	Experiment title: Size-effects on the orbital moment and magnetic anisotropy of Co nano-particles	**Experiment number**: HE1214
Beamline: ID08	**Date of experiment**: from: 09 March 2002 to: 13 March 2002	**Date of report**: 27 August 2003
Shifts: 12	**Local contact(s)**: Dr. Peter BENCOK	*Received at ESRF:*

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The anisotropy of nanometer-sized magnetic particles usually exceeds that of the bulk material and depends on the shape and especially on the fraction of atoms that are located at the surface of the clusters. To investigate if the anisotropy can be also modified by embedding the particles in a suitable metallic matrix and to compare the properties of clusters in insulating and metallic matrices, we prepared $Al_2O_3/Co/Al_2O_3$ and $Al_2O_3/Co/Cu$ (1.5 nm) $/Al_2O_3$ trilayers, which will be referred as "Co/Al_2O_3" and "$Co/Cu/Al_2O_3$" samples respectively. These samples are nearly spherical Co clusters homogeneously dispersed in Al_2O_3 or Cu/Al_2O_3 matrices [1,2]. During the shifts allocated to HE1214 we performed a sistematic soft XMCD study at the $L_{2,3}$ Co edges on the following samples:

Co/Al_2O_3 with <D> (in nm) = 0.5, 0.8, 1.3, 1.4, 2.2, 2.5, 2.8, 5.2 and a thick Co film sample.
$Co/Cu/Al_2O_3$ with <D> (in nm) = 1.3, 2.2, 2.8.

For each sample we performed a series of XMCD experiments at two different temperatures (the lowest available and T = 3 times the superparamagnetic blocking temperature of the sample). At each temperature, several magnetic fields were used to measure XMCD in order to investigate the magnetization process. Both total fluorescence and electron yields were recorded. As an example, Fig. 1 shows circularly polarised x-ray absorption scans at the $L_{2,3}$ Co edges on the Co/Al_2O_3 (upper panel) and $Co/Cu/Al_2O_3$ (middle panel) samples with < D > =2.8 nm. μ_- (μ_+) is the normalised absorption when magnetization of the sample and photon helicity of the incident beam are kept parallel (antiparallel).

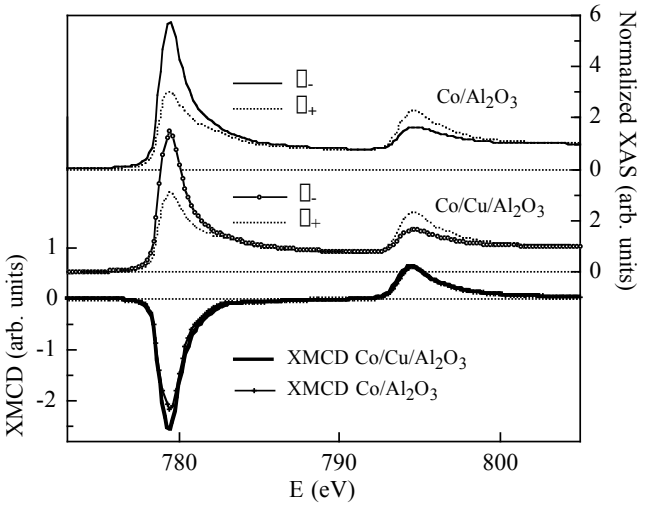

Fig. 1: XAS spectra of Co in Co/Al_2O_3 (upper panel) and $Co/Cu/Al_2O_3$ (middle panel) samples with <D>=2.8 nm recorded at T=2 K, H=2 T. Lower panel: The corresponding XMCD spectra.

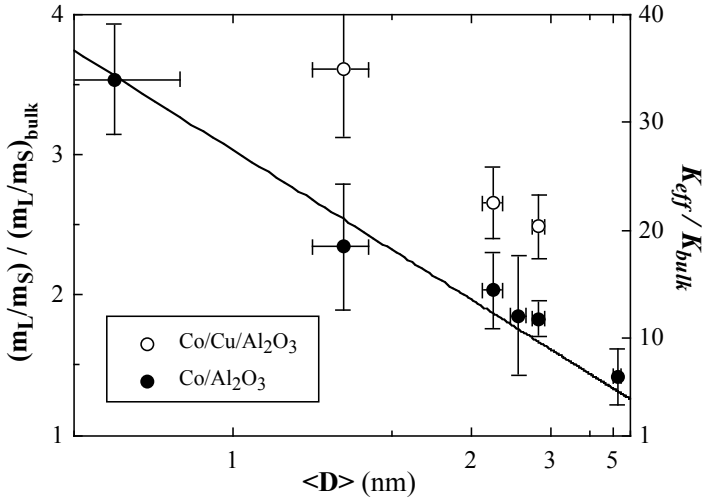

Fig. 2: Left axis: $(m_L/m_S)/(m_L/m_S)_{bulk}$ of the Co/Al_2O_3 (●) and $Co/Cu/Al_2O_3$ (❍) series. Right axis: Linear fit to the effective anisotropy (K_{eff}-K_{bulk}) of Co/Al_2O_3 series from Ref. 1 (line).

The lower panel shows XMCD for both samples, obtained as (□-□+). XMCD sum rules [3] have been used to determine the ratio of the orbital to spin magnetic moment. We limit ourselves to use the orbital to spin ratio (m_L/m_S), which is independent of the effective number of 3d holes. The XMCD curve obtained for the Co/Al_2O_3 sample (crossed line) has been scaled by a factor = 0.93 in such a way that the L2 feature (at 793 eV) is identical to that of the $Co/Cu/Al_2O_3$ one (full line). The area of the L3 XMCD feature (at 778 eV) relative to the L2 one is definitely larger for the clusters covered by a copper layer than for those only in contact with alumina, and hence it is (m_L/m_S), as it is derived from the XMCD sum rules.

The (m_L/m_S) normalised to the (m_L/m_S) value for bulk Co obtained on a thick layer is shown in Fig. 2 for every studied sample, both for the Co/Al_2O_3 (●) and for the $Co/Cu/Al_2O_3$ (❍) series We obtained the $(m_L/m_S)_{bulk}$ = 0.091(1) in agreement with previous results. In general, (m_L/m_S) is much larger in the cluster arrays than in the bulk, the difference being proportional to 1/<D>. Furthermore, clusters of the same average size but in contact with a metallic (Cu) matrix, have a large (m_L/m_S) than those dispersed in alumina.

Our results show that the effect of an increase on (m_L/m_S) is one order of magnitude more effective as source of anisotropy in the surface than in the bulk.

We have presented an oral contribution on this subjet at the ICM 2003 held in Rome in July-August 2003, and the corresponding publication has been accepted in the Conference proceedings [4]. This work has been partially financed by the CICYT research projects MAT2002-0166, MAT2002-04178-C04-03, the Fundación Ramón Areces, and the FEDER program.

References:

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