). SXRMS has already been demonstrated to be sensitive to the domain structure and to be a unique probe of closure domain. [3,4] Fig. 2 shows SXRMS from the FeGd films under three different scattering conditions taken at the Fe L_3 absorption edge. In Fig. 2(A) the detector was moved to the 2ϑ position and kept at a constant angle while the sample was rocked. In Fig 2(B) the sample was rocked after it was rotated by 45º about the surface normal while in Fig 2(C) the stripe domains were kept parallel to the scattering plane while the detector was scanned perpendicular to the scattering plane. The satellite peaks arise from the periodicity of the stripe domains while the scattering amplitude is governed by dipole selection rules which allow $\pi_i \rightarrow \sigma_f$ and $\pi_i \rightarrow \pi_f$ scattering channels. It has already been demonstrated that, with closure domains, the two channels interfere to give dichroism in the SXRMS under appropriate scattering geometries [3,4] For the scattering geometry shown in Fig. 2(A) only the $\pi_i \rightarrow \sigma_f$ channel is allowed which arises from the perpendicular stripe domains. With the $\pi_i \rightarrow \pi_f$ switched off in this geometry no dichroism in the SXRMS peaks is seen. However, for the geometry of Fig. 2(B) the scattering symmetry is reduced and the $\pi_i \rightarrow \pi_f$ channel is switched on leading to the observed dichroism in the magnetic satellite peaks. For the geometry shown in Fig. 2(C), the maximum dichroism is seen for the first order magnetic satellites. This geometry also permits second order magnetic satellites to be observed whose intensity seems to reduce with switching the light polarization. This behaviour seems peculiar and may result from the extreme baffling down of the beam needed for this particular geometry. This leads to complex intensity variations between the two light helicities.

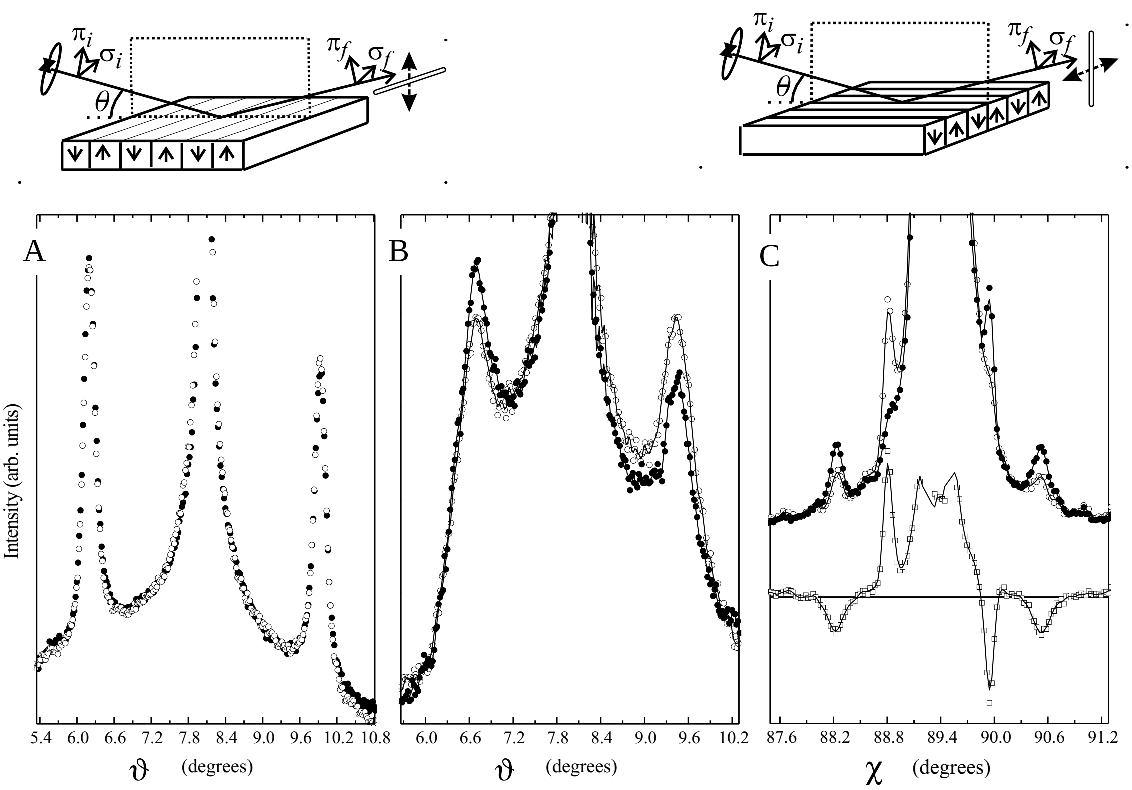

Figure 2 SXRMS from FeGd alloys under grazing incidence, recorded with left (open circles) and right (closed circles) circularly polarized light with the stripe domains (A) perpendicular to the scattering plane, (B) at 45º to the scattering plane and (C) parallel to the scattering plane; the resulting dichroism is also shown (open squares). The experimental geometries for A and C are shown above the respective figures with the geometry for B intermediate between A and C.

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[1] S.S. Dhesi, G. van der Laan, E. Dudzik, and A.B. Shick, Phys. Rev. Lett. **87**, 067201 (2001).
[2] S.S. Dhesi, H. A. Dürr, M. Münzenberg, and W. Felsch, Phys. Rev. Lett. **90**, 117204-1 (2003).
[3] H. A. Dürr *et al*., Science **284**, 2166 (1999).
[4] E. Dudzik *et al*, Phys. Rev. B **62**, 5779 (2000).