ESRF	**Experiment title:** Clarification of the magnetic structure of the beta-phase of MnAs	**Experiment number:** HE-2553
Beamline: ID 12	**Date of experiment:** from: 28.11.2007 to: 04.12.2007	**Date of report:** 18.04.2008
Shifts: 18	**Local contact(s):** F. Wilhelm	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

A. Ney*, V. Ney*, T. Hesjedal*

Report:

The aim of this experiment was to study the magnetic structure of β-MnAs by means of x-ray magnetic linear dichroism (XMLD). Since α- and γ-MnAs are hexagonal crystals and β-MnAs is orthorhombic, all phases exhibit a significant sturctural x-ray linear dichroism (XLD). Therefore we first studied the XLD of all phases (α – 257 K, β – 330 K and γ – 420 K) as shown in Figs. 1 and 2. As expected, the XLD between the c-axis and two perpendicular directions within the a-plane (termed a and b in the following) show significant and very similar XLD signatures as shown in Fig. 1. Simulations using the FDMNES code (Y. Joly, PRB **63**, 125120 (2001)) are currently underway, but they have to taken into account the epitaxial constraints of the GaAs substrate which are imposed on the MnAs film. These expitaxial constraints are also responsible that there is a small XLD signal detecable if the difference is taken between the two spectra recorded along a- and b-axis as shown in Fig. 2 for all three phases. Since GaAs and MnAs have very different thermal expansion coefficients, these a/b-XLD spectra change with temperature. In addition the a-axis is clamped by the substrate (A.K. Das et al., PRL **91**, 087203

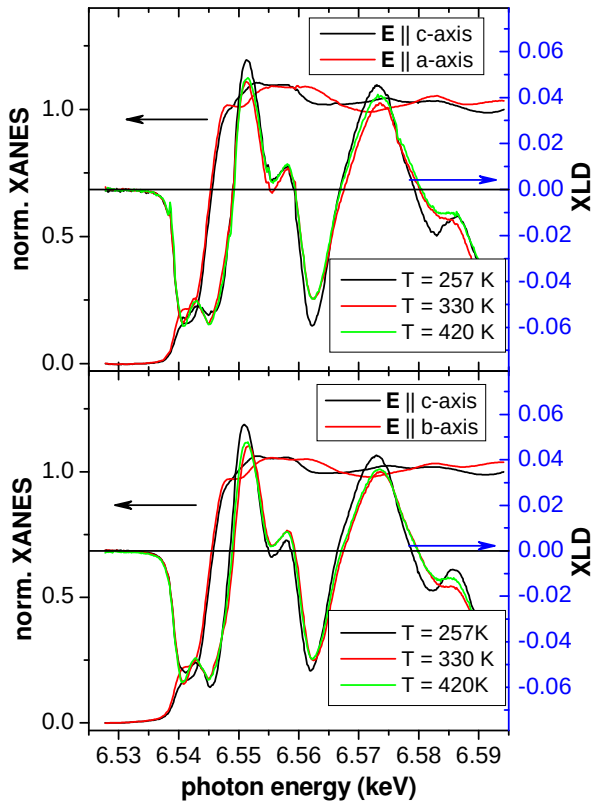

Figure 1: XLD spectra recorded for all three phases of MnAs in two different geometries: c-axis versus a-axis (top) and c-axis versus b-axis (bottom) Both XLD signatures are very similar as expected..

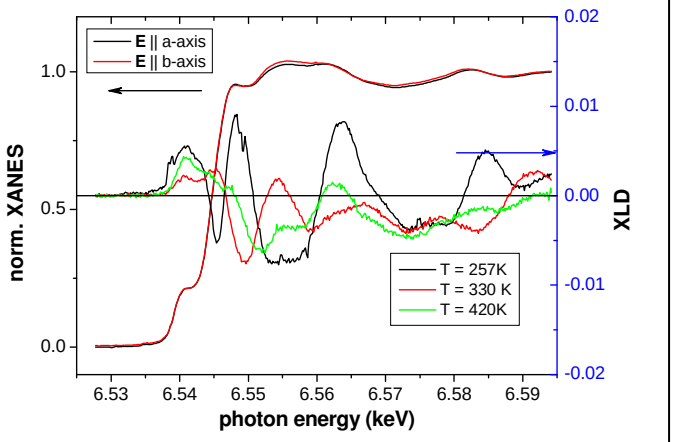

Figure 2: XLD spectra recorded for all three phases of MnA recorded for a-axis versus b-axis. All three phases exhibit very different XLD signatures.

(2003)) leading to an additional distortion of the a-plane resulting is a considerable XLD in the β-phase. These signals make it very difficult to detect any reliable XMLD signal. We first tried to verify the presence of any XMLD signal in the pure α-phase, which is ferromagneitc and therefore must exhibit XMLD signatures as well. The blue line in Fig. 3 shows the average of various different experimental geometries to derive the XMLD, e.g. two perpendicular magnetic fields. We then tried various different methods to measure the XMLD signature in the β-phase. One solution was to enter into the β-phase once from the paramagnetic γ-phase without magnetic field and once form the ferromagnetic α-phase with magnetic field. This should result either in a dis-ordered or in an ordered antiferromagnetic state. This resulting XMLD is shown by the black line in Fig. 3. Although a detecable signal above the noise level is visible, it is difficult to assign it to an antiferromagnetic ordering of the β-phase since the spectral shape is different for the XMLD of the α-phase. On the other hand, also the a/b-XLD signature changes upon going from the α- to the β-phase, see Fig. 2. We also tried to directly measure the XMLD of the β-phase as a difference along the respective axes which is shown as red line and the measured spectral shape of the XMLD is very different. Therefore, we have to conclude that the proof of antiferromagnetic ordering of the β-phase of MnAs is not possible with sufficient experimental evidence. e largest difficulty is to achive a magnetically disordered state of the ferromagnetic phase. Note that in a previous work (E. Bauer et al. JVST B **25**, 1470 (2007)) the presence of the structural XLD was ignored and the observed effects were interpreted as "true" XMLD, which is questionable in the view of our findings, especially Fig. 2. To proof some antiferromagnetic order in β-MnAs other experimental techniques have to be applied. Alternatively crystallographi-cally orderes but expitaxially unconfined MnAs samples has to be used.

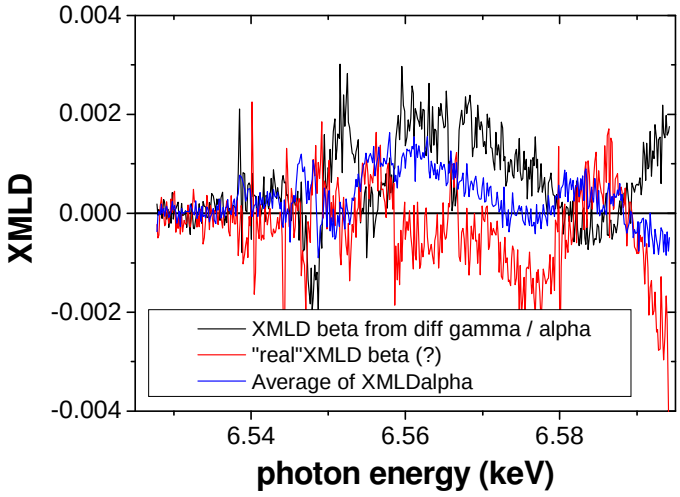

Figure 3: Resulting XMLD spectra. Average spectral shape of the XMLD of the α-phase (blue line) is shown in comparison with two XMLD signatures of the β-phase derived by two different experimental protocols. No clear experimental evidence can be given for the presence of substantial XMLD in the β-phase.

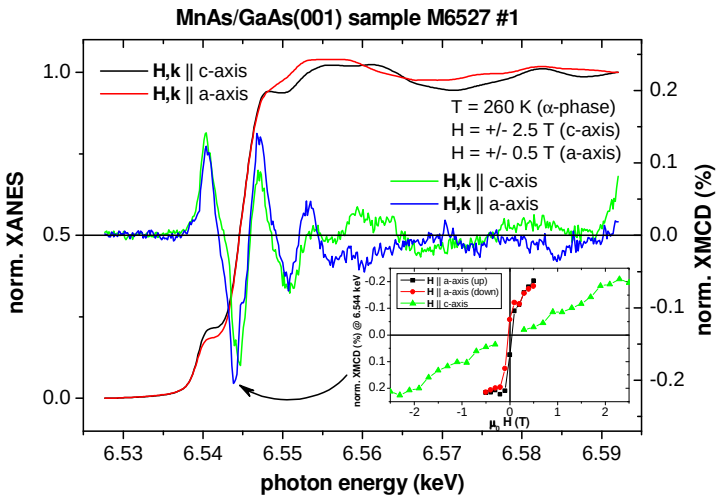

Figure 4: XMCD spectra at the Mn K-edge for the easy and the hard axis of α-MnAs. Inset: Element specific hysteresis confirm the assignment of hard and easy axes.

Finally, we completed the our studies with recording the XMCD spectra in the α-phase for the hard (c-) axis and easy (a-) axis of MnAs which both lie in the sample plane. The results are shown in Fig. 4. No signi-ficant anisotrpy of the Mn K-edge XMCD is visible at saturation. Element specific M(H) curves demonstrate that the two axes are indeed the hard and soft one, respectively. We further confirmed the absence of any XMCD signal for the β-phase (not shown). This a prerequisite for assigning any XMLD signal in the β-phase to antiferromagnetism rather than ferromagnetism.