ESRF	**Experiment title:** Dimensional and single-atom effects on critical fluctuations of magnetic surfaces and thin films	**Experiment number**: HE-1099
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Report:

This report describes activities of the long-term proposal HE1099 during part of the run of October 2002. One of the goals of this proposal was to develop an experimental tool based on x-ray scattering to study structural and magnetic effects in surfaces, thin films and nanostructures. Within this framework we have studied the microscopic magnetization reversal behaviour of perpendicular exchange coupled ferromagnetic/antiferromagnetic (F/AF) systems.

Exchange anisotropy is the result of an interfacial exchange interaction between F and AF materials. The most notable changes in the F hysteresis loops are an enhanced coercivity H_C and a shift away from the zero field axis, called exchange bias H_E [1]. From the technological point of view this effect is already used to pin magnetic layers in spin electronics devices. During the last decades, numerous experimental investigations on exchange biased F/AF systems have been performed to understand the origin of the effect [2]. Most studies have focused on in-plane exchange coupled F/AF systems. Recently perpendicular exchange coupled F/AF systems have been reported [3-7].

Magnetic field-dependent measurements using circular polarization light at the Co L_3-edge were performed in a [2.3 nm Pt/0.4 nm Co]$_{15}$ multilayer with perpendicular anisotropy exchange coupled with a 10 nm FeMn layer (see Fig. 1). The film was previously grown by sputtering on a 100 nm SiN membrane. The UvA diffractometer set-up was used in the transmission geometry. We used both 1D (1 cm^2 Si diode) and 2D (phosphor-coated vacuum window with a 12 bits CCD camera) detectors. The field dependence of the absorption intensity shown in Fig1.a (black circles) reproduces the magnetization hysteresis curve measured previously by Kerr. Due to the preparation conditions and the absence of a field cooling procedure, no exchange bias is present in this particular sample. However, the interface exchange coupling leads to an enhancement of the coercive field to about 120 Oe, with respect to the ~50 Oe in the same Pt/Co multilayer without AF layer.

Using a beam stop for the transmitted beam we measured the scattering intensity of the sample over all the *q*-space available with the UvA diffractometer (below 1 micron) as a function of the applied field. This is shown with square red symbols in Fig1.a. Magnetic scattering originates from deviations from uniform magnetization, and its maximum intensity is orders of magnitude stronger than the scattering at saturation. It is therefore extremely sensitive to the nucleation processes at the onset of magnetization reversal. In this context, at large field, the F is uniformly magnetized and there is no contribution to the scattering signal. At the nucleation point, i.e. at the onset of domain reversal, the scattering increases. The slope of this increase gets smaller when the reversal transition becomes slower, and the scattering reaches a maximum roughly at the middle of this slower transition. The scattered signal then decreases monotonously up to the saturation field. The same behaviour is observed for the two sweep directions. Field dependent *q*-space resolved images were also measured. From the latter, valuable information on the magnetic domain structure during the reversal can be obtained. For instance, in Fig. 1b the image corresponding to the maximum scattered intensity is shown. The ring shape of the scattered signal indicates that a randomly oriented magnetic domain structure is formed during the reversal. An average domain size of 600 nm is extracted from the separation between this ring and the transmitted beam. This size is much smaller than for a normal Pt/Co multilayer without the AF layer (~ 100 microns, measured by Kerr microscopy), as is expected for exchange-coupled systems.

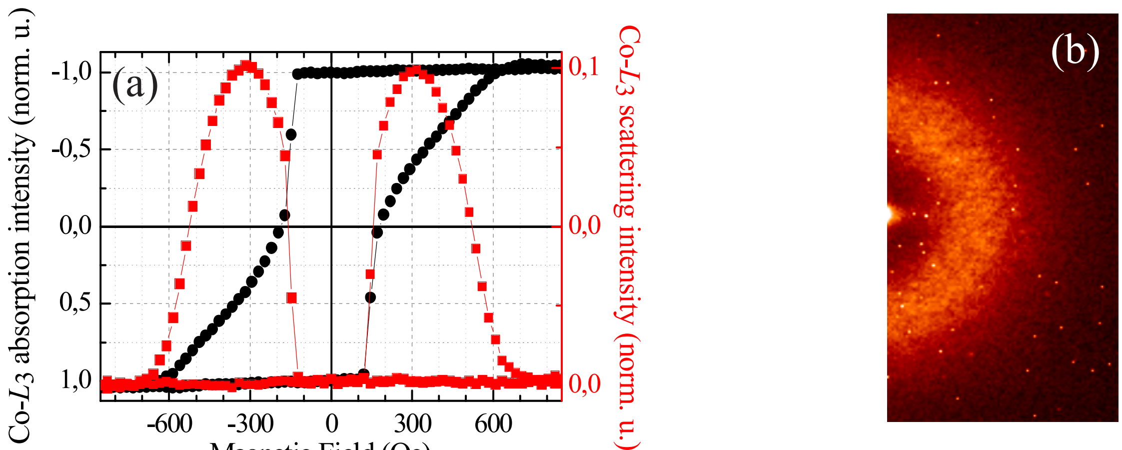

Fig.1. Typical soft X-ray magnetic scattering measurements on a [2.3 nm Pt/0.4 nm Co]$_{15}$/15 nm FeMn film (see text).

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