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Exotic magnetic behavior due to competing anisotropies in a multiferroic crystal revealed by soft x-ray resonant magnetic scattering

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The induction of magnetic frustration and complex magnetic orders by tuning synthesis thus breaking the spatial inversion symmetry is an effective way of producing multiferroic (MF) and magnetoelectric (ME) materials. The (Mn,Co)WO4 family are reference models for the study of the mutual interaction between spins and polar orders. Co favors a strong competition between its magnetocrystalline anisotropy (McA) and Mn-Mn exchange interactions, stabilises the characteristic ferroelectric (FE) behavior of MnWO4 at low temperatures (T), and uplifts the T-x phase diagram richness with the appearance of new FE phases and magnetic structures. By means of soft x-ray resonant magnetic scattering (SXRMS) we have investigated in detail the magnetic order in a MF crystal with the Mn0.85Co0.15WO4 critical composition above its FE transition, focusing on the well-known collinear AF4 phase. Thanks to SXRMS chemical selectivity we have demonstrated that Co moments arrange antiferromagnetically following their own strong uniaxial McA, although the collinear order of Mn spins point to a different direction. This implies intrinsic remarkable deviations of the spin arrangement at the local scale from the average description provided by neutron diffraction. These element-resolved magnetic results call for reexamining the phase diagram of this model family of MFs. The occurrence of a similar non-collinearity of ordered spins from different magnetic ions must be investigated in other mixed compounds with competing anisotropic interactions.

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