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| ESRF | **Experiment title:** Probing the tetragonal distortion of epitaxially strained $Ba(Fe_{1-x}Co_x)_2As_2$ superconductors by XLD and its interplay with magnetism | **Experiment number**: HE-3573 |
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**Names and affiliations of applicants** (* indicates experimentalists):

A. Ney*, V. Ney, B. Holzapfel, K. Iida*, S. Haindl*, K. Ollefs

## Report:

The aim of this experiment was to study the tetragonal distortion and magnetic properties of Co-doped and undoped BaFe2As2 ("122") superconducting layers by means of x-ray linear dichroism (XLD and x-ray magnetic circular dichroism (XMCD). For the beamtime a pair of doped/undoped samples grown on Fe buffer layers on MgO was available as well as various Co-doped 122 layers on different substrates out of which STO and YAO were studied as well. Fig.1 shows all XLD at the Fe K-edge revealing an increase of the tetragonal distortion from undoped over o doped 122 on Fe/MgO to Co-doped on YAO and STO. For the 122 on Fe/MgO the XLD at the As K-edge is shown as well corroborating the increase of distortion with Co doping. Note that in the Fe K-edge XANES spectra there are indications of a carrier redistribution upon Co-doping. In

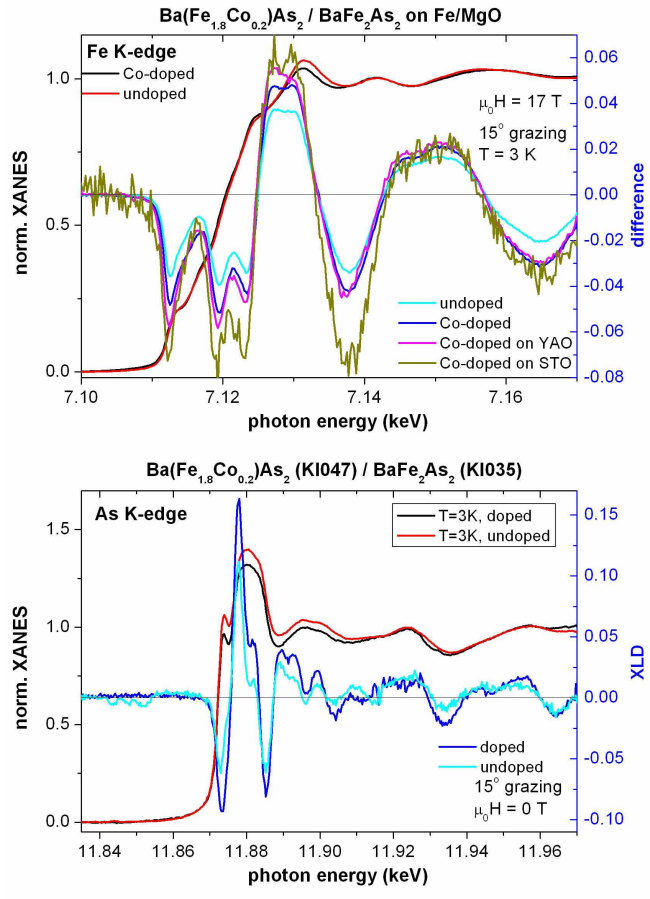


*Fig 1: XLD at Fe and As K-edges of doped and undoped 122.*

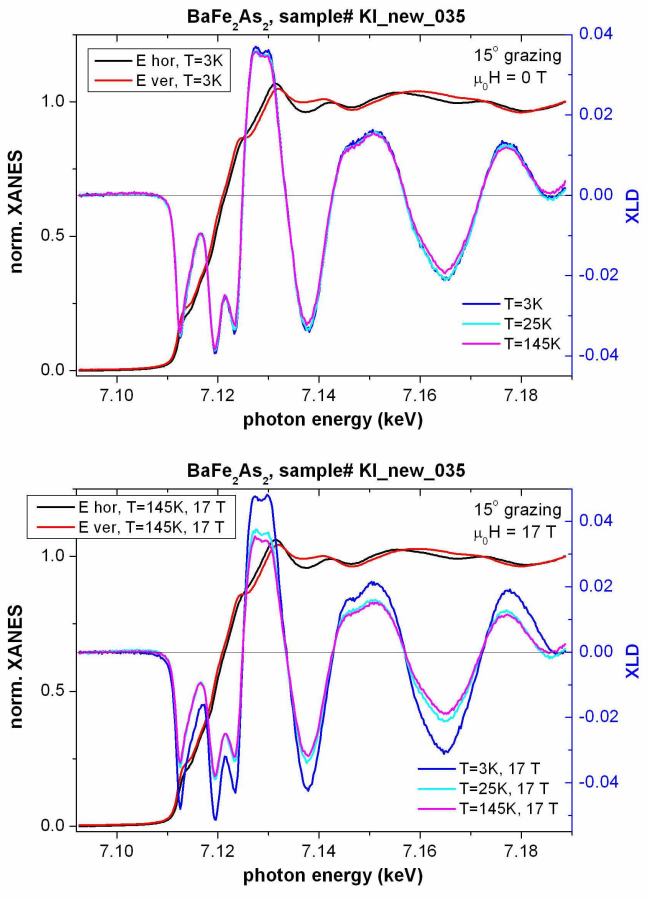


*Fig 2: XLD spectra of undoped 122 depending of T and B.*

the following the samples on YAO and STO will not be discussed further, since the substrate material causes large background signals, especially the Ti of the STO (cause for the large noise in the XLD in Fig. 1).
Fig. 2 summarizes the change of the tetragonal distortion of the undoped 122 on Fe/MgO with temperature and an external B-field of 17 T. Whereas the influence of temperature is weak, at low T, i.e. in the spin density wave (SDW) phase, there is a notable influence on the XLD, i.e. it have magnetostrictive character. Fig. 3 reveals that such an influence of the B-field is not present in the Co-doped 122, where the SDW is absent and the system becomes superconducting. In addition, the presence or absence of the superconducting phase does not influence the size or shape of the XLD. Fig. 3 also displays the XMCD at the Fe K-edge for the Co-doped 122 on Fe/MgO. Because of the buffer layer, the XCMCD is dominated by metallic Fe which could be corroborated by measuring the XMCD at 295K and 1 T (not shown). This XMCD is virtually identical in size and shape as the XMCD shown in Fig. 3. The XMCD spectra do not show any notable changes whether or not the sample is in the superconducting (3 K) or normal conducting (25 K) phase. The element selective M(H) curve for the Co-doped 122 layer (not shown) exhibits a square-shaped behavior with low saturation field and hysteretic behavior at low B-field, which is typical for a ferromagnetic Fe (buffer)layer. In contrast, in the undoped 122 where the SDW is present small changes in the XMCD spectra can be noticed when the sample is measured in either 1 T or 17 T at 4 K, i.e. in the SDW phase. This change cannot be due to the Fe buffer (see Fig. 3). It can be taken as indication of the onset of a spin-flop transition, which however could not be corroborated by the element selective M(H) curve, which is also shown in Fig. 4 and was recorded at the first positive peak in the XMCD. A similar result (absence of any increase of the XMCD at high fields) was obtained for an M(H) curve recorded at the first negative peak in the XMCD (not shown). Therefore the XMCD is obviously dominated by the Fe buffer layer, which was corroborated by XMCD spectra recorded on the 122 layer on YAO, which did not show any significant XMCD in the superconducting as well as in the normal conducting phase (not shown).
In summary, a large set of XLD and XMCD spectra could be recorded for four different 122 layers to compare different substrates Fe/MgO, YAO and STO as well as undoped versus Co-doped layers. Whereas the XLD, i.e. the tetragonal distortion, changes with substrate, no significant influence of the presence of the superconducting phase on the XLD as well as the XMCD could be found.

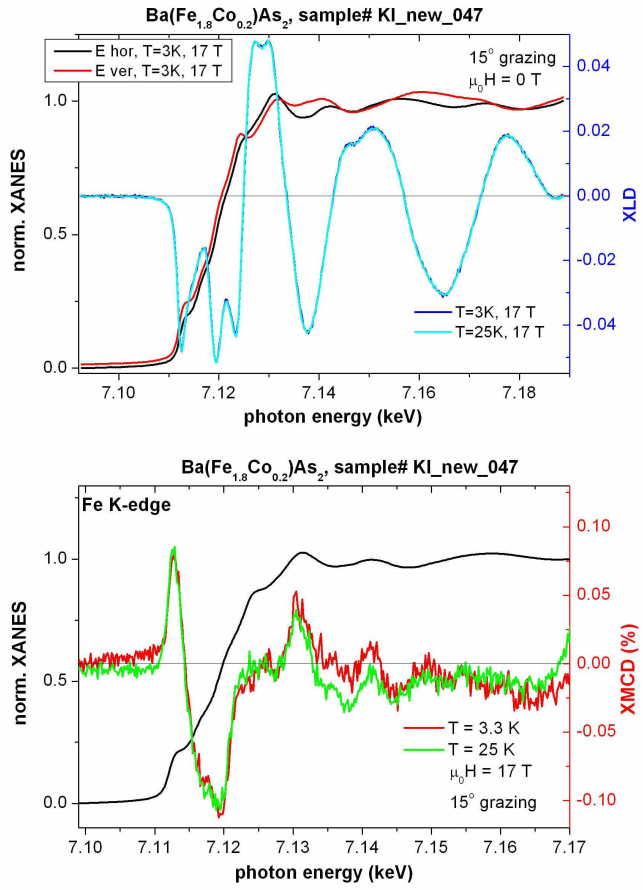


*Fig. 3: XLD and XMCD of doped 122 in 17T below and above the superconducting transition temperature.*

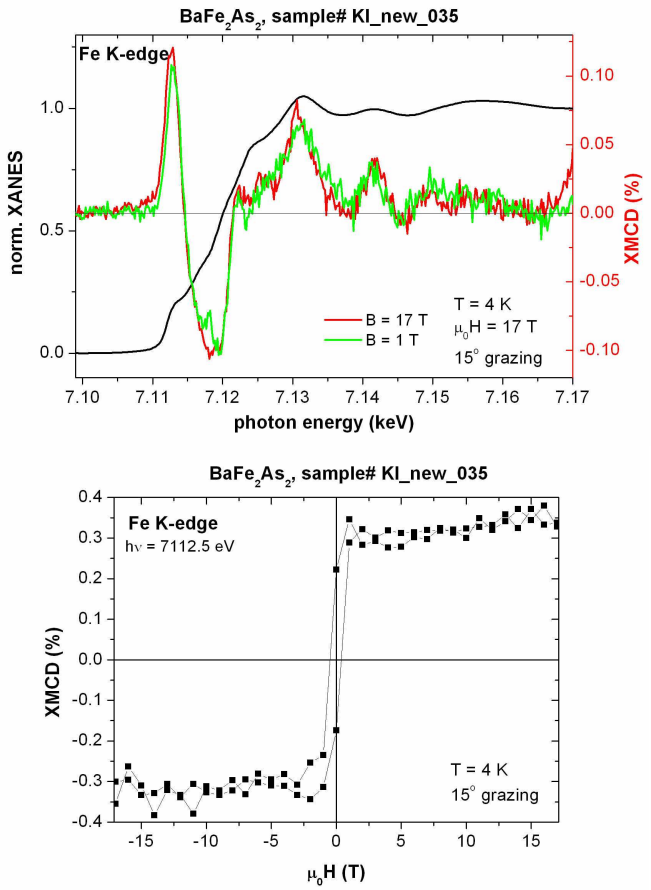


*Fig 4: XMCD and M(H) of undoped 122 in the SDW phase.*