Experimental report

15/09/2016

Proposal: 5-31-2380 **Council:** 10/2014

Title: Magnetic phase diagram of multiferroic YBaCuFeO5

Research area: Physics

This proposal is a new proposal

Main proposer: Maria Luisa MEDARDE BARRAGAN

Experimental team: Maria Luisa MEDARDE BARRAGAN
Mickael MORIN

Local contacts: Maria Teresa FERNANDEZ DIAZ

Samples: YBaCuFeO5

Instrument	Requested days	Allocated days	From	To
D20	3	3	30/04/2015	04/05/2015

Abstract:

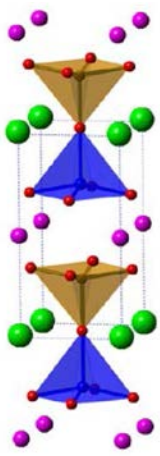
The O-deffective double perovskite YBaFeCuO5 displays magnetism-driven ferroelectricity at an extraordinarily high temperature (TN= 230K) coinciding with the appearance of spiral magnetic order. We propose to investigate the stability of its magnetic structure under magnetic field. This information should provide important insight about the the mechanism at the origin of the coupling between magnetism and ferroelectricity in this material

Scientific Report

The goal of this experiment was to investigate the magnetic phase diagram of YBaCuFeO5 [1] using neutron powder diffraction under external magnetic fields up to 10 T. The renewed interest on this layered perovskite, extensively investigated during the 80's [2,3] due to its parentage with the high-temperature superconductor YBa2Cu3O6+x, is the recent observation of magnetism-driven ferroelectricity at an unexpectedly high temperature . 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 [2,3]. 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.

As part of Mickael Morin's PhD work, we have recently succeeded to prepare $YBaCuFeO_5$ ceramic samples of unprecedented quality in our group at the PSI [6]. We have also reported the first model for the low temperature incommensurate phase, which is of spiral type, and we are presently investigating the M-H magnetic phase. As shown in Fig. 1, bulk magnetization measurements under magnetic fields up to 9T show the existence of several field-induced phase transitions.

In order to get insight about the different magnetic phases, we investigated the temperature dependence of the crystal and magnetic structures of $YBaCuFeO_5$ between 1.5 and 300K in D20 for magnetic fields up to 9T. For this purpose we prepared a solid rod (D = 0.5 mm, H = 4 cm) that we fixed inside of a standard vanadium can. A standard powder sample measured before the experiment indicated that the rod did not display appreciable preferential orientations. Then we carried out field scans between o and 9T at several temperatures between 1.5 and RT using a high take-off angle (90°) and 2 different wavelengths (1.55 and 2.41A). The choice of the take-off angle was motivated by the better resolution available using this configuration. Since it was never used before with a 10T magnet, an assessment of the technical personnel was required in order to evaluate the strength of the magnetic forces at the instrument shielding. The maximal field allowed was fixed to 9T. With this restriction the experiment was carried out without any problem.



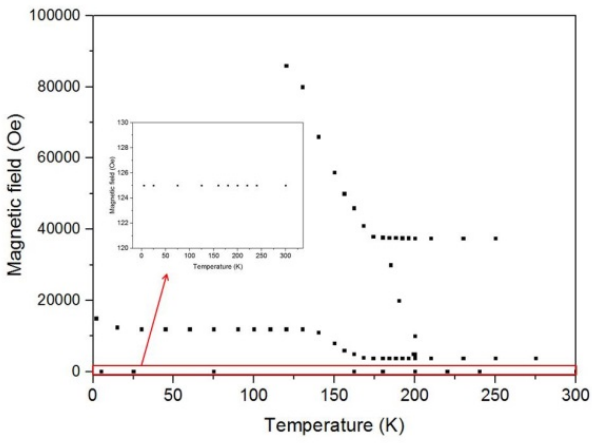


Fig. 1. Magnetic phase diagram of $YBaCuFeO_5$,as determined from SQUID magnetometry

Fig. 2. Field dependence of the (½ ½ ½ ±q) magnetic satellites at 150 and the (½ ½ ½) Bragg reflection at 250K.

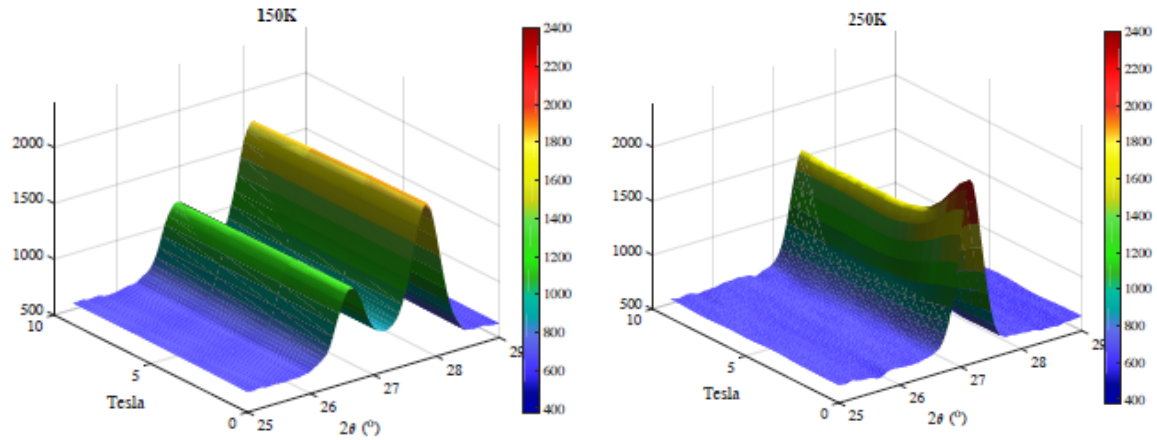


Figure 2 shows the field dependence of the (½ ½ ½ ±q) magnetic satellites characteristic of the low temperature spiral phase measured at 150 and 250K. These results don't show any clear evidence of the line boundary at H = 1.5T inferred from bulk magnetic measurements. However, the line boundary between the collinear phase and another high-field-induce phase at H = 4T is clearly observed. Interestingly, we could not observe any significant change in the propagation vector as a function of magnetic field. The analysis of the magnetic intensities is currently in progress.

References

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