ESRF	**Experiment title:** **Tailoring the magnetic anisotropy of Co nanomagnets: role of the electronic environment**	**Experiment number:** HE-1880
Beamline: ID12	**Date of experiment:** from: 06 July 2005 to: 11 July 2005	**Date of report:** 01/08/06
Shifts: 12	**Local contact(s):** Dr. Fabrice WILHELM	*Received at ESRF:*

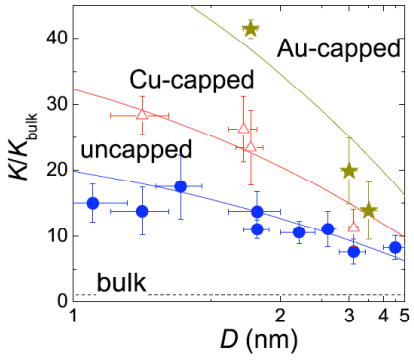
Names and affiliations of applicants (* indicates experimentalists):

Dr. Fernando BARTOLOME*, Dr. Juan BARTOLOME*, Dr. Luis Miguel GARCIA, and Dr. Fernando LUIS
ICMA, CSIC. Pedro Cerbuna 12, 50009 ZARAGOZA, SPAIN

Dr. Frédéric PETROFF, Dr. Vincent CROS, and Dr. Henri JAFFRES
Unite Mixte de Physique, CNRS- Thales 91404 Orsay, France
and Université Paris-Sud - 91405 Orsay Cedex, France

Report:

Nanometer-sized Co clusters were prepared by sequential sputtering of amorphous alumina and Co layers on a Si substrate. The Co layer segregates into nearly spherical metallic clusters. Their size can be controlled by varying the nominal thickness, t_{Co} that the Co film would have, were it continuous. In this work, we studied granular films with $t_{Al_2O_3}$ = 3 nm and 0.2 nm < t_{Co} < 0.7 nm, corresponding to average particle diameters D between 1 and 3.5 nm, which within each layer are separated by an average distance of 2.2 nm. By the same procedure, Cu, Au, and Pt--capped clusters can be prepared, by depositing a thin (1.5 nm) noble metal film (M) right after the deposition of Co. Usually samples are made by piling up a number N of Al2O3/Co or Al2O3/Co/M repetition units.



We use ac susceptibility data to obtain the effective magnetic anisotropy constant K, which can be estimated simply as the ratio between U and V for particles with average diameter D. (see references below and therein)
In order to study how the noble metal affects the effective anisotropy we studied a series of uncapped and capped Co-particles samples.

The variation of the effective anisotropy (normalized to the bulk value) is shown in the figure. In order to correlate this with changes in the electronioc structure, we measured XMCD at the $L_{2,3}$ edges of Au and Pt and at the K edge of Cu (which is the available one for Cu). Our results are shown in the figures in next page for the t_{Co} = 0.7nm (D=3 nm). The $L_{2,3}$ Co edges measured in capped and uncapped samples are also shown (measured in ID08 in other experiments).

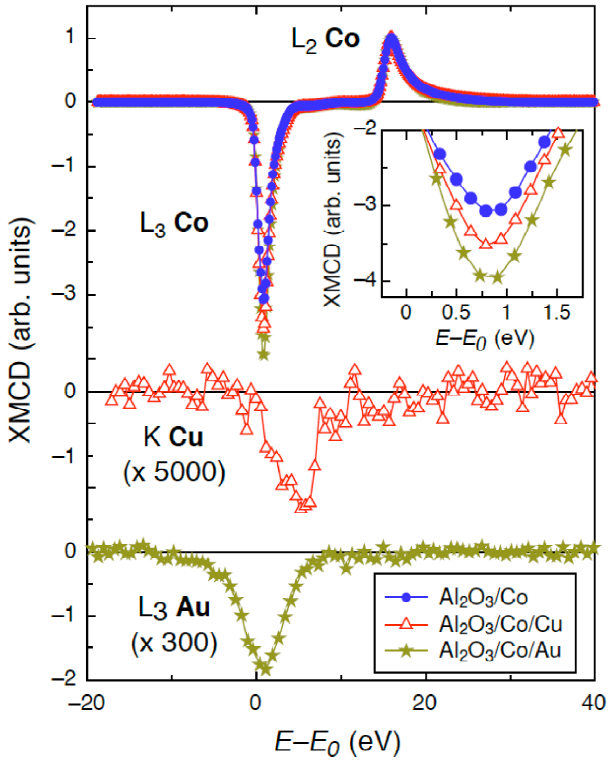


Fig. 5 – (Color online) XMCD spectra obtained at $T = 5$ K and under an applied magnetic field of 1 T of several Al_2O_3/Co, $Al_2O_3/Co/Cu$, and $Al_2O_3/Co/Au$ granular multilayers with $t_{Co} = 0.7$ nm. The Co - $L_{2,3}$ XMCD data are shown in the upper plot. To emphasize the changes induced by metal capping, they are normalized to the height of the L_2 peak. The inset shows a detail of the L_3 edge region. XMCD signals near the Au-L_3 and Cu-K edges are shown in the medium and lower plots, respectively. The origin of the energy scale is taken at the inflection point of the adequate absorption edges.

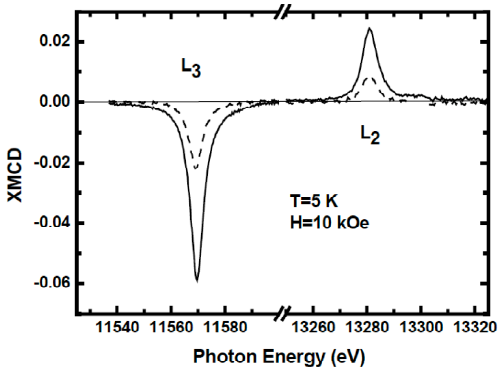


Fig. 4. Pt- $L_{2,3}$ edges XMCD spectra. (-) t_{Co}=0.7 nm, (---) t_{Co}=0.4 nm. The corresponding XAS spectra were normalized to a ratio between the L_2 and L_3 jumps of r_L=2.22 [13]. The gap in the data near 13300 eV was due to coincidence of a Bragg peak of the Si substrate appearing at that energy.

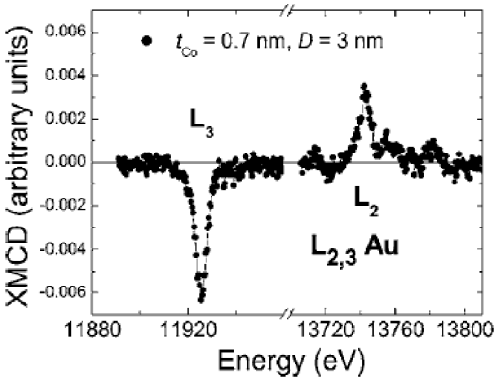


FIG. 4. X-ray magnetic circular dichroism of two samples of Au-capped (t_{Au}~1.5 nm) Co clusters with different average diameters. The spectra were measured at the $L_{2,3}$ edges of Au, at T=4.2 K and under a magnetic field of 1 T.

Evidences for electronic interaction at the interface are also observed in the absorption spectra of the capping metals. Both the Cu and Au spectra show XMCD signals near their K and $L_{2,3}$ absorption edges, respectively. Their signs show that the s – p and d electrons of Cu and Au, respectively, are ferromagnetically polarized by the corresponding electrons of Co. The polarization of Cu s – p electrons, of order $0.02\mu_B$ per atom), is similar to that observed in Co/Cu multilayers. For the 5d Au electrons, we find $m_L/m_S = 0.20(2)$, which is of the same sign but somewhat larger than the value $m_L/m_S = 0.12(2)$ found in the case of Au/Co/Au multilayers. This polarization does not appreciably change the effective magnetic moment per particle, as magnetization confirms, but plays an important role in determining the anisotropy.

Pub lications containing results from HE1880:

Enhancement of the magnetic anisotropy of Co clusters by Au capping, F. Luis, J. Bartolomé, F. Bartolomé, M. J. Martínez, L. M. García, F. Petroff, C. Deranlot, F. Wilhelm and A. Rogalev, Journal of Applied Physics 99, 08G705 (2006).

Magnetic dynamics of Co nanospheres: origin of the anomalous anisotropy , J. Bartolomé, F. Bartolomé, L.M. García, F. Luis, F. Petroff, J. Carrey, A. Vauresin "Smart materials for ranging systems" J. Franse et al. (eds.), NATO, ARW Science Series II, vol. 226, pp 1-25, 2006.

Magnetic properties of Co nanoparticle granular films capped with Pt J. Bartolomé, L.M. García, F. Bartolomé, F. Luis, F. Petroff, C. Deranlot, F. Wilhelm, A. Rogalev, Accepted in the Journal of Magnetism and Magnetic Materials (2006)

Tuning the surface magnetic anisotropy of Co nanoparticles by metal capping, F. Luis, F. Bartolomé, F. Petroff, J. Bartolomé, L. M. García, C. Deranlot, H. Jaffrès, M. J. Martínez, P. Bencok, A. Rogalev, and F. Wilhelm. Submitted to Europhysics Letters (2006)

Spin polarization of copper in Cu-capped Co clusters. L.M. García, F. Bartolomé, J. Bartolomé, F. Luis, F. Petroff, C. Deranlot, F. Wilhelm, A. Rogalev, P. Bencok, and N.B. Brookes, Submitted to the Journal of Magnetism and Magnetic Materials (2006)