Tuning the tilting of the spiral plane by Mn doping in $YBaCuFeO_5$ multiferroic

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The low-magnetic ordering temperatures (typically<100 K) critically restrict the potential uses of magnetoelectric multiferroics for spintronics and low-power magnetoelectric devices. The frustrated perovskite $YBaCuFeO_5$ (YBCFO) displays magnetism-driven ferroelectricity at unexpectedly high temperatures [1,2]. It is considered one of the best candidates to high-temperature chiral multiferroics with strong magnetoelectric coupling. In $RBaCuFeO_5$ perovskites (R: rare-earth or Y) A-site cations are fully ordered whereas their multiferroic properties strongly depend on the preparation method and the partial Fe/Cu disorder at the B-site. Cationic disorder is normally promoted changing the cooling rate after the last annealing, generating magnetic frustration and incommensurate spiral order that can persist above room temperature [1].

However, in this chiral magnetic oxide the orientation of its magnetic spiral can be critical for the multiferroic and magnetoelectric response. In this work, we have synthesized and studied $YBaCuFe_{1-x}Mn_xO_5$ samples doped with Mn, with the aim of increasing spin-orbit coupling effects, and found that the overall Fe/Cu cation disorder at the B-sites can be increased by doping without changing the sample preparation process. In $YBaCuFe_{1-x}Mn_xO_5$ samples prepared under the same conditions, the T-x magnetic phase diagram have been constructed in the range 10K-500K combining magnetometry, x-ray and neutron diffraction measurements [3]. The tilting angles of the spins in the collinear, θ_{col}, and spiral phases, θ_{spiral}, barely vary with temperature. In the collinear phase θ_{col} is also independent of the Mn content. In contrast, the presence of Mn produces a progressive reorientation of the plane of the magnetic helix in the incommensurate phase, capable to transform the helicoidal spin ordering into a cycloidal one, which may critically determine the ferroelectric and magnetoelectric behavior in these compounds. When increasing the Mn content the rotation plane of the spins moves away from the ab plane where the Dzyaloshinskii–Moriya based models predict null spontaneous polarization.

References:

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