	Experiment title: Effect of uniaxial strain on CDW in underdoped YBCO	Experiment number: HC1909
Beamline:	Date of experiment: from: 13/05/2015 to: 16/05/2015	Date of report:
Shifts:	Local contact(s): G. Garbarino	*Received at ESRF:*

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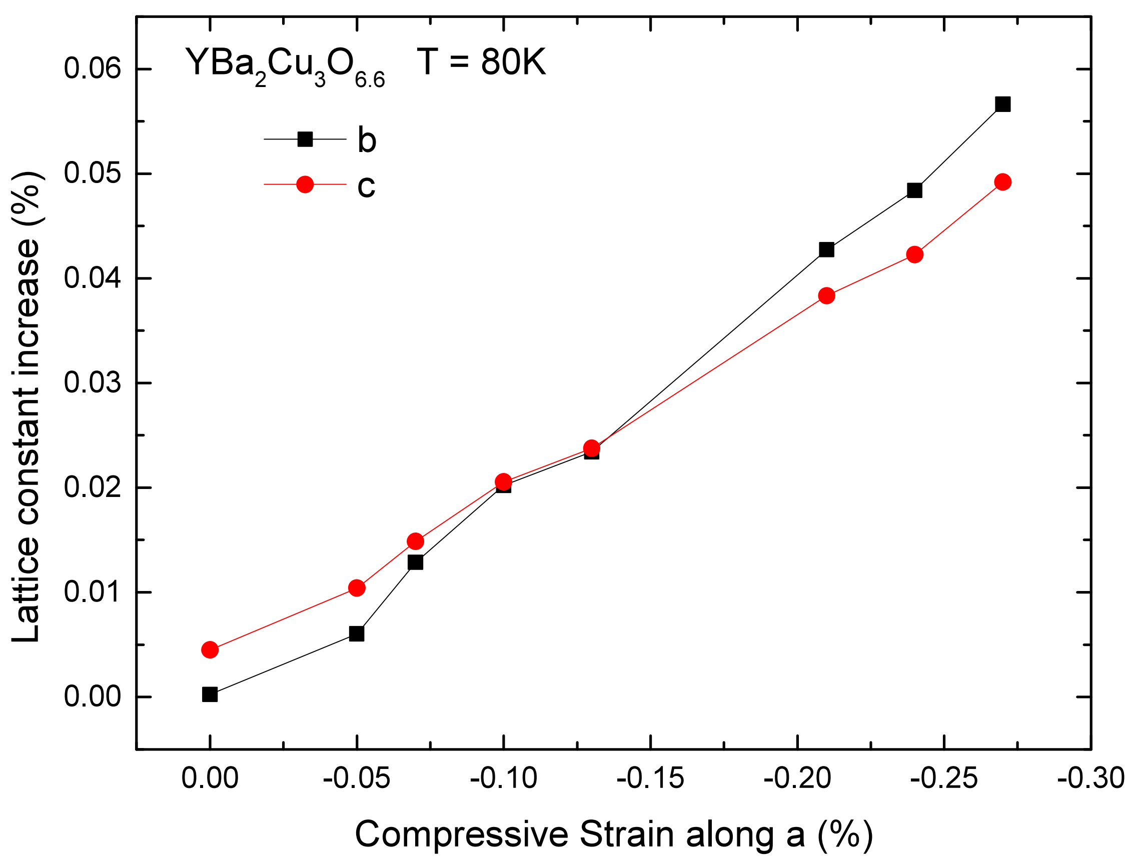
Report:

In this proposal, we aimed at studying the response of the CDW recently discovered in the underdoped phase of several high temperature superconductors to uniaxial strain using single crystal x-ray diffraction (XRD).

Our goal is to address the question of the dimensionality of the order parameter driving the CDW, a crucial question that is remains unanswered despite the intense research activity on the subject in the last three years. Establishing whether the bi-axial structure of the CDW reflect a 2D checkerboard modulation driven by a 2D order parameter, or rather the even distribution of orthogonal, uniaxial domains, will allow to distinguish between two widely used theoretical approaches that account for charge ordering in underdoped cuprates, : the weak coupling one, in which the CDW is believed to occur from an instability of the Fermi Surface, versus the strong coupling one where it rather reflects the charge order tendencies, driven by the Coulomb repulsion, of holes doped in Mott insulating states.

Following our previous experience (see Fig. 1 in [1]), we have used a Pilatus detector in order to minimize the background level and facilitate the observation of the weak CDW satelittes. We have adapted a piezzoelectric-based device similar to the one described in ref. [2] to allow application of strictly uniaxial strain on our sample. The version of the device used during the experiment was not compatible with the available cryostats (a compatible version is currently under development).
Experiments were first carried out a room temperature, and then the sample has been cooled down using a cryostream.

We have started the experiment by looking at a $YBCO_{6.6}$ single crystal, similar to that used in [1]. We first did a series of measurements at room temperature to observe changes in the lattice structure as strain compressive strained was applied along the a-direction (H0L was in the scattering plane). No clear effects were first observed. We established that this was mostly caused by the poor transmission of the displacement of the strain rigs to the samples by the stycast used to attach the sample, that becomes too ‘soft’ at high temperature (transport and susceptibility measurements previously carried out on the same device were done a lower temperatures, where the Young’s modulus of the stycast increases by a factor of 3). In order to try to detect the CDW, we have cooled the sample down to the lowest reachable temperature, 80K with the cryostream. Because of the large contribution of disordered CuO chains in the H0L plane at this doping level, the device was rotated to access the 0KL, in which, according to our experience [1] the CDW is more easily visible. We could obtain clean 0KL panorama pictures and follow the changes of the lattice parameters as strain was applied. As the compressive strain was applied along the a-axis (the amount of strain is calibrated using a capacitive sensor), extension of the b- and c- axis lattice constants were observed (see figure).
The measurement was overall complicated by the formation of ice on the device after long exposure to the cryogenic stream and many, time consuming, thermal cycles were necessary to avoid this.
Finally, no clear signature of the CDW were seen during this experiment, for various reasons. In particular, the pilatus detector was not optimal for the photon energy used (33keV), yet necessary to ensure optimal transmission of the beam through the sample. As a result, the intensity of the Bragg reflections (the synchrotron was furthermore operating in 16 Bunch at the time of the experiment) was borderline for the observation of the weak CDW satellites. Working with lower photon energies requires smaller samples thicknesses (< 80 μm) that we have managed to prepare since, and together with a device compatible with the cryostat available on ID27 beamline, we are confident that a continuation experiment will yield positive outcomes.



1. Le Tacon, M. et al. Nature Physics **10**, 52 (2014)
2. Hicks, C.W. et al., Review of Scientific Instruments, **85**, 065003 (2014).