Experimental report

23/05/2024

Proposal: CRG-3057 **Council:** 4/2023

Title: Investigating high-Tc spiral orders in YBa(Cu1-xZnx)FeO5 multiferroics by modifying the magnetic coupling interactions

Research area:

This proposal is a new proposal

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Samples: YBaCuFeO5/YBa(Cu,Zn)FeO5

Instrument	Requested days	Allocated days	From	To
D1B	4	2	27/10/2023	29/10/2023

Abstract:

Experimental report D1B CRG-3053 Proposal Nº CRG-D1B-22-463

Experimental report D1B CRG-3057 Proposal Nº CRG-D1B-23-521

CRG-D1B-22-463 & CRG-D1B-23-521

Investigating high-Tc spiral orders in YBa(Cu1-xZnx)FeO5 multiferroics by modifying the magnetic coupling interactions

Abstract. YBCFO exhibits high-temperature magnetism-driven ferroelectricity, making it a top candidate for zero-field switchable multiferroics. The goal of this investigation is to push the spiral phase transition temperature (T_{N2}=T_S) of YBCFO-based multiferroics well beyond room temperature while maintaining key features related to moment orientation, amplitudes, and incommensurability for strong magnetoelectric coupling. The experiment aims to apply chemical pressure by partially substituting Cu2+ by non-Jahn Teller (JT) active ions to compress the bipyramids in YBa(Cu,M)FeO5 compounds and to characterize in detail the evolution of the incommensurate spiral and commensurate collinear magnetic phases in the new YBa(Cu1-xZnx)FeO5 spin-induced multiferroic family.

Measurements were performed using λ=2.52 Å . The polycrystalline samples were measured using the cryofurnace. NPD patterns for the cooling in 300K/h samples were collected first at fixed temperature (10 K). In addition, neutron diffraction patterns were

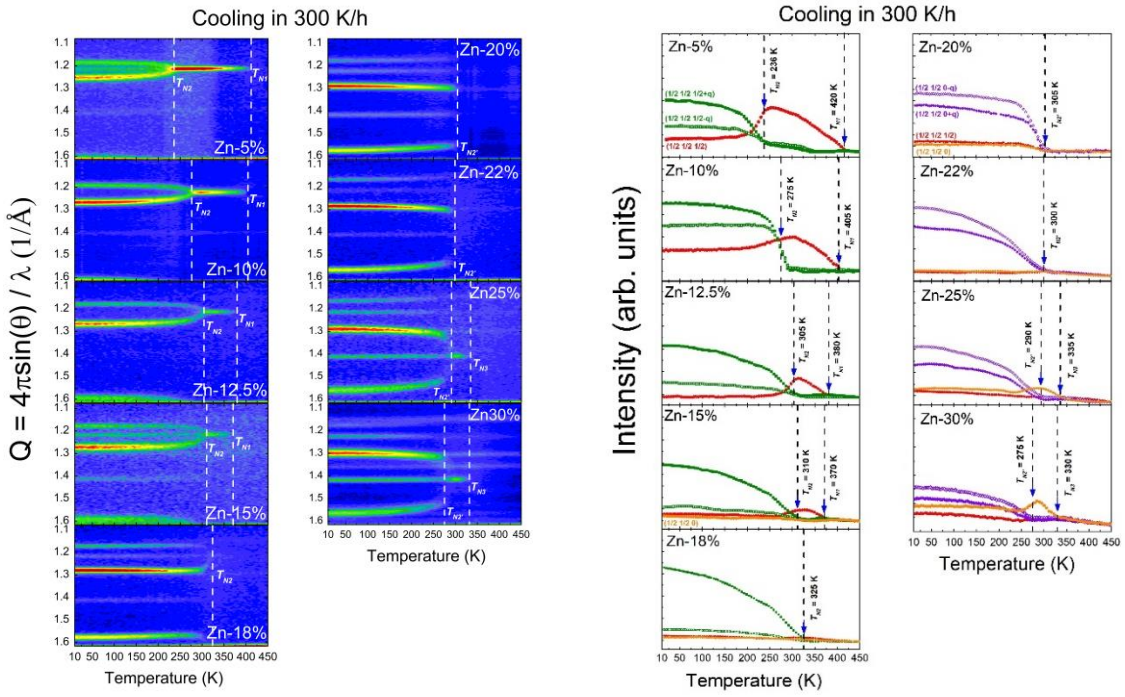

Figure. (Left) T-2Theta contour plots of the temperature dependence for the neutron-diffracted intensities around the (1/2 1/2 1/2) reflection and (1/2 1/2 0) reflection for the 300K/h cooling compositions. (Right) The corresponding average ordered magnetic moment associated to the commensurate and incommensurate magnetic phases as a function of temperature. The dash vertical line correspond to the T_N of K2 = (1/2 1/2 1/2±q) and K1 = (1/2 1/2 1/2) magnetic orders.

also recorded using the continuous mode following temperature ramps with a heating rate of 2K/min. Due to the limited time available, for the first set of samples (controlled 300 K/h cooling rate), we measured three compositions: x=0.05, 0.10, 0.15, x=0.18 and 0.22

in the 10-450 K range; meanwhile for the second set of samples (quenched), we measured just the three compositions x=0.18, x=0.22, and 0.25 in the same 10-450 K range.

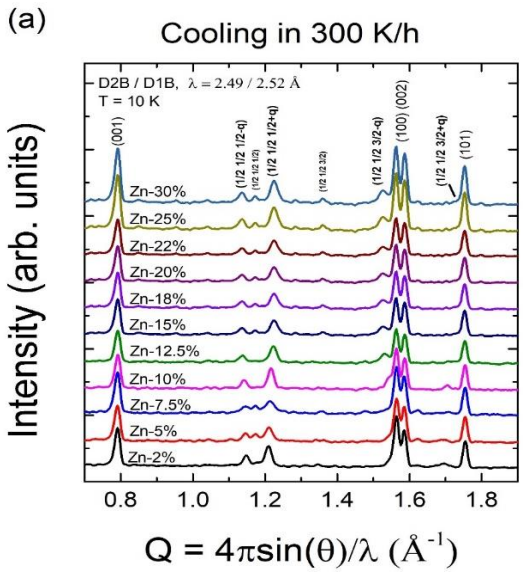

Figure. $YBaCu_{1-x}Zn_xFeO_5$ (300K/h cooling). Low-angle region of the neutron diffraction patterns collected at 10 K for the 300K/h cooling sample series.

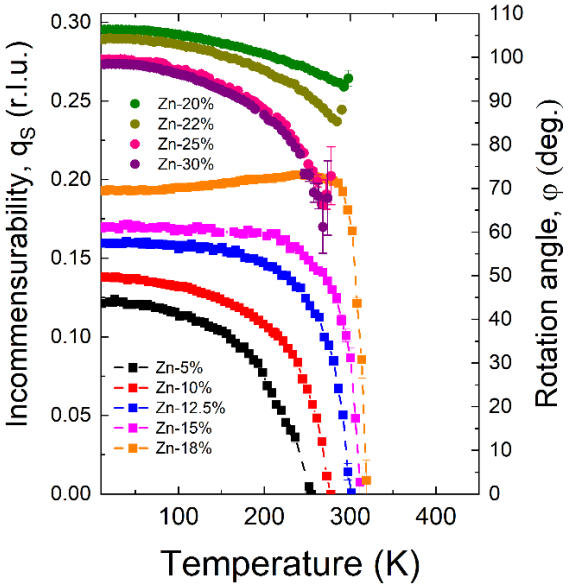

Figure. Influence of temperature on the ICM modulation q_s of the AF2 spiral phase, obtained from NPD refinements at T = 10 K. The right Y-axis shows an illustration of the twist angle φ (canting) formed by the two spins of a bipyramid in the spiral phase ($\varphi = 2\pi q_s$). Temperature dependence of q_s obtained from neutron thermodiffractograms measured in cooling in 300 K/h rate samples with x[Zn] = 5, 10, 12.5, 15, 18, 20, 22, 25, 30%.

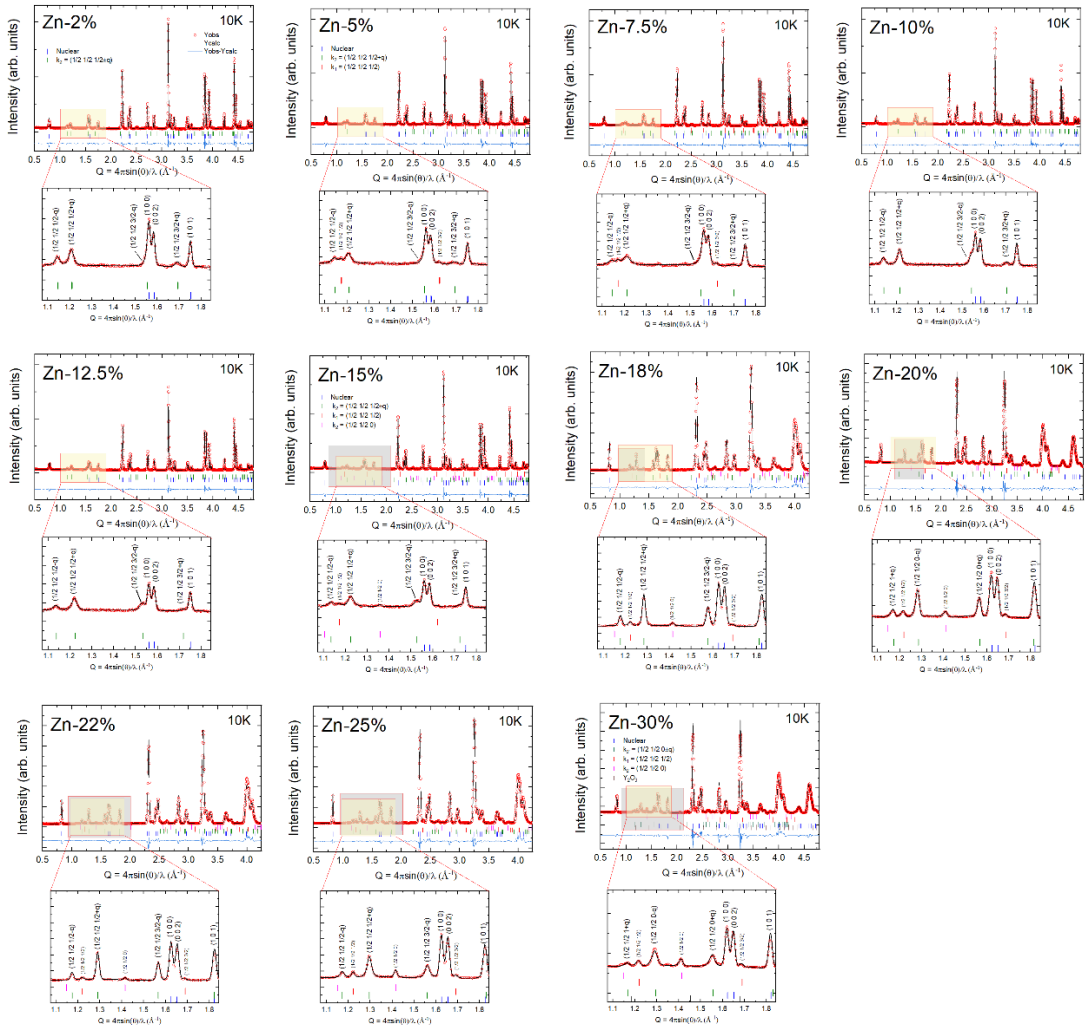

Figure. $YBaCu_{1-x}Zn_xFeO_5$. Rietveld refinements of the incommensurate magnetic spiral order in neutron patterns collected at 10 K varying the Zn content.

The full T-x magnetic phase diagrams for the $YBaCu_{1-x}Zn_xFeO_5$ family prepared applying two different final cooling processes: (a) cooling at a 300 K/h rate; (b)quenched into liquid nitrogen have been obtained and will be published (paper in preparation). As well as the information obtained concerning the impact of the Zn doping on the magnetic anisotropy, the thermal stability of the spiral ordering and other central structural and magnetic details of relevance for this family of potential high-temperature multiferroics.