Report to the project HE1201

Among the alloys of the ferromagnetic 3*d* transition metals (TM) and paramagnetic 5*d* elements, those based on platinum have attracted much attention because of their interesting magnetic and electronic properties. CoPt systems appear to be relevant for magneto-optical applications. Very small amounts of platinum (about 1 %) diluted in bulk TM give rise to so-called giant-moment systems, in which the total magnetic moment exceeds considerably the bulk magnetic moments found in the pure ferromagnetic 3*d* metals.
A large variety of magnetic structures have also been found in such systems, depending on the chemical ordering, the concentration of Pt atoms and the particular 3*d* element (V, Cr, Mn, Fe, Co). During the last three years we have measured the XMCD signal under pressure at the Pt-$L_{2,3}$ edges in $Pt_3Mn_xCr_{1-x}$ alloys (x varying from 0 to 1). The goal is to understand the exchange mechanism between the Pt and the 3d transition metal element.

For Pt_3Cr and Pt_3Mn (respectively x = 0 and x = 1) theoretical and experimental studies [1, 2] have shown that the major magnetic moment is carried by the Cr and Mn atoms and that the Pt atom carries a small induced moment. In Pt_3Cr (x = 0), a previous study [1] shows an anti-parallel coupling between the dominant Cr magnetic moment and the small Pt magnetic moment whereas in Pt_3Mn (x = 1) a parallel alignment between the magnetic moment carried by Pt and Mn atoms is evidenced [2]. Therefore, for intermediate concentration ($0 < x < 1$), the alignment of the magnetic moment carried by the Pt atom could be expected to change from anti-parallel to parallel with x. Nevertheless, calculations of spin density around the Pt atomic site in Pt_3Cr present positive and negative regions, so that the sign of the integrated moment could change with environmental conditions in a non-trivial way.

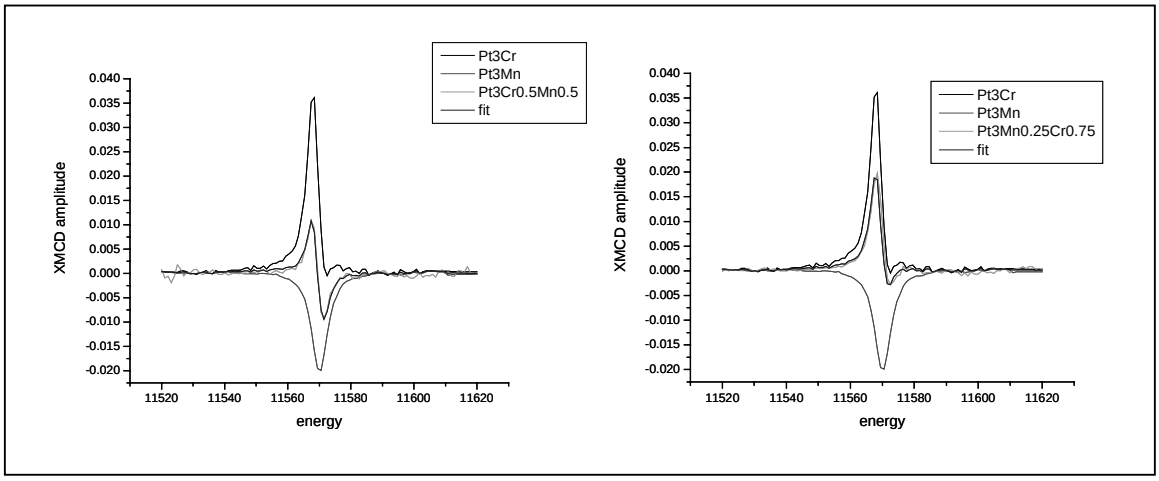
To elucidate this point, we measured XMCD under pressure ~~is used~~ at the Pt-$L_{2,3}$ edges in compounds for different Cr/Mn concentrations (x = 0, 0.25, 0.5, 0.75, 1) and in a large pressure range (0 - 14 GPa). XMCD is one of the best suited techniques to measure the local spin and orbital polarization around one particular site [3, 4] whereas high pressure allows to test these magnetic properties for different inter-atomic distances.

This project has been going on for 3 years due mainly to experimental difficulties:
I - At the beginning of the project, the quality of the data recorded on beam-line ID24 did not allow to extract any information concerning the Pt magnetic moment. But due to a constant improvement of the beam-line (local feedback, third vertical refocusing mirror, polychromator stability), these kind of experiments are now possible.
II - In a second step, we observed that our pressure transmitting medium (silicone oil) was not appropriate, leading to unwanted magnetic transitions due to non hydrostatic conditions above 6GPa.

III - Finally, we repeated our measurements in 2002 (this report) using a methanol/ethanol/water mixture as pressure transmitting medium. We have now enough good quality data and are preparing a publication.

The main results are:
i- An improved signal-to-noise ratio on the XMCD signal showing clearly the contribution of Mn and Cr to the Pt magnetization.
ii- A large pressure domain, up to 14 GPa, where the Pt spin and orbital induced polarization increases.
iii- We have been able to cover a large $Mn_x/Cr_{(1-x)}$ concentration range.
iv- We show that the $L_{2,3}$ Pt XMCD signal relative to different concentrations can be derived by a linear combination of pure Pt_3Cr and Pt_3Mn contributions with stoechiometric weight.

As an example, the figure below shows the Pt-L_3 XMCD signal obtained at room pressure on $Pt_3Cr_{0.5}Mn_{0.5}$ (left) and on $Pt_3Cr_{0.75}Mn_{0.25}$ (right). This signal is compared to the pure Pt_3Cr and Pt_3Mn Pt-L_3 XMCD signals. The fit is obtained by applying a simple additive law between the two pure Pt_3Cr and Pt_3Mn XMCD signals pondered by the stoechiometric weight.



The data show that the $Pt_3Mn_xCr_{(1-x)}$ XMCD signal obtained at Pt-$L_{2,3}$ edge is exactly the superposition of the pure Pt_3Cr and Pt_3Mn XMCD signals with stoechiometric weight. This is very surprising from the XMCD theory point of view. Our data seems to suggest that this signal follows a simple additive law when the magnetic polarization of a conduction band is induced by two different origins. This is also noteworthy from the solid state physics point of view because the spin and orbital polarization of Pt does not vary simply from a parallel coupling with Mn to an anti-parallel coupling with Cr but presents both behaviors at the same time.

References [4, 5] show that the Pt magnetic moment induced in Pt_3Cr is a pure orbital moment whereas in Pt_3Mn it is a pure spin one. In a first approximation these studies seem to suggest that in $Pt_3Mn_xCr_{1-x}$ the magnetic moment of the 5d Pt band can be decomposed into an orbital part induced by Cr and a spin part induced by Mn with no remarkable “spin-orbit” coupling between them.
This noteworthy deconvolution of the Cr and Mn contribution to the Pt magnetic moment allows us to follow the evolution of both contributions with pressure. Under pressure the

XMCD signal increases and the deconvolution of the $Pt_3Mn_xCr_{(1-x)}$ XMCD Pt signal into Cr and Mn contribution is still possible. However, we observe that at the highest pressures reached in the experiment the deconvolution factor is not proportional to the stoechiometric weight anymore since the Cr part becomes larger than the Mn one.

The highest pressure data is still being analyzed, but a paper is in preparation.

[1] Z.W. Lu, Barry M. Klein and h. T. Chau, phys. Rev. B **58**, 9252-9263, (1998).
[2] D. Brown *et al*., J. Phys. Condens Matter **9**, 9435-9443 (1997).
[3] H. Maruyama *et al*., J. Magn. Magn. Mater. **140**, 43 (1995).
[4] W. Grange *et al.*, J. Synchrotron Rad., **6**, 679-681 (1999).
[5] K. Iwashita, T. Oguchi and T. Jo Phys. Rev B, **54**, 1159 (1996).