EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Detecting stripes in cuprates with resonant hard X-ray scattering	**Experiment number**: HE2299
Beamline:	**Date of experiment**: from: 14.02.07 to: 20.02.07	**Date of report**: 1.03.07
Shifts:	**Local contact(s)**: Valerio Scagnoli	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Abhay Shukla, IMPMC, Université Pierre et Marie Curie

Paola Giura, IMPMC, Université Pierre et Marie Curie

Matteo D'Astuto, IMPMC, Université Pierre et Marie Curie

Report:

This experiment was carried out on a single crystalline sample of $La_{2-x}Ba_xCuO_4$ with x=0.15. The floating zone grown sample is of good quality and has a Tc of 21 K. This particular sample was chosen because Ba substitution is known to induce distortions in the lattice which may be crucial in pinning stripes and thus helping to reveal them in a scattering experiment. When doping is slightly lower (x=0.125, $La_{1.875}Ba_{0.125}CuO_4$), it has been reported [1] that near static pinned stripes are formed due to the commensurate nature of the doping with a stripe periodicity of every four unit cells (1/(0.125x2)). For x=0.125, there is a structural transition from the low temperature orthorhombic (LTO) phase to the low temperature tetragonal (LTT) phase at 60K which is also expected to contribute to the pinning of stripes. All these factors contribute to lowering the Tc of this sample and various Tc's ranging from 2K to 15-20K have been reprted for the x=0.125 doping level indicating the fragile nature of the pinning which may depend on the individual fabrication history of the sample.

In our sample the doping was slightly higher and near optimal. It is still very much lower than the corresponding value for the Sr doped sample with x=0.15 (38 K) indicating that a stripe pinning mechanism may indeed be active. This particular sample was chosen so as to have the possibility to easily access temperatures below the critical temperature. The sample had been pre-oriented and the decision was made to mount it in the high field setup from the start since it was judged that at least a day of beam time would be lost in transferring from one setup to another. This decision turned out to be a mixed blessing as it will be seen in the following because though it did allow the use of the magnetic field with interesting results, it considerably limited access in reciprocal space due to the magnet. We now discuss some of the results obtained in this experiment though the data still has to be analyzed in detail as the experiment finished only ten days ago.

1) The first result that was established was the measurement of the LTO-LTT transition in this sample which was necessary for characterizing the temperature range that we were inclined to

work in. We measured a wide transition (~ 5K FWHM) with a midpoint at about 34K by observing the splitting of the 3 1 0 peak as temperature is raised indicating the advent of the orthorhombic phase (Figure 1). The gradual transition may be due to constraints in the sample which had been solidly glued to the sample holder to avoid damage with an applied field in the superconductng phase. We note however that the temperature is much lower than the 60K reported for the x=0.125 sample and also that the x=0.15 sample provides an interesting opportunity to measure effects below Tc, between Tc and the LTO-LTT tranistion and above this transition.

2) The second interesting feature was detected at the antiferromagnetic ordering vector (h+π/2 k+π/2 l) in the $\sigma-\pi$ channel. We used a Pd analyser which gives the required 90° scattering angle at the Cu K edge. We observed a strongly resonantly enhanced peak at the Cu K edge, at 3.5 1.5 0. Strictly speaking there should be no scattering intensity at this point in the reciprocal lattice for this sample which is not antiferromagnetic (fluctuations apart). The observed intensity being strongly resonant, may however be a manifestation of local symmetry breaking due to distortions around the Cu atom. We followed this peak with temperature and found that it does undergo a radical change at the LTO-LTT transition which justifies this hypothesis (Figure 2). However this transformation is a *precursor* to the LTT-LTO transition, since it is precedes it by about 4K. This interesting observation needs to investigated further and the orgin of this measured intensity understood as it could provide a cause for this transition.

3) Finally we looked for any signal which may be attributed to scattering from stripes. This is, as we had specified in our proposal, a difficult task since the expected signal is weak and may be limited to the first Brillouin Zone due to form factor considerations. We had to battle with many 'small' signals which we were luckily able to identify as spurious contributions (trace powder peaks for example) at the cost of painstaking and time consuming elimination, but we did detect some diffuse intensity in the first BZ (Figure 3). As can be seen from the figure we see a double humped signal with ordering vectors around
0.2π 0 0.5 and 0.3π 0 0.5. The expected intensity woud be around 0.3π 0 L. The shape of the signal changes, especially around 0.25π, both with temperature and with magnetic field (solid line: H=5T, dashed lines: H=0T, before and after the application of the 5T field). Though there are reasons to believe that this indeed may be the signal we are seeking, we observed only a very weak resonant effect, and further, time limitations did not permit a full investigation as a function of both temperature and magnetic field. Finally we would like to do the same study in another sample where stripes have been observed, ($Sr_{14}Cu_{24}O_{41}$). This sample had actually been simultaneously mounted on the insert but we had no time to look at it. These considerations therefore form the subject of a new proposal.

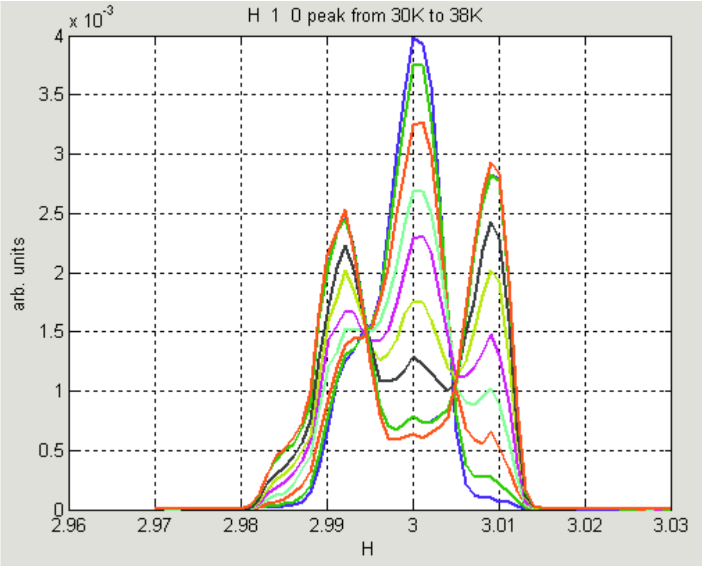

Figure 1 Bragg peak at 3 1 0 as a function of temeprature. LTO-LTT transition

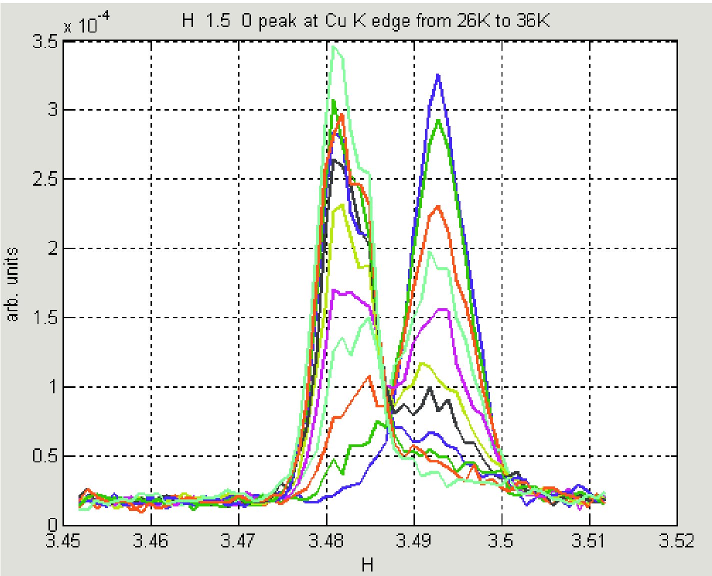

Figure 2 Resonant intensity at 3.5 1.5 0 as a function of temeprature. Precursor to the LTO-LTT transition

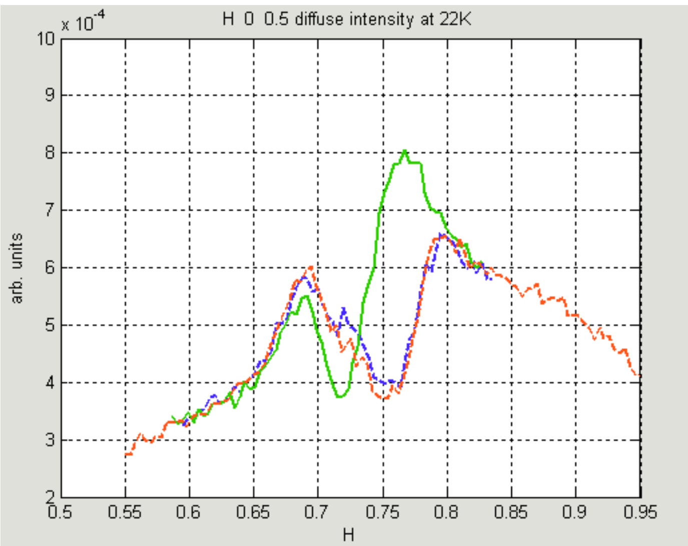

Figure 3. Diffuse intensity in the 1st BZ. solid line: H=5T, dashed lines: H=0T, before and after the application of the 5T field