ESRF	**Experiment title:** Antiferromagnetic domain observation in MF_2 single crystals (M=Mn, Fe, Co) using their piezomagnetic properties.	**Experiment number**: **HS-879**
Beamline: ID 19	**Date of experiment**: from: 25.03.99 to: 27.03.99	**Date of report**:
Shifts: 9	**Local contact(s)**: Elodie Boller, Holger Klein	*Received at ESRF:*

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Report:

We have performed X-ray topography on single crystals of CoF_2 in a cryostat at temperatures between 10K and 40K applying external magnetic fields up to 0.4T. This compound shows 180° antiferromagnetic domains at temperatures below 37K. Due to its piezomagnetic properties an external magnetic field leads to a mechanical strain. This strain has opposite signs for the different antiferromagnetic domains, leading to different contrasts in X-ray topography. We have used this effect to visualize the domain structure of CoF_2.

During this experiment we encountered several technical problems:

- The single crystals used contained internal stresses leading to strong contrasts in topography even in the absence of an externally applied magnetic field (fig. 1a). A simple comparison of two photographic films taken on the same sample with and without an external magnetic field did not allow us to visualize clearly the effect induced by the magnetic field (fig. 1a, b). A solution to this problem was provided by the use of the FReLoN camera. This allowed us to subtract numerically the images corresponding to the state with and without an applied magnetic field (fig. 1c). Here the differences between the two pictures become clearly visible.
- In the beginning only blurred images were obtained because the sample moved during the exposure time of approximately 10 s. In order to avoid any distorsion of the sample due to different thermal expansions the samples were glued at a single small point onto an aluminum frame. In the X-ray beam the sample was electrically charged and thus was

attracted to the aluminum frame. The longer it stayed in the beam the more it became charged until, eventually, the sample bent enough to touch the frame opposite to the gluepoint. Then it discharged and went back to its original position thus performing a nearly periodic motion. The solution to this problem was to glue the sample in a way such that it could not touch the opposite side of the frame. Then it distorted slightly due to its electric charge, but it stayed in a stable position.

Despite these problems we were able to observe contrasts in X-ray topography stemming from the antiferromagnetic domain structure of CoF_2. The nature of these contrasts, however, is complicated. The contrasts can be black, i.e. more diffracted intensity, when the magnetic field is applied, or white. While the naïve expectation is to observe more diffracted intensity due to the increased distortion of the crystal, the white contrasts are not fully understood, yet. In the case of field-cooled samples an inversion of the contrast when increasing the magnetic field was also observed under certain conditions. Further experiments are required to clarify the actual contrast mechanism.
The following observations have been made on these contrasts as a function of temperature and external magnetic field in the cases where the contrast didn't inverse on increasing the magnetic field:

- The intensity of the contrasts increased with increasing magnetic field. This was expected as the induced strain is an increasing function of the applied magnetic field.
- The intensity of the contrasts decreased with increasing temperature, vanishing at the Neel temperature of 37 K.
- The contrasts inversed when the direction of the magnetic field was inversed.
- A memory effect was observed. Heating the sample above the Neel temperature, where it is in a paramagnetic state, and cooling down again did not change the domain structure. Heating above the Neel temperature and cooling down the sample while applying an external magnetic field did change the domain structure. More experiments will be necessary to elucidate the details of this memory effect.

a b c

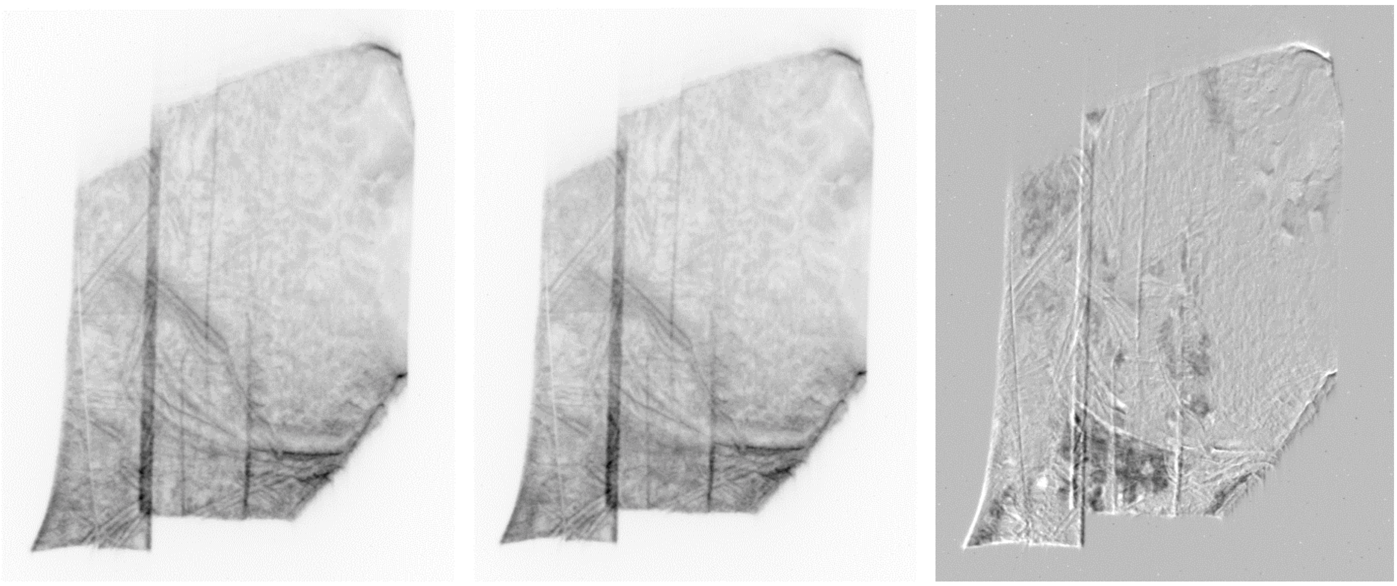

figure 1: a) and b) X-ray topographs of a CoF2 single crystal at T=10 K, respectively without and with an externally applied magnetic field. c) difference of the images a) and b). Dark contrasts due to the antiferromagnetic domain structure are clearly visible.