	Experiment title: Doping dependence of electron-phonon interaction in YBCO and its influence on charge density waves	**Experiment number**: HC1121
Beamline:	**Date of experiment**: from: 20/11/2013 to: 26/11/2013	**Date of report**:
Shifts:	**Local contact(s)**: R. Burkovsky	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Mathieu Le Tacon* (Max Planck Institute for Solid State Research)

Bernhard Keimer*

Sofia-Michaela Souliou

Alexei Bossak*

Michael Krisch*

Giacomo Ghiringhelli*

Greta Dellea

Mark Dean (non co-proposer but present at the beamtime)

Report:

We have recently discovered a fluctuating incommensurate charge-density-wave (ICDW) in underdoped superconducting cuprates using resonant inelastic x-ray scattering at the Cu-L3 edge, an approach which however cannot establish the low energy scale typical of these fluctuations.

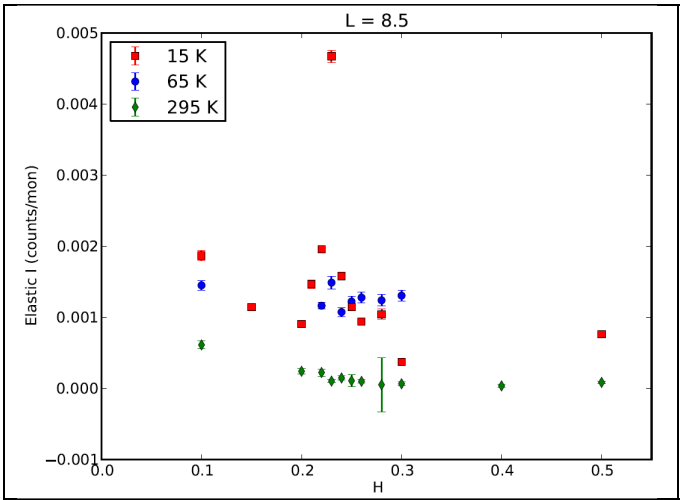
In experiment HC-861, we have studied this ICDW using high resolution inelastic x-ray scattering.
We observed a quasi-elastic 'central peak' and strong phonon anomalies, associated respectively to the formation of CDW nanodomains and to strongly anisotropic electron-phonon interaction. These results have been recently published as an article in Nature Physics (Le Tacon et al. Nature Physics 10 52-56 (2014)).

The main purpose of the experiment HC-1121 was originally to extend these measurements for different doping levels: $YBa_2Cu_3O_7$ and $YBa_2Cu_3O_{6.43}$.
The first sample happened to be measured prior to the beamtime (during in-house time), as it was required to answer some of the referee's criticism to the aforementioned paper. The results are reported in the supplementary materials of the paper.
As the field is rapidly moving, work performed on other beamlines by us and competing groups demonstrated that measurements on the second sample were not so relevant. Instead we decided to investigate a related compound, $YBa_2Cu_4O_8$. This compound has a rather high doping level ($p\sim0.14$) and displays very nice quantum oscillations, but so far no CDW have been reported.

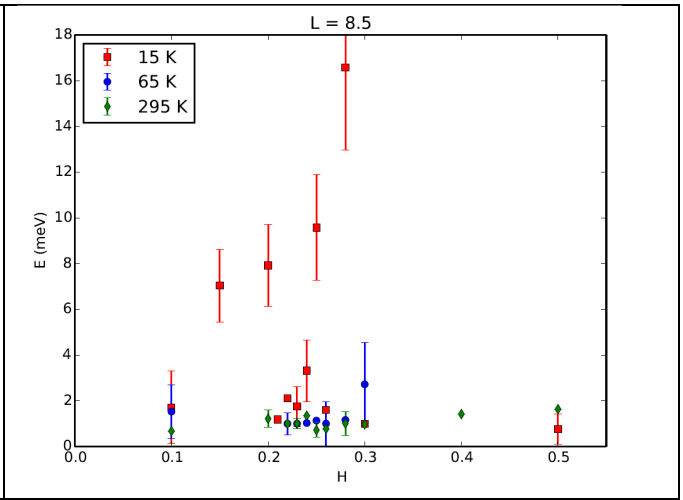
We invested several days in the study of this material, without success because of the very large intensity of the elastic line that preempted any decent analysis of the inelastic part.

We then turn to a back-up sample, for which we have an accepted proposal (HC-1395) that is $La_{1.875}Ba_{0.125}CuO_4$.
In YBCO compounds, the BZ where the measurements ought to be performed could be identified using diffuse scattering reciprocal space mapping. Due to technical constraints however, these measurements cannot be performed below temperatures of ~80 K, that are above the charge and spin ordering of LBCO. We choose to do the IXS measurements close to (0 0 8.5) where recent hard x-ray diffraction measurements showed a large superstructure peak. We could only investigate a couple of temperatures (15K, 60 K and room temperature).

At 15 K, we could clearly see and enhancement of the elastic line similar to the one observed in YBCO, at a rather different wave vector (0.23 0 8.5). At the other temperatures the enhancement disappeared as expected.



Elastic intensity along the (H,0,8.5) line



Phonon width along the (H,0,8.5) line

The position of the analyzers in the reciprocal space allowed us to map the (H,0,L) plane from L=8 to L=10 but these data are still being analyzed.
Inelastic scans up to ~20 meV energy loss where performed allowing to extract the low energy (acoustic and optical) transverse phonon dispersion. At L=8.5, at first glance, no anomalies were seen in the dispersion of the phonons. Preliminary analysis of the data indicates some large broadening of the phonon on a broader Q range at low temperature. We note however, Stokes/Anti-Stokes intensity ratio analysis revealed that the sample was not very well thermalized.

New measurements on a large piece of crystal, with better thermal contact, have been performed during beamtime HC1395. A more complete temperature dependence has been measured, and the first trend of the analysis, that is still undergoing, seem to confirm the preliminary results presented above (elastic 'central peak' and phonon broadening close to the CDW wave vector).