ESRF	**Experiment title:** Synchrotron Mössbauer reflectometric study of magnetic interlayer coupling in Fe/X (X = Cr, Ag) multilayers	**Experiment number**: SI 423
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Names and affiliations of applicants (* indicates experimentalists):

Prof. Dénes Lajos NAGY*, KFKI Research Institute for Particle and Nuclear Physics, P.O.B. 49, H–1525 Budapest, Hungary

Dr. László BOTTYÁN, KFKI Research Institute for Particle and Nuclear Physics, P.O.B. 49, H–1525 Budapest, Hungary

Dr. Johan DEKOSTER, Instituut voor Kern- en Stralingsfysica, Katolieke Universiteit Leuven, Celestijnenlaan 200D, B-3001 Heverlee, Belgium

Prof. Guido LANGOUCHE, Instituut voor Kern- en Stralingsfysica, Katolieke Universiteit Leuven, Celestijnenlaan 200D, B-3001 Heverlee, Belgium

Dr. Valeria LAUTER-PASSIOUK, Universität Konstanz, Postfach 5560, D–78434 Konstanz, Germany

Report:

The original subject of the proposal was to study interlayer coupling effects in Fe/FeSi multilayers. However, we have later realised that the two main parameters influencing the character of the magnetisation curve of an antiferromagnetic multilayer, viz. the ratio of the bilinear to biquadratic coupling and the perpendicular (out-of-plane) anisotropy can be better studied on two similar systems, each showing only one of these effects. Therefore we selected a Fe/Cr multilayer with a Cr thickness in the 2nd (i.e. relatively weak) antiferromagnetic maximum and a Fe/Ag multilayer that was known to have a significant perpendicular anisotropy.

A MgO(100)/[^{57}Fe(1.43 nm)/Cr(3.06 nm)]$_{16}$ superlattice was prepared by molecular beam epitaxy and was characterised with standard methods. A series of time integral and time differential synchrotron Mössbauer reflectometry (SMR) curves were recorded at room temperature in increasing magnetic field. Fig. 1. [1] presents the time integral curves that clearly show the suppression of both (1/2 and 3/2 order) electronically forbidden antiferromagnetic reflections. Details of the field-dependent orientation of the sublattice magnetisations were extracted from the time differential SMR curves (not shown here).

The reorientation of the easy axis of magnetisation was studied in (001) Fe/Ag superlattices using vibrating sample magnetometry, Mössbauer spectroscopy and, in frames of the present experiment, with time integral and time differential SMR. The lack of the antiferromagnetic reflections in time integral SMR curves (Fig. 2) ruled out possibility that the reason for the magnetisation curve mimicking antiferromagnetism was really the antiferromagnetic coupling [2]. Time differential SMR yielded clear evidence, that the Fe-layer magnetisation can be oriented considerably out of the plane of the sample at room temperature, even for Fe-layer thicker than 6 ML at which the spin-reorientation transition usually occurs in Fe/Ag [2]. Upon increasing the Ag layer thickness the canting disappears. In-situ scanning tunnelling microscopy measurements performed during the growth of the superlattice proved that the density of the Ag steps of the Ag spacer layers decreases rapidly with increasing thickness and that the steps have preferred orientations. Thus the spin canting is attributed to frustration and a strong contribution of a step-induced anisotropy.

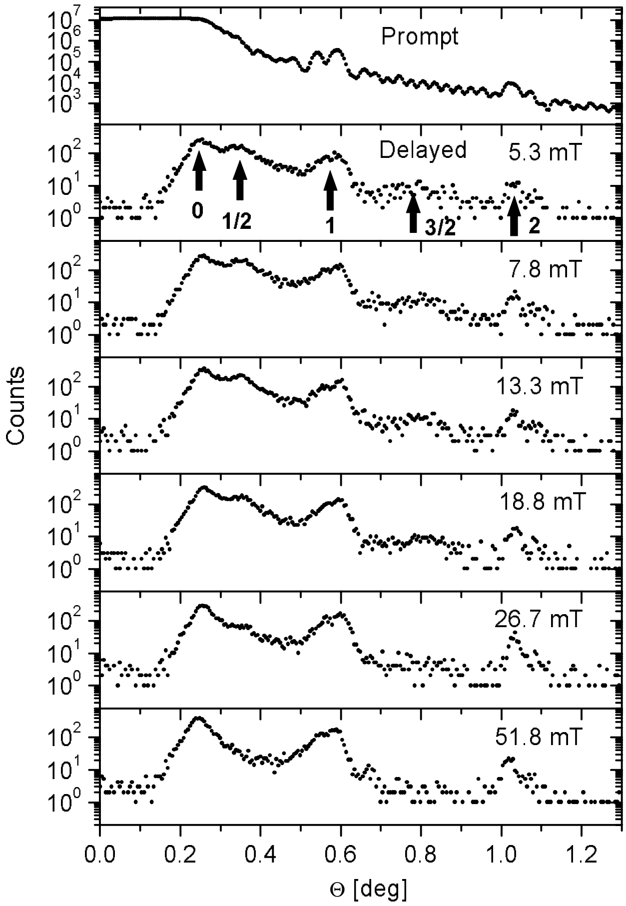

Fig. 1. Θ–2Θ scans measured on a $MgO(100)/[^{57}Fe(1.43\ nm)/Cr(3.06\ nm)]_{16}$ superlattice in various external magnetic fields. The AF reflections are suppressed as the field increases. The arrows indicate the Bragg reflections of different order.

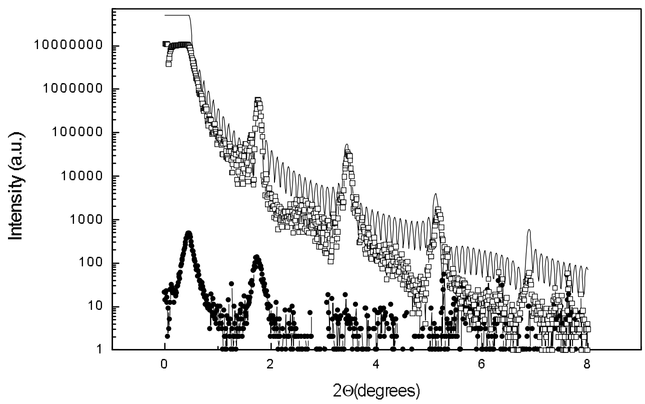

Fig.2. Non-resonant x-ray reflectivity (open squares), SUPREX simulation (full line) and time integral reflectivity (full circles) of a $[^{57}Fe(15ML)/Ag(4ML)]_{16}$ superlattice. The complete absence of an anti-ferromagnetic reflection in the time integral reflectivity indicates that there is no AF-coupling between the consecutive Fe layers.

Publications:

1. J. Dekoster, J. Meersschaut, B. Degroote, S. Degroote, C. L'abbé, G. Koops, M.J. Prandolini, T. Phalet, L. Vanneste, H.D. Pfannes, D.L. Nagy, L. Bottyán, R. Rüffer, O. Leupold, G. Langouche: *Step induced canting of magnetization in Fe/Ag superlattices*, Hyp. Int. 126(2000)353–361.
2. D.L. Nagy, L. Bottyán, L. Deák, E. Szilágyi, H. Spiering, J. Dekoster, G. Langouche: *Synchrotron Mössbauer Reflectometry*, Hyp. Int. 126(2000)349–352.