Experimental report

14/09/2018

Proposal: **CRG-2404** **Council:** 4/2016

Title: Tuning spiral magnetic order in RBaCuFeO5

Research area:

This proposal is a new proposal

Main proposer: **XAVIER TORRELLES ALBAREDA**

Experimental team: Jose Alberto RODRIGUEZ VELAMAZAN
Maria Luisa MEDARDE BARRAGAN
Tian SHANG
Victor POREE
XAVIER TORRELLES ALBAREDA

Local contacts: Jose Alberto RODRIGUEZ VELAMAZAN

Samples: YBa1-xSrxCuFeO5

Instrument	Requested days	Allocated days	From	To
D1B	6	5	01/06/2018	06/06/2018

Abstract:

Scientific Report

The goal of this experiment was to investigate additional ways of tuning the spiral ordering temperature of the layered perovskite $YBaCuFeO_5$ [1], whose crystal structure is schematically shown in Fig. 1. The renewed interest on material, extensively investigated during the 80's [2,3] due to its parentage with the high-temperature superconductor $YBa_2Cu_3O_{6+x}$, is the recent observation of magnetism-driven ferroelectricity at an unexpectedly high temperatures. As reported in refs. [4,5], spontaneous electrical polarization develops in $YBaCuFeO_5$ below T_{N2} ~ 240K, coinciding with a spin-reorientation of the Fe^{3+} and Cu^{2+} magnetic moments [4,5]. This reorientation involves a change in the periodicity of the magnetic order, which is commensurate with the crystal unit cell above T_{N1} (k_c = ½ ½ ½) and becomes incommensurate below this temperature.

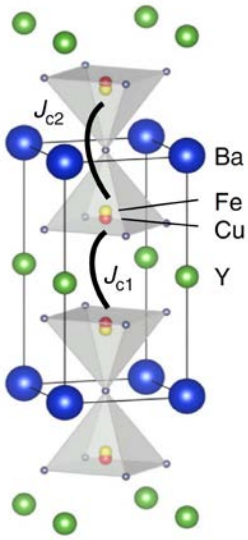

Fig. 1. Crystal structure of $YBaCuFeO_5$ (from ref. 7)

As part of Mickael Morin's PhD work, we recently succeeded to prepare $YBaCuFeO_5$ ceramic samples of unprecedented quality in our group at the PSI [6]. We also reported the first model for the low temperature incommensurate phase, which is of spiral type. Moreover, we managed to increase the spiral order temperature up to 310K using a novel route based in the targeted manipulation of the Cu/Fe chemical disorder in the structure [7]. As shown in Fig. 1, the spiral order temperature, signaled by the red arrow, is quite low for the sample with the smallest amount of disorder (154K, upper panel) , but it increases up to 310K for the most disordered sample (310K, lowest panel). At the same time, the paramagnetic-to-collinear transition temperature (indicated by a blue arrow) displays the opposite behavior. From Fig. 2, it is clear that both temperatures should merge for larger degrees of disorder.

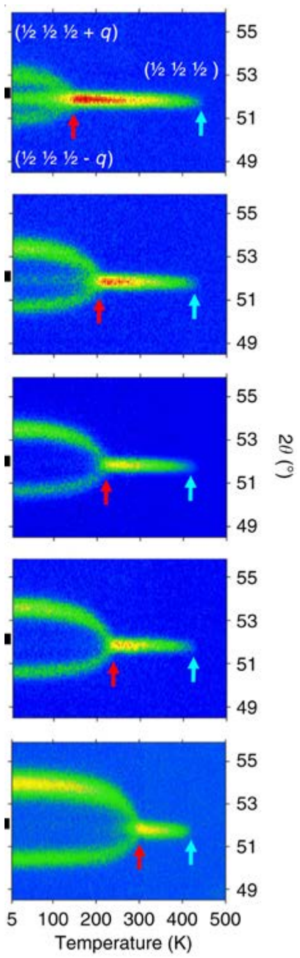

Fig. 2. Low angle part of the neutron powder diffraction patterns of 5 $YBaCuFeO_5$ samples with different degrees of disorder (from ref. 7)

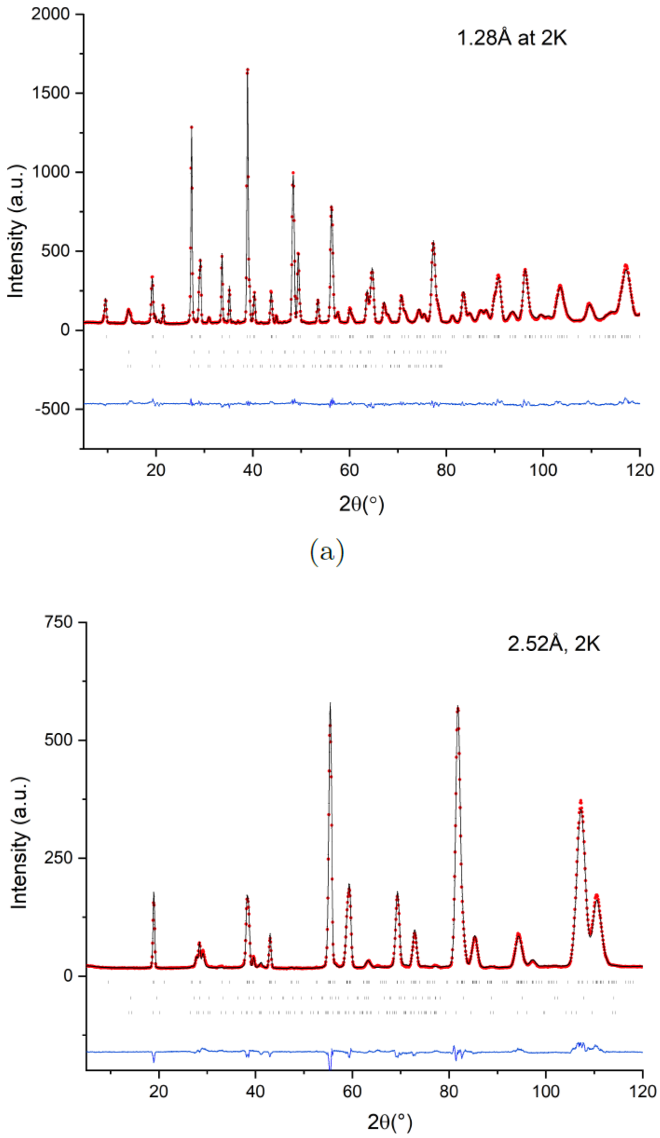

Fig. 3. Neutron powder diffraction patterns of YBa0.8Sr0.2CuFeO5 at 2K measured using two different wavelengths at D1B.

In the present experiment we have tried to reach this limit by combining a maximal chemical disorder with a targeted manipulation of some magnetic exchange couplings. For this purpose we prepared the YBa1-xSrxCuFeO_5 (0 ≤ x ≤ 1) series aimed to change Jc2 (see Fig. 1). After a preliminary examination of the data recorded on D1B for the full family could confirm our previous findings on half of the series ((0 ≤ x ≤ 0.5), namely a) the spiral does not exist beyond the crossing point of T_{spiral} and $T_{collinear}$ [8], and b) a new collinear magnetic phase replaces the spiral. The detailed analysis of the neutron diffraction patterns is currently in progress.

References

[1] L.Er-Rakho et al., J. Solid State Chem. **73**, 531 (1988)

[2] V. Caignaert et al., J.Solid State Chem. **114,** 24 (1995)

[3] A.W. Mombru et al., J. Phys.: Comdens. Matter 10, 1247 (1998)

[4] B. Kundys et al., Appl. Phys. Lett. **94**, 072506 (2009)

[5] Y. Kawamura et al, J. Phys. Soc. Jpn **79**, 073705 (2010)

[6] M. Morin, A. Scaramucci, M. Bartkowiak, E. Pomjakushina, D. Sheptyakov, L. Keller, J. Rodriguez-Carvajal, N.A. Spaldin, M. Kenzelmann, K. Conder, and M. Medarde, PRB **91**, 064408 (2015).

[7] M. Morin, E. Canevet, A. Raynaud, M. Bartkowiak, D. Sheptyakov, V. Ban, M. Kenzelmann, E. Pomjakushina, K. Conder, and M. Medarde, Nature Communications **7,** 13758 (2016)

[8] T. Shang, E. Canevet, M. Morin, D. Sheptyakov, M.T. Fernandez-Diaz, E. Pomjakushina, and M. Medarde, Science Advances, accepted (2018)