ESRF

Experiment title:

Magnetic circular dichroism in the L_{23} fluorescence of 4d transition metals : alloys and multilayer

Experiment number:

HC 552

Beamline:	**Date of Experiment:**		**Date of Report:**
ID12A	from: 13/03/96	to: 23/03/96	19/04/96
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16	José Goulon		24 APR 1996

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Report:

Briefly stated, the purpose of these experiments was to test the possibility that spin polarisation in the occupied states of the 4d transition metals (TM) alloyed to a ferromagnet might be detected using selectively-excited x-ray fluorescence.

Two techniqueswere envisaged:

1) Direct use of Helios II to eject a $2p_{3/2,1/2}$ TM core electron into the continuum with ~100% circularly polarised polychromatic radiation.

2) Use of monochromatic radiation (two-crystal monochromator on ID12A) to resonantly excite the $2p_{3/2,1/2}$ TM core electron into the spin polarised empty states just above E_F.

To date the only experiments concerning dichroic fluorescence of valence states have dealt with the 3d ferromagnets [Hague et al., Phys Rev B 48RC, 3560 (1993), Duda et al., Phys Rev B 50RC, 16758 (1994), Hague et al., Phys Rev B 5lRC 1370 (1995)]. We point out in our papers that though excitation well above the ionisation threshold leads to intrinsically smaller dichroism, it has the advantage that it measures unambiguously differences in the **valence** spin occupancy rather than the convolution of unoccupied and occupied dichroism. We therefore chose the first of the above-mentioned techniques.

Our x-ray spectrometer design used a quartz (1011) crystal bent to a 0.8 m radius and a position sensitive detector. It was specially designed to fit the limited space of the “white beam” section of ID12A without any modification to the beamline. We concentrated our efforts on a $Co_{75}Rh_{25}$ fully characterised bulk alloy sample. It was magnetised parallel to its surface with a permanent magnet and cooled by liquid nitrogen. The experiments were mostly performed with the undulator peak tuned to above the $2p_{3/2}$ threshold energy but below the $2p_{1/2}$ threshold energy and well below the 2s threshold. With an undulator

peak width of ~140 eV we were able to show that essentially all satellite structure from the Rh $4d \rightarrow 2p_{3/2}$ ($L\beta_{2,15}$ emission band) could be eliminated by careful tuning.
The dichroic signal is shown in figure 1.

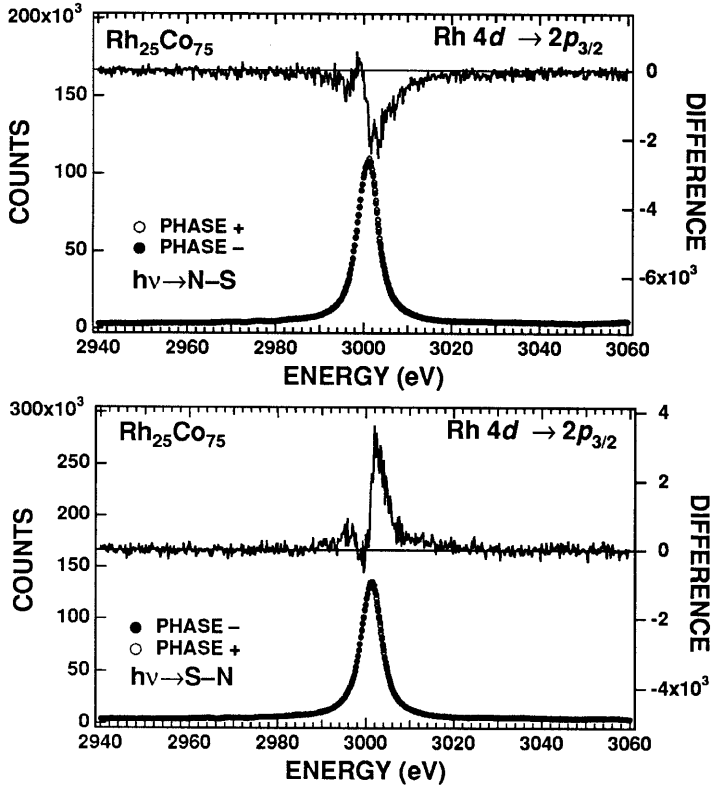

Figure 1. Rh $L\beta_{2,15}$ recorded with right circular polarisation (phase+) and left circular polarisation (phase -). Bottom: photon propagation antiparallel to the magnetic field. Top: photon propagation parallel to the magnetic field. Differences are taken as (phase –)–(phase +).

This is the first observation, for a 4d element in an alloy, of spin polarisation in valence states. It should be born in mind that because of its element selectivity, dichroic x-ray fluorescence addresses a fundamental problem: the spin dependent difference in electron scattering from site to site in an alloy. This is an essential ingredient of magnetism in complex materials. This technique may now be considered seriously as a viable new tool for studying magnetism in such materials. A spin-polarised relativistic band structure calculation of this hcp alloy is under way to assist in interpretation.

This type of experiment is uniquely possible on beamline ID12A because of its specific properties: remarkable stability, on the order of 100% polarisation, and ease of switching from right to left polarisation. In our opinion the latter is of crucial importance. Certainly step by step recording combined with switching of the magnetic field direction at each step remains the best way to detect very small dichroic signals. Where magnetisation depends on low temperatures and quite large saturation fields (as is common for magnetic multilayer and alloys), switching the phase rather than the field considerably simplifies experiments. Some systematic measurements as a function of composition are now urgently required to understand how close we may be to measuring ground state properties.