ESRF	**Experiment title:** Magneto-volume instabilities in nanoparticles of Invar-type Fe_3C studied by XMCD	**Experiment number**: HE-1704
Beamline: ID24	**Date of experiment**: from: 09.06.2004 to: 15.06.2004	**Date of report**:
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Report:

Fe_3C is a common hardening constituent in carbon steels, and its amount in a steel can be regulated by various heat treatment processes. There is also a completely different aspect to Fe_3C next to being a steel component. Fe_3C is ferromagnetic below the Curie temperature T_C of about 450 K with the very interesting magnetic property of having a large magneto-volume instability: it is an Invar compound for which the temperature dependence of the thermal expansion is nearly identical to that of the archetype Invar alloy $Fe_{65}Ni_{35}$ [1].

To investigate the changes in the magnetic properties of Fe_3C under pressure, we have measured the variation of the XMCD signal with pressure at the K edge of Fe. A rapid variation in the dichroism signal at the instability is expected to be observed. A membrane type diamond anvil pressure cell was used in the experiments.

We have investigated the XMCD at the *K*-edge of Fe in Fe_3C at room temperature and pressures up to 20 GPa on increasing and decreasing pressure. The measurements were made on the ID24 beam line. The circular polarization was attained using a quarter wave plate. Two sets of measurements at each pressure with both polarization elipticities and both magnetic field directions were taken in order to eliminate systematic errors arising from the quarter wave plate and the magnetic field. A magnetic field of 0.4 T was applied using an electromagnet. The magnetization in this field reaches about 80% of the saturation value of the sample used in the present experiments [3].

Fig. 1 shows the XMCD spectra from ambient pressure up to 20 GPa at selected pressures. The data on decreasing pressure are similar and are not shown here. The feature at the *K*-edge is not a single peak as in the case for Fe, but one rather observes two peaks separated by 0.25 eV. Since, in Fe_3C, Fe occupies two electronically nonequivalent sites, the occurrence of two peaks can be understood to arise from the different interactions of the excited 4*p* photoelectrons with the spin polarized *d*-bands for the two different Fe sites.

The absolute value of the integrated XMCD intensity, obtained after subtracting the background intensity before and after the *K*-edge, is plotted in Fig. 2. The intensity initially shows no appreciable variation with pressure and, then, begins to decrease rapidly around 8 GPa, and at about 13 GPa, it has dropped down to about 80% of its value at ambient pressure. The present results give evidence for the presence of the magnetovolume instability in Fe_3C.

References

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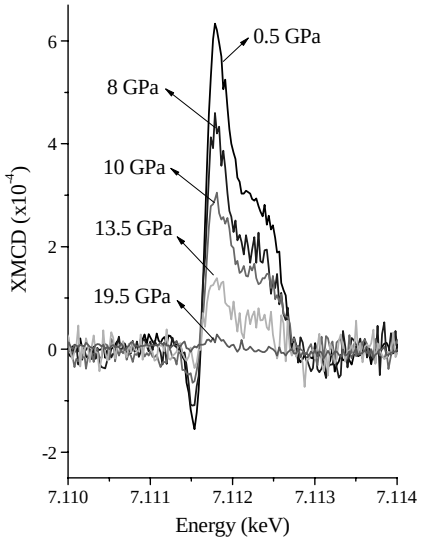

Fig. 1

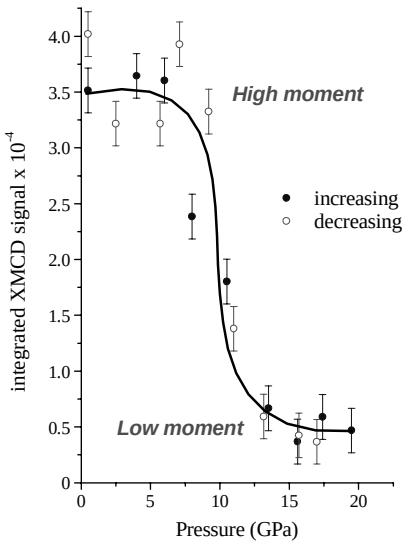

Fig. 2

Title and abstract of manuscript prepared for publication

Magnetovolume instabilities in the pressure dependence of the K-edge circular dichroism of Fe_3C Invar particles

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Abstract

The *p*-electrons of carbon in the interstitial compound Fe_3C hybridize with the Fe *d*-band and enhance the valence electron concentration of Fe from 8 to 8.67. At this concentration, substitutional 3*d* transition metals and alloys exhibit strong moment-volume coupling phenomena and associated magnetovolume instabilities, otherwise known as the Invar effect. For this reason, Fe_3C is also expected to incorporate a strong magnetovolume instability, and therefore, we examine the pressure dependence of the of the K-edge x-ray magnetic circular dichroism in Fe_3C at ambient temperature and pressures up to 20 GPa. We find clear evidence for a high-moment to low-moment transition at about 10 GPa.