| ESRF | **Experiment title: X-ray natural and non reciprocal dichroism in single domain chiral magnets** | **Experiment number**: **HC-1198** |
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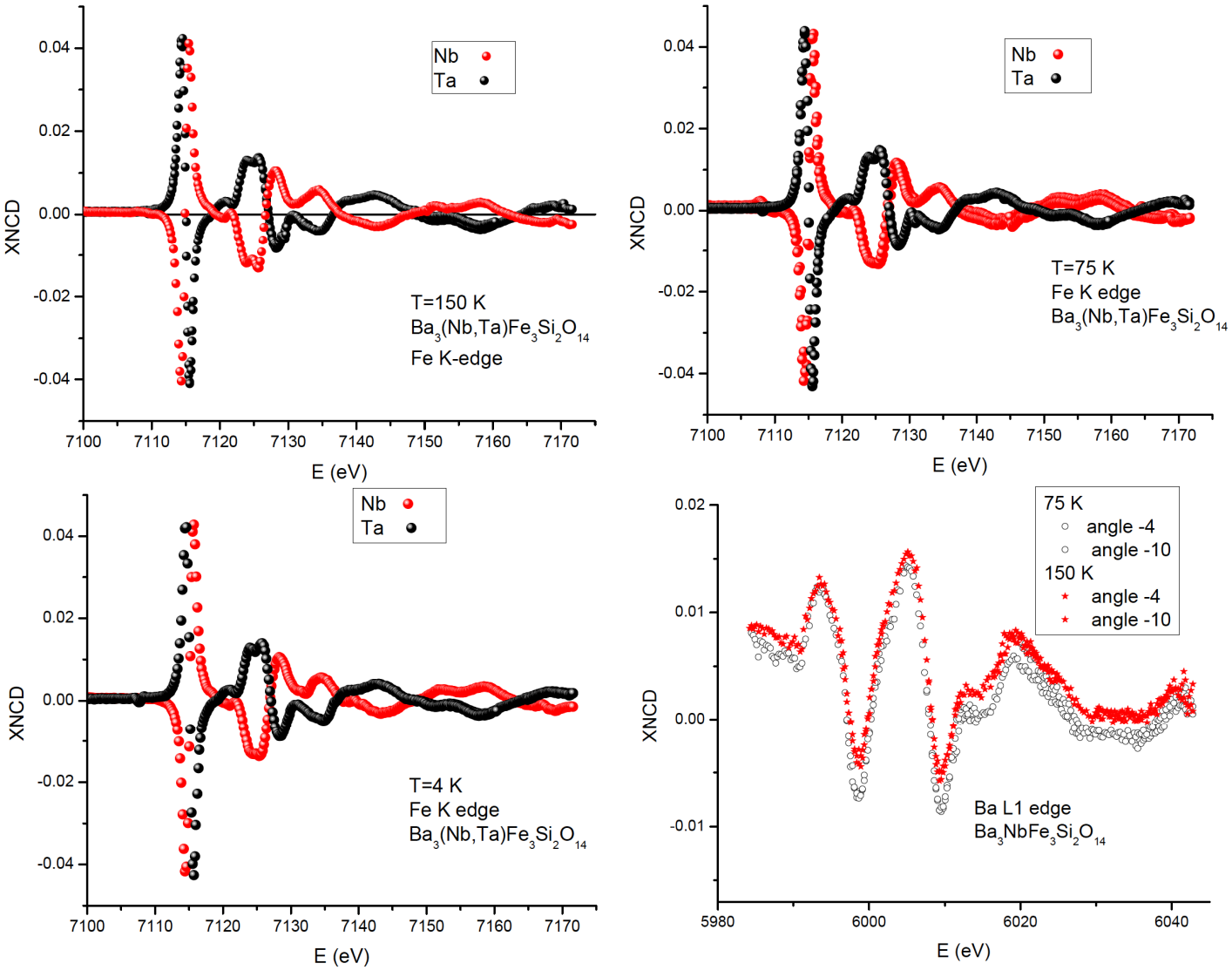
**Report:**

X-ray natural circular dichroism (XNCD) at the K-edge of Fe and at the $L_{1,2,3}$ edges of Ba and X-ray magnetochiral dicroism (XM$\chi$D) at the K-edge of Fe were measured in single crystals of $Ba_3NbFe_3Si_2O_{14}$ and $Ba_3TaFe_3Si_2O_{14}$. An helically modulated triangular antiferromagnetic order is stabilized in these compounds below the Néel temperature $T_N \approx 27$ K, the study of which by polarized neutron showed that it is single domain in the triangular chirality and in the helical chirality. The selection of the triangular chirality is answerable to the Dzyaloshinskii-Moriya interactions whereas the selection of the helical chirality is explained through the twist of the exchange interactions paths along the trigonal axis, the sense of which is inherent to the structural chirality. In turn, this indirectly suggested that the investigated single crystals were enantiopure. The magnetic helicities, and therefore the structural chiralities, were inverted between the investigated single crystals of $Ba_3NbFe_3Si_2O_{14}$ and $Ba_3TaFe_3Si_2O_{14}$. A correlated helical liquid phase precedes the magnetic transition. Its enantiopurity partially persists and fades away only around 35 K. Unusual electroactive and magnetoactive excitations detected by X-ray absorption spectroscopy finally led to speculate that a helical electric polarization might be stabilized at Tp ≈ 100 K.

XNCD were extracted from the XANES spectra collected in the total fluorescence yield mode with left and right-circularly polarized X-rays. Slightly different incidence angles of the X-rays on the single crystals were considered, which allowed getting rid of the parasitic contribution of high order Bragg peaks in the final data by appropriate juxtaposition of uncontaminated spectra. The measurements were performed at 300 K, 150 K, 75 K and 5 K,

to probe whether some anomalies might accompany the occurrence of the electroactive and magnetoactive excitations earlier detected by X-ray absorption spectroscopy. The experiment started with two newly grown single crystals of $Ba_3NbFe_3Si_2O_{14}$ and $Ba_3TaFe_3Si_2O_{14}$, which led to similar XNCD spectra. This indicated that they have the same structural chirality. They were dismounted and no longer considered. Older single crystals, extracted from the ingot from which the single crystals investigated by polarized neutrons were extracted, were then mounted. The figure below shows examples of XNCD spectra measured on these single crystals at different temperature at the K edge of Fe and the $L_1$ edge of Ba. The opposite structural chirality of the investigated samples is immediately revealed by the displayed spectra at the K edge of Fe. No change of the spectra is observed as the temperature is decreased.




XMχD was probed from the difference in the isotropic absorption spectra recorded by applying a magnetic field parallel and antiparallel to the trigonal axis. An isotropic spectrum is obtained as a sum of spectra recorded with right and left circular polarizations, which therefore also provided data to compute X-ray Magnetic Circular Dichroism (XMCD). Measurements were performed at 5 K and 30 K. No signal of XMχD nor of XMCD was detected, in spite of an applied magnetic field as large as 17 T. A reason of this lack of signal might be an extremely efficient orbital quenching of the 3d electrons of the Fe ions, leading in particular to a too tiny orbital toroidal moment (orbital anapole). This would also suggest that the magneto-electric coupling in the considered compound is most probably not linear.