ESRF	**Experiment title:** Magnetic X-ray resonant study of the magnetic coupling in Sm based superlattices (Sm/La, Sm/Lu, Sm/Nd)	**Experiment number**: HE-703
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Report:

Epitaxial single crystalline (0001) films of samarium and samarium-based superlattices with high crystal quality have been grown for the first time in Nancy by Molecular Beam Epitaxy. Depending on elaboration parameters, the crystal structure of the Sm epitaxial films can be either similar to the bulk one (stacking sequence of nine close packed planes along the c-axis) or dhcp, as most of other light rare earths. This feature allows us to grow Sm/Nd superlattices, where both elements present the dhcp structure, leading to a coherent crystal structure over the whole sample.

Following the HE-477 and HE-719 experiments, devoted to the magnetism of "sm structure Sm films and Sm/Y superlattices" and "dhcp Sm films" respectively, we focussed on the magnetic properties of two Sm/Nd superlattices with different thicknesses of the Nd layers: [Sm(93Å)/Nd(37Å)] and [Sm(97Å)/Nd(69Å)]. We performed resonant x-ray magnetic scattering measurements at the Sm and Nd L_{III} edges, using polarization analysis. The samples were mounted in a He cryostat and studied in horizontal scattering geometry. The use of polarization analysis allowed the measurements of magnetic signal in the $\pi-\sigma$ polarization channel, with low charge background. The Sm L_{III} edge (6.716keV) and Nd L_{II} edge (6.722keV) are very close and there is no obvious way of identifying a dipolar resonance as coming from Sm or Nd polarization. We observed a quadrupolar resonance at 6.708 keV that can be safely attributed to the Sm 4f polarization. Nd was studied at the L_{III} edge (6.208 keV). No magnetic contribution was observed, either at the expected bulk Nd magnetic reflections, or at the Sm ones.

The main results collected at the Sm L_{III} edge are gathered figure 1 for both superlattices.

At low temperature, two sets of magnetic satellites have been measured. The first set corresponds to a magnetic propagation vector $\tau=c^*$. This can be interpreted in terms of an antiferromagnetic arrangement of ferromagnetic basal planes with hexagonal symmetry, as already observed in a dhcp samarium film (experiment HE-719). The magnetic contributions at the (007) position are reported in the top panels of figure 1 for each superlattice. From the comparison with the off-resonance spectrum (E=6.7keV), this magnetic phase seems to be coherent through Nd in the superlattice [Sm(93Å)/Nd(37Å)], since satellites are also visible around the main contribution. The FWHM gives a coherence length of 309Å, i.e. two bilayers. For the superlattice [Sm(97Å)/Nd(69Å)], the satellites, also present for E=6.7keV, are likely due to the chemical periodicity and not to a magnetic coherence.

The second set of satellites has been observed around (0.25 0 7) (bottom panels of figure 1). These peaks are characteristic of the magnetic order of moments localized on atomic sites with cubic symmetry. They form a ++--++--++--… in-plane magnetic modulation, with an antiparallel arrangement between two "cubic" basal planes. Obviously, these results show that this phase propagates coherently between Sm layers through Nd in the superlattice with 37Å thick Nd layers. The distance between the two magnetic peaks leads to a value close to the chemical periodicity and their FWHM reveals a magnetic coherence length of 219Å, i.e. more than one bilayer. There is no coherent propagation through the 69Å thick Nd layers. The magnetic coherence length is confined to single samarium layers and decreases from 103Å at 1.5K down to 79Å at 22K.

The thermal variation of various magnetic contributions shows that, in both superlattices, the magnetic phases of the moments localized on hexagonal and cubic atomic sites simultaneously disappear around 22K.

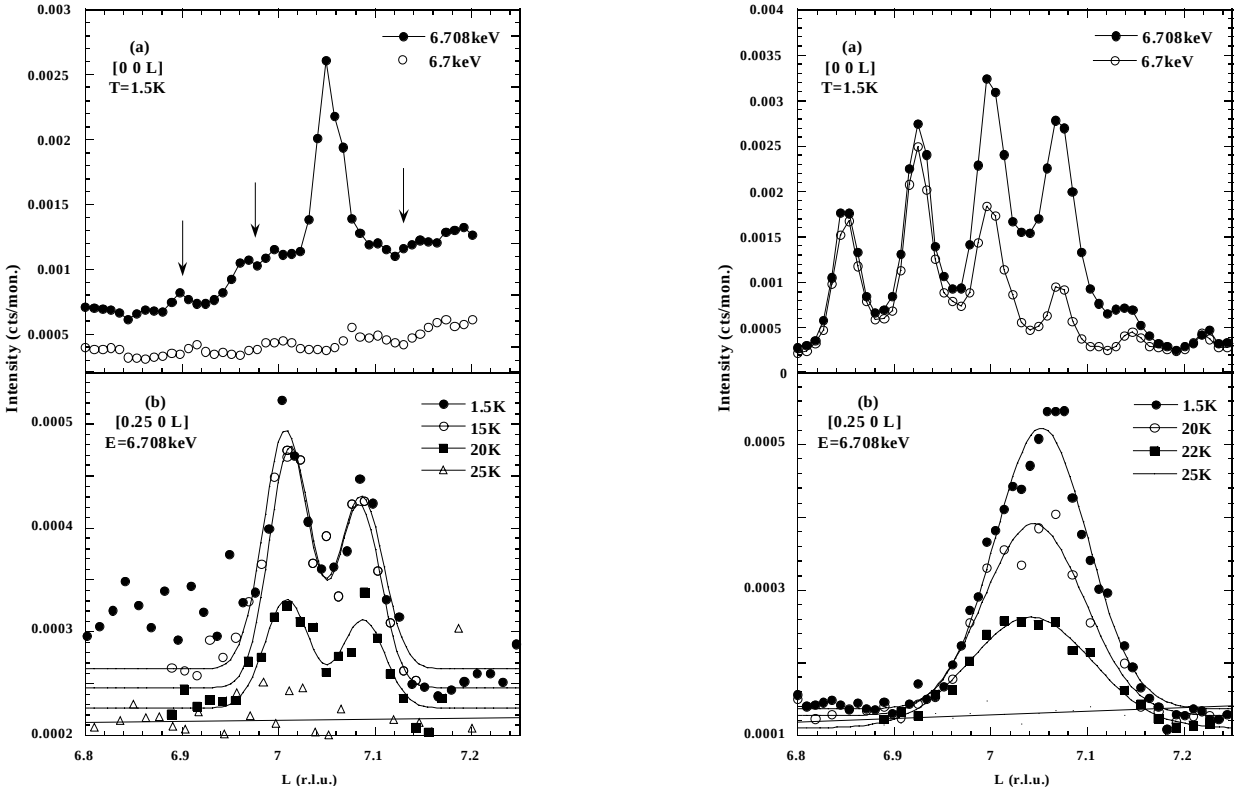

Fig. 1: Magnetic contributions measured in π–σ
(a) along [00l] for two incident photon energies and (b) along [10l] at various temperatures for the superlattices [Sm(93Å)/Nd(37Å)] (left column) and [Sm(97Å)/Nd(69Å)] (right column)