

Investigation of Non-Collinear Magnetisation in FM/AF/FM Trilayers by PNR

C. Schanzer¹, S. Valloppilly¹, T. Gutberlet², M. Gupta², M. Horisberger², P. Böni¹, H.-B. Braun³

¹Physik Department E21, Technische Universität München, James-Frank-Str., D-85747 Garching, Germany

²Labor für Neutronenstreuung, ETHZ & PSI, CH-5232 Villigen PSI, Switzerland

³Department of Mathematical Physics, University College Dublin, Belfield, Dublin 4, Ireland

Using PNR we examined the magnetic depth profile during the magnetisation reversal of FeCoV (FM) / NiO (AF) / FeCoV (FM) trilayers for various NiO thicknesses. With neutrons polarised within the film plane, we distinguished a uniform rotation vs. a separate magnetisation reversal of the two FM layers for NiO thicknesses less than and more than 20 nm, respectively. A direct observation of the spin twist was possible by means of selecting the neutron polarisation perpendicular to the magnetic moment of the sample and our results confirm the role of AF in mediating the interlayer exchange according to the recent theoretical predictions.

In FM/AF/FM trilayers, a possible interlayer exchange coupling, accommodated by a twist of the AF spins has been proposed from macroscopic magnetisation measurements [1]. The twist angle between the FM layer magnetisations is found to depend linearly on the AF thickness until 180° where the domain wall width of the AF is reached.

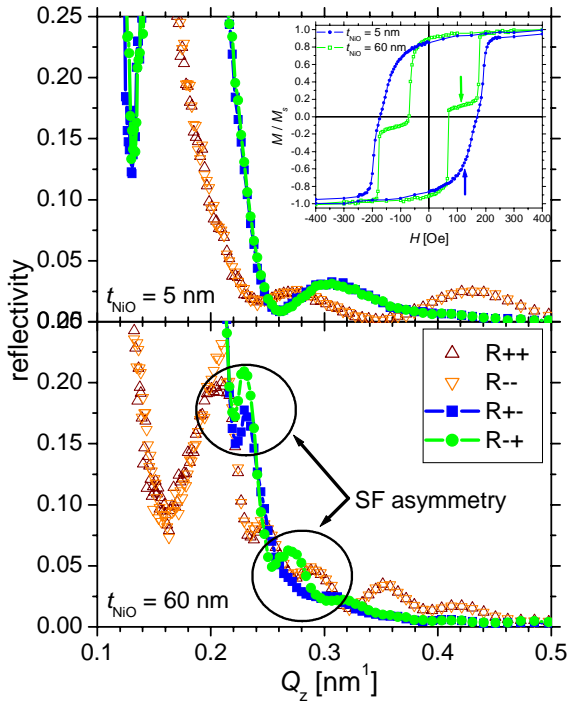


Fig. 1: PNR with neutron polarisation perpendicular to the sample of FeCoV/NiO/FeCoV trilayers with $t_{\text{NiO}} = 5$ and 60 nm. The samples were at remanent magnetisation after magnetising to a state as indicated by the arrows in the M - H loop (inset figure). For $t_{\text{NiO}} = 60$ nm the circles mark regions of strong spin flip asymmetry, due to a non-collinear arrangement of the magnetisation of top and bottom FeCoV layers. No asymmetry is present for $t_{\text{NiO}} = 5$ nm indicating a nearly collinear magnetisation state of the two FeCoV layers.

Polarised neutron scattering is most sensitive to the chirality of magnetisation when the neutrons are polarised either parallel or antiparallel to the propagation direction of the magnetic spiral [2]. In this geometry all magnetic scattering is spin flip scattering and an asymmetry in the spin flip (SF) signal will arise if the magnetic structure is

chiral. As the magnetisation of FeCoV layers is confined in the plane of the films, a neutron polarisation perpendicular to the film plane is necessary. This is in contrast to the conventional geometry for polarised neutron reflectometry. It could be realised at the AMOR reflectometer by providing a small perpendicular magnetic field over a finite sample region. An appropriate overlap of the perpendicular field at the sample with the guide field of the incident and reflected beam enabled an adiabatic transformation of the neutron polarisation from in-plane to perpendicular and vice versa. PNR with a perpendicular neutron polarisation was performed on sputter deposited trilayers of FeCoV (20 nm) / NiO (t_{NiO}) / FeCoV (20 nm) with $t_{\text{NiO}} = 5, 20, 40, 60, 80$ nm. During the experiment the samples were at remanence after magnetising to the desired states during the magnetisation reversal. This process was done externally in an in-plane magnetic field. A Q range of 0.1-0.5 nm^{-1} was covered by measuring the reflected TOF spectrum at an angle of incidence of 0.6°. The genuineness of the data and exclusion of the instrumental contributions were tested by inverting the incident polarisation. The expected inversion of the spin flip asymmetry was obtained confirming the success of the experiments and non-collinear structure. Fig. 1 shows selected results for thin and thick NiO spacer layer cases.

An asymmetry of the spin flip signal was observed for thick NiO layers (≥ 20 nm). The results confirm that for thin NiO layers (< 20 nm) the magnetisation of the FeCoV layers reverses together due to a strong coupling mediated by the NiO layer. For thicker NiO the coupling presumably relaxes by accommodating a spin twist up to 180° in NiO [3,4].

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