ESRF	**Experiment title:** Probing magnetism in crystal by hard X-ray standing wave: application to ferromagnetic crystal.	**Experiment number**: MI602
Beamline: ID12	**Date of experiment**: from: 06/11/02 to:12/11/02	**Date of report**: 14/04/03
Shifts: 18	**Local contact(s)**:Wilhelm Fabrice and Rogalev Andrei	*Received at ESRF:*

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Report:

1. Introduction and objectives:

The aim of this experiment was to extended x-ray standing wave technique, that is a well established tool for obtaining structural information [1], to study an element-specific magnetic order in crystals.

On the basis of von Laue and Ewald's theory for X-ray diffraction, Batterman [2] demonstrated that an x-ray standing wave (SW) is generated inside a perfect crystal during Bragg diffraction. The length scale of the standing wave probe is characterized by its period, which is equal to the d spacing of the diffraction planes. Therefore rocking the crystal through a strong Bragg reflection causes the antinodes of the standing wave to shift inward by one-half period. By monitoring the modulation of the fluorescence yield from a specific atomic species while phase shifting the XSW one can determine the atomic distribution relative to the bulk diffraction plane.

The experimental plan was to demonstrate the feasibility of such experiment for a standing wave field generated by circular polarisation radiation. By reversing the incident polarisation, for a beam along the crystal magnetization direction, we expected to measure a magnetic contribution in the fluorescence yield and therefore to perform the first Magnetic x-ray standing wave experiment on a single crystal. As we will show in the following this could give access to magnetic information for atoms located in a specific crystallographic position.

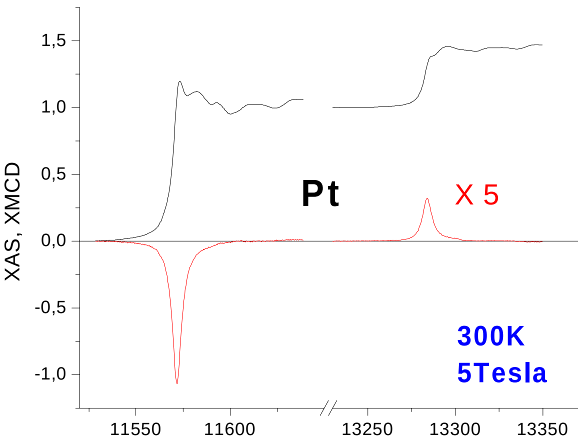

Fig. 1. XAS and XMCD spectra from the $Ni_{90}Pt_{10}$ crystal at the Pt $L_{2,3}$ edges.

2. Experimental details

The experiment has been performed at the Pt L edges on a Ni single crystal containing 10% of Pt impurities.

Previous to the beamtime the crystal were characterized and aligned along the (111) direction by X-ray diffraction on a laboratory source. The first par of the allocated beamtime was utilized to recorded free noise XMCD spectra at the Pt $L_{2,3}$ edges using the 7T magnet available on ID12 beamline. The results are shown in Fig. 1. Using the magneto-optical sum rules we will obtain the spin and orbital magnetic moments of the Pt impurities in the Ni single crystal average over all the sample.

In a second time we successfully realized the proposed Magnetic X-ray standing wave experiment. We use the newly developed UHV reflectometer available on ID12 beamline [3]. A dedicated sample holder was designed in order to applied a 0.5T saturating magnetic field. We scan the incident angle through the [111] rocking curve and we recorded simultaneously the Bragg reflected intensity and the total fluorescence yield spectra for several energies closes to the Pt $L_{2,3}$ absorption edges. By reversing either the applied magnetic field and the helicity of the incoming x-ray beam, we succeeded to recorded IN THE SAME EXPERIMENT the x-ray magnetic scattering and the first magnetic x-ray standing wave (MXSW) spectra from a single crystal. Fig. 2. show the XRMS and MXSW spectra recorded as the function of the incident angle recorded for an excitation energy corresponding to the Pt L_3-edge (11.472 keV).

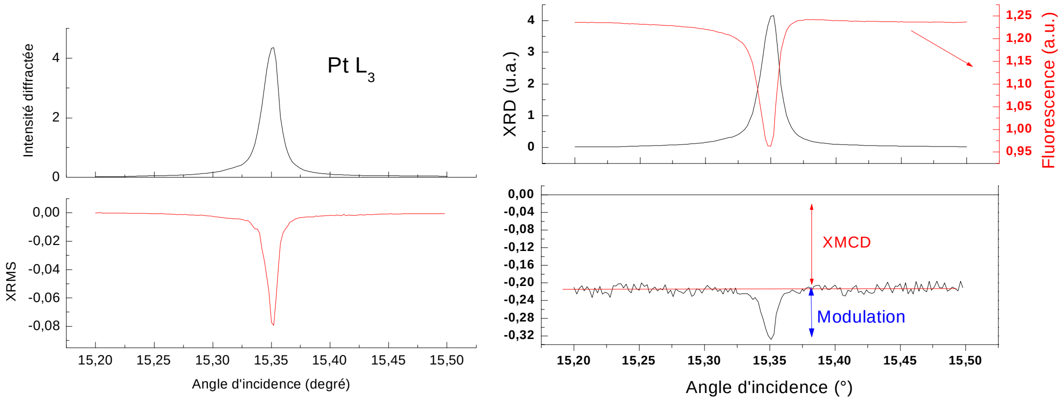

Fig. 2. X-ray magnetic diffraction (left) and magnetic x-ray standing wave (right) recorded at 11.472 keV through the (111) Bragg reflection from a $Ni_{90}Pt_{10}$ ferromagnetic crystal

As shown in Fig 2. we succeeded to recorded magnetic diffraction signal free from experimental noise. The most promising results come from the fluorescence yield spectrum. The upper part present a "classical" standing wave modulation (red value) of the fluorescence yield when the crystal is rock through a strong Bragg reflection (black line) and at the bottom we present the difference of two consecutive scan recorded for opposite helicity of the incoming beam.

The excellent signal to noise ratio, allow us to clearly identify two regime: one far from the Bragg condition, which correspond to the XMCD amplitude (see Fig. 1.) and a strong modulation when the Bragg condition are satisfied. We would like to point out that the complete energy dependence of both XRMS and WXSW were recorded (not show here) through the Pt L-edges.

As a preliminary explanation, we attribute this modulation to a difference of magnetic properties between Pt impurities atoms located in the Ni (111) planes, which are probe when the standing wave field modulated the fluorescence yield.

To resume we **demonstrate the feasibility of magnetic x-ray standing wave experiment on single crystal**, but also that this SW approach allow to obtain spectroscopic information on dilute impurities without being polluted by segregation of impurities at the surface region or the existence of aggregates in the whole sample. We also point out that in the impurity case the lack of long range ordering prevent the use of diffraction approach which give the same average information than the XMCD one, making this new spectroscopic approach based on SW very promising.

References

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[2] B.W. Batterman, Phys. Rev. A 133, 759 (1964); Phys. Rev. Lett. 22, 703 (1969).

[3] N. Jaouen, F. Wilhelm, A. Rogalev, private communication.