ESRF	**Experiment title:** **Observation of Spin-Flop Phenomena and their Consequences in Magnetic Superlattices by Synchrotron Mössbauer Reflectrometry**	**Experiment number**: SI-508
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Names and affiliations of applicants (* indicates experimentalists):

Name: **László BOTTYÁN*, Márton MAJOR*, Dénes Lajos NAGY***
Address: KFKI Research Institute for Particle and Nuclear Physics, P.O. Box 49, H-1525 Budapest, Hungary

Name: **Bart CROONENBORGHS*, Bart DEGROOTE*, Johan DEKOSTER, Guido LANGOUCHE,**
Address: Instituut voor Kern- en Stralingsfysica, Katholieke Universiteit Leuven, Celestijnenlaan 200D, B-3001 Leuven, Belgium

Name: **Olaf LEUPOLD*** (also local contact)
Address: Nuclear Resonance Group, ESRF, BP 220, F-38043 GRENOBLE CEDEX, France

Report:

As a further step towards better understanding spin-flop, finite stacking and domain transformation phenomena in antiferromagnetically (AF) coupled multilayers by Synchrotron Mössbauer Reflectrometry (SMR), a project referred to as 'Direct Observation of Surface Spin Flop Transitions in Magnetic Superlattices', we used SMR to study spin-flop phenomena and their consequences in MgO/$[Fe/Cr]_n$ superlattices.

First we attempted to directly demonstrate the jump in the orientation of the individual layer magnetisation during the surface spin flop (SSF) transition. For this purpose two samples of uniaxial magnetic anisotropy, viz. MgO(110)/Cr(80Å)/$[Fe(22Å)/Cr(12.5Å)]_{10}$ with the resonant isotope ^{57}Fe in the 1st/3rd and the 2nd/4th Fe layers, respectively, were prepared with molecular beam epitaxy. Magnetisation measurements showed that the samples were antiferromagnetically coupled so that there was a chance to directly observe the SSF by SMR.

The samples were placed in the variable temperature insert of a superconducting split-coil cryostat which was mounted on a one-circle goniometer. The prompt X-ray reflectivity showed strongly damped Kiessig fringes and almost no sign of a structural Bragg peak. No delayed photons could be detected in the total reflection region. This was a clear sign of an unexpectedly high interface roughness and/or interdiffusion which forced us to discontinue experiments on these samples.

In the rest of the beamtime we performed off-specular SMR experiments on a MgO(001)/$[^{57}Fe(26Å)/Cr(13Å)]_{20}$ superlattice with fourfold in-plane magnetocrystalline anisotropy at the first order AF reflection of an angle of $2\Theta = 0.80°$ in various magnetic fields. The purpose of this measurement was to check the feasibility of such kind of experiments and to see whether and to which extent the off-specular nuclear resonant scattering was sensitive to the magnetic field. The number of prompt photons from electronic scattering and the time integrated number of delayed photons from the nuclear resonant scattering

process were recorded as a function of the angle of grazing incidence ω in the range from 0 to 2Θ. The off-specular scattering shown in Fig. 1. had a very surprising magnetic-field-history dependence.

When the sample was saturated along the Fe[100] easy direction by an external field of 2.44 T and measured in zero field afterwards, no specular reflected beam appeared in the ω-scan (Fig. 1a). The specular reflected beam only appeared when a magnetic field was applied in the perpendicular direction (i.e., parallel to the actual direction of the magnetisation). Fig. 1b shows this situation after a field of 1 T was applied and removed.

The lack of the specular reflected beam in Fig. 1a clearly shows the presence of small AF domains. The specular reflected beam in Fig. 1b is, obviously, due to the fact that, at least partly, large domains were formed from the small ones.

The magnetic field in the perpendicular direction resulted in a spin-flop transition. At this stage it remains open whether the transition from the small-domain state to the large-domain state is a consequence of the spin-flop transition or not.

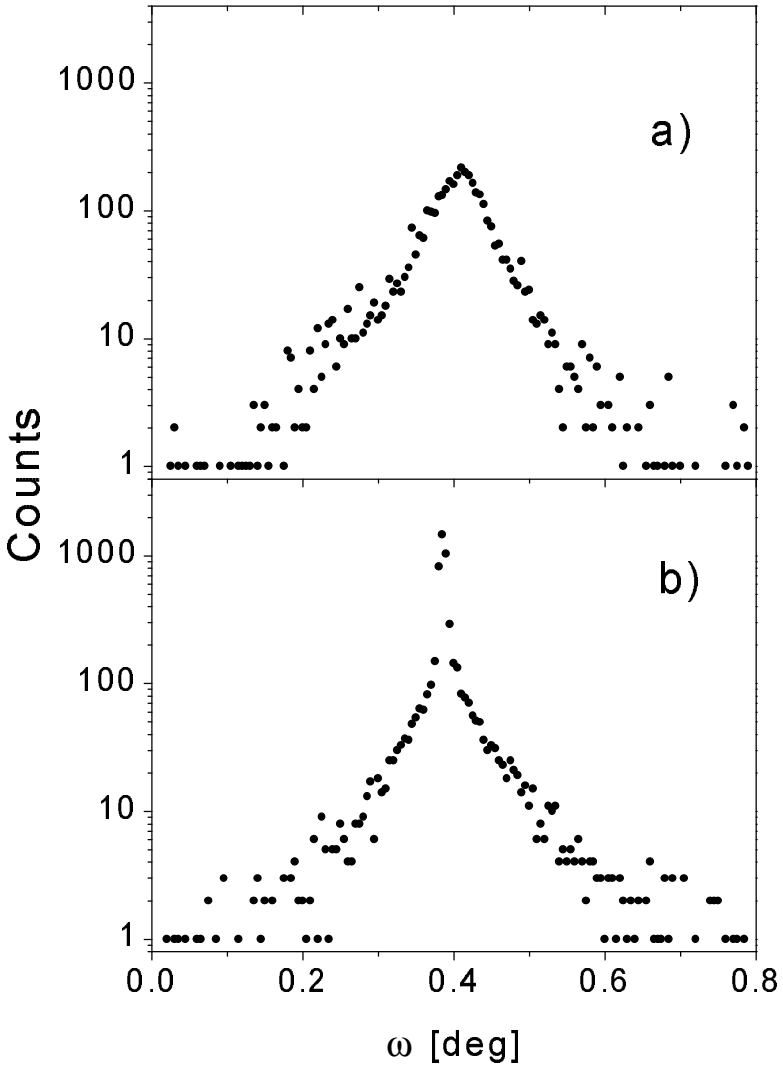

Fig. 1. Off-specular SMR scans at the AF reflection of a MgO(001)/[^{57}Fe(25Å)/Cr(14Å)]$_{20}$ ML: a) small-domain state, b) large-domain state.

Reference

D.L. Nagy, L. Bottyán, B. Croonenborghs, L. Deák, B. Degroote, J. Dekoster, H.J. Lauter, V. Lauter-Pasyuk, O. Leupold, M. Major, J. Meersschaut, O. Nikonov, A. Petrenko, R. Rüffer, H. Spiering, E. Szilágyi, submitted for publication