ESRF	**Experiment title:** High-pressure XMCD study at the Fe-K edge in invar alloys	**Experiment number**: HE1946
Beamline: ID24	**Date of experiment**: from: 15 april 2005 to: 21 april 2005	**Date of report**: 08.08.05
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Report:

Magnetovolume instabilities leading to a high spontaneous magnetostriction and a very small (almost zero) thermal expansion are known as the invar effect. Discovered more than one century ago and extensively used at the industrial scale, invar compounds are still the subject of numerous theoretical and experimental studies [1] because the microscopic processes are not fully understood. One of the most accepted models, the 2 γ-state model, explains the invar effect by a first order transition from a high-spin(HS)/high volume to a low-spin(LS)/low volume state ; the gradual population of the LS state at the expense of the HS one compensates the usual thermal expansion up to a given volume, where all the electrons are in the LS state. For Fe-Ni alloys, on the basis of *ab-inito* calculations [2], the invar behaviour has been more recently interpreted as a continuous variation of the iron spin alignment as the volume is decreased. This model is in good agreement with recent high-pressure x-ray diffraction results [3] or polarized neutron diffraction measurements [4]. Our objective was to measure the pressure evolution of the Fe magnetic moment which should have a two-step decreasing from the 2 γ-state model point of view or a continuous decreasing from the non-collinear model.

In a previous study [5], we have demonstrated the existence of two magnetic transitions as pressure is raised for a disordered Fe_3Pt : a HS to LS transition and a LS to non-magnetic state at higher pressure. More recently, we have performed ultrasonic measurements up to 7 GPa on the archetype invar alloy $Fe_{64}Ni_{36}$, giving rise to an abrupt change of the pressure dependence of the bulk modulus at 3 GPa [6]. Moreover, Rueff *et al* [7] have investigated the same sample ($Fe_{64}Ni_{36}$) under pressure using the x-ray emission spectroscopy technique. They found a two-step reduction of the iron local moment amplitude. All these results are well interpreted in terms of a HS to LS transition and thus support the 2 γ-state model.

We have performed X-ray Magnetic Circular Dichroism measurements at the Fe K-edge on a polycrystalline $Fe_{64}Ni_{36}$ at room temperature and up to 20 GPa. We have used membrane diamond anvil cells, with ethanol-methanol mixture as pressure medium. The pressure was measured with the luminescence of a ruby ball. The experiments were carried out on the ID24 beamline, using a quarter wave plate to obtain the circular polarization. As the XMCD signal is very small, we have taken the spectra for both polarization ellipticities and both magnetic field directions at each pressure point, in order to reduce systematic errors.

XMCD spectra obtained from ambient pressure to ~16 GPa are shown on figure 1, for some selected pressure. We were able to measure the dichroic signal up to about 14 GPa, even though the intensity is reduced by half. Looking to the integrated XMCD signals (fig. 2), we observe that the intensity, related to the projection of the Fe magnetic moment, decreases slowly and continuously up to ~ 16 GPa, where there is no more dichroic signal. This decreasing corresponds to what is assumed by the non-collinear model. This is the first time that an experiment measuring magnetic properties cannot be interpreted by the 2 γ-state model.

This result is in contradiction with what has been observed on Fe_3Pt [5] and Fe_3C [8] by the same technique and also with what has been observed on $Fe_{64}Ni_{36}$ by x-ray emission spectroscopy [7]. To be sure that our result is not due to an experimental artefact (mainly the sample history), the present results have to be confirmed by carrying out a high pressure XMCD experiment on the sample with the same chemical composition but extracted from a different source.

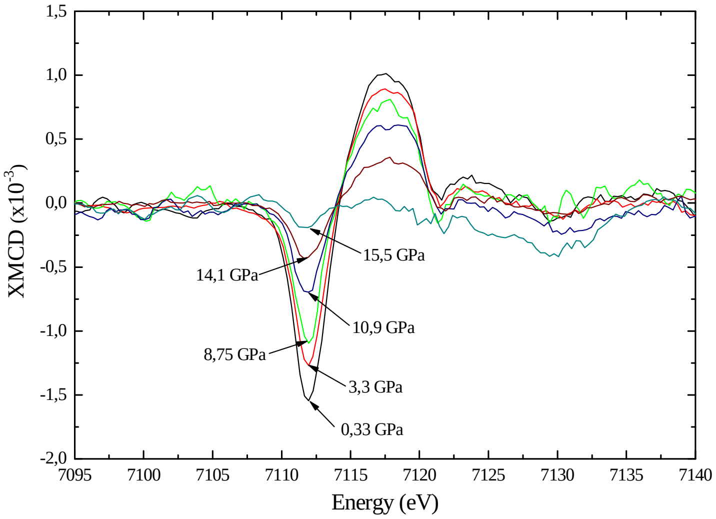

Figure 1 : XMCD spectra

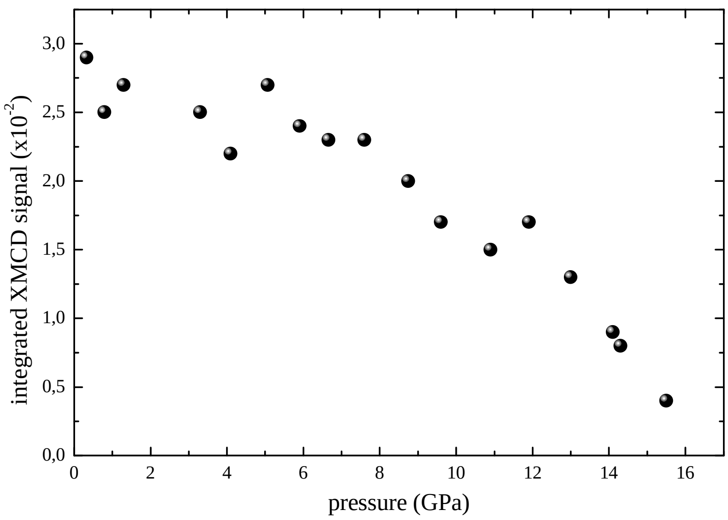

Figure 2 : integrated XMCD signal

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