ESRF	**Experiment title:** **RXMS study OF THE MAGNETIC COUPLING IN dhcp Sm/Nd SUPERLATTICES**	**Experiment number:** **HE-1392**
Beamline: BM28	**Date of experiment:** from: 11.12.02 to: 19.12.02	**Date of report:** 25/02/04
Shifts:18	**Local contact(s):** David Paul	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

S. Soriano***,** C. Dufour*, K. Dumesnil*, Ph. Mangin, Lab. de Physique des Matériaux, Université Henri Poincaré, Nancy I

A. Stunault*, ILL, Grenoble

Report:

In bulk form, the light rare earths Nd and Sm crystallise in a compact hexagonal lattice with respectively a four planes (dhcp) and a nine planes periodic stacking along the **c**-axis. Sm/Nd superlattices where both elements exhibit the same dhcp stacking have been grown along (001) in our group by MBE. This dhcp stacking is *coherent* over several bilayers. In pure dhcp Sm and Nd, atomic sites with hexagonal and cubic symmetry coexist. In dhcp Sm, both sublattices order magnetically around 24K, with moments *along **c***. In bulk Nd, the moments on the hexagonal and cubic sites order *in the basal* plane, below 19.9 K and 8.2K respectively. Previous experiments on ID20 have already shown that RXMS is an adequate technique to investigate magnetic phenomena in Nd and Sm layers separately.

Experiment HE 703 has been performed at the Sm L_3 edge in $[Sm(9.7nm)/Nd(3.7nm)]_{43}$ and $[Sm(9.7nm)/Nd(6.9nm)]_{43}$. The magnetic phases in Sm layers are very close to the ones observed in dhcp thick films. The experiment has shown the dependence of the magnetic coherence length for the Sm magnetic order on the Nd thickness. Experiment HE-1046 was mainly devoted to the investigation of Nd magnetism in $[(Sm(3.7nm)/Nd(18.7nm)]_{42}$. A new magnetic phase, with propagation vectors presenting intermediate $\mathbf{Q_H}$ values between the ones usually attributed to hexagonal and cubic sites, has been evidenced in Nd layers below 5K. This phase propagates coherently through the Sm spacer. Magnetic moments located on the hexagonal and cubic sites seem to exhibit a common magnetic order. Moreover, above 5K, the Nd hexagonal order propagates coherently through Sm whereas Nd cubic order remains confined in the Nd layers.

During this experiment HE 1392, the magnetic properties of two new superlattices with different Sm and Nd thickness have been investigated at Nd L_2 edge on BM28: a superlattice with small Sm and Nd

thickness ($[Sm(3.4nm)/Nd(3.4nm)]_{125}$) and another superlattice with a larger Nd thickness ($[Sm(3.7nm)/Nd(6.2nm)]_{84}$) in order to confirm results of experiment HE-1046 .

In $[Sm(3.4nm)/Nd(3.4nmm)]_{125}$, the magnetic peaks usually attributed to the Nd hexagonal sites ordering have not been detected whereas the magnetic phase attributed to Nd cubic sites ordering is present in the same temperature range as in bulk Nd (Fig. 1). Moreover, below 14K, a new intense magnetic peak is evidenced at $\mathbf{Q_H}$ =0.25 r.l.u. (Fig. 1). For the incident energy tuned to a Nd edge, such a modulation has never been observed neither in bulk Nd nor in Nd based superlattices, while it is usually accredited to Sm cubic sites ordering in dhcp Sm. This new magnetic phase is commensurate in the basal plane. One can suppose that this magnetic phase corresponds to Nd hexagonal site ordering. Moreover, this phase exhibits another original feature: the systematic study through the reciprocal lattice indicates that the propagation vector is : t=(0.25 0 0.91). Thus, the magnetic order is no longer an antiferromagnetic one along the **c** direction as usually observed in Nd. Scans collected in the **c*** direction (fig. 2) exhibit a thin central peak surrounded by two satellites. Their positions correspond to the bilayer thickness. The **c** axis magnetic correlation length is 37nm. The new Nd order thus propagates coherently through approximately 5 superperiods.

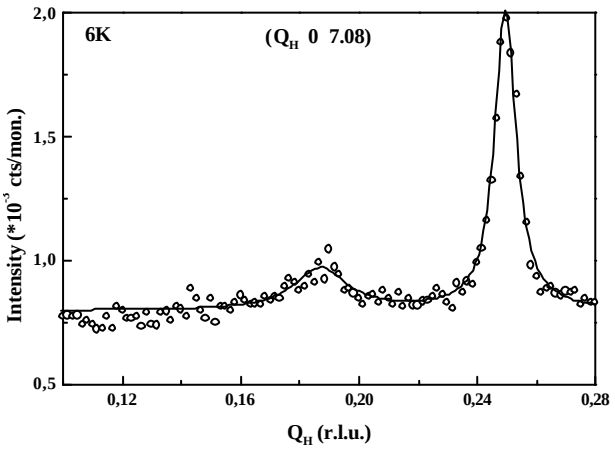

Fig. 1: RXMS intensity at the Nd L_2 dipolar resonance for $\mathbf{Q}=(\mathbf{Q_H}\ 0\ 7;08)$ at 6K for $[Sm(3.4nm/Nd(3.4nm)]_{125}$.

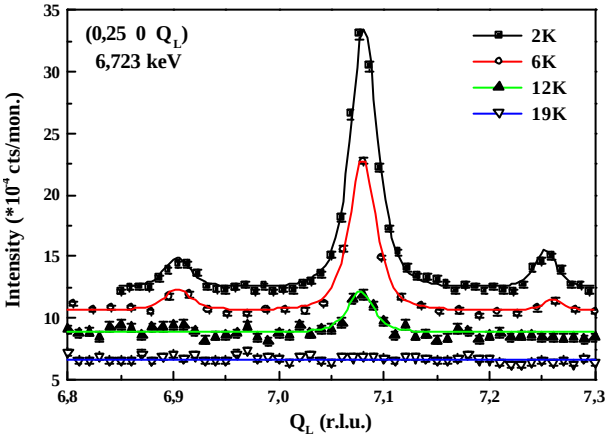

Fig. 2: Scans in the **c*** direction at the Nd L_2 dipolar resonance through the new commensurate magnetic phase at various temperature for $[Sm(3.4nm/Nd(3.4nm)]_{125}$

In $[Sm(3.7nm/Nd(6.2nm)]_{84}$, a magnetic phase with intermediate propagation vectors has been evidenced at low temperature, as in $[Sm(3.7nm)/Nd(18.7nm)]_{42}$ (HE 1046). The new magnetic peaks are located at $\mathbf{Q_H}$=0.157 and 0.163 r.l.u. at 4K. Again, this phase with intermediate propagation vectors is coherent through the Sm layers.

Finally, it is to note that during this experiment, it was impossible to extract any significant data at the Sm edge because the incident beam is less intense on BM 28 than on ID20.