Structure of multiferroic single crystals probed with Synchrotron X-ray Renninger scanning

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Synchrotron X-ray Renninger scanning (XRS) is a single crystal technique that combines ultra-high sensitivity to three major features: photon energy, crystal system (unit cell parameters), and structure factors (modulus and phase). To reproduce a given XRS, the accuracies in the unit cell parameters, as well as in energy, have to be better than 10^{-4}. But, these informations provide only the positions over the XRS where the n-beam diffractions would occur. The exact intensity profile of each n-beam diffraction depends on the structure-factor phases of the involved reflections. Since phase shifts are usually observed as the photon energy is scanned across an absorption edge, the asymmetry of the profiles are hence highly susceptible to the near-edge energy.[1] Multiferroics are a relatively new class of materials presenting coexistence of ferromagnetic and ferroelectric phenomena. Attention has been devoted to these materials due to the interesting physics involved as well as relevant potential applications in devices with new functionalities. Magnetic transition followed by a corresponding ferroelectric transition is in general a clear signature of coupling between magnetic and electric properties in these materials.[2] However, besides monitoring these properties, to fully understand such systems it is also necessary to monitor structural distortions responsible for given rise to ferroelectricity. In other words, magnetic transitions have to induce some kind of tiny lattice distortion for ferroelectricity to appear.[3] XRS has, in potential, the capability of probing very small distortions, or twist, of the crystal lattice. This work is the first attempt to witness the sensitivity of XRS to changes taking place at the Mn^{3+} and Mn^{4+} sites in $EuMn_2O_5$ samples, a well known multiferroic material. In this case, the changes in these sites were induced by tuning the photon energy selectively at the absorption edge of both Mn ions. Astonishing alterations in XRS patterns were observed even for small changes of just a few tens of eV. Moreover, by using an XRS simulation routine, great discrepancies between experimental and theoretical patterns are reported and possible explanations of such discrepancies discussed.

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