ESRF	**Experiment title:** Pressure dependence of the charge density wave instability and the electron-phonon interaction in underdoped cuprates	**Experiment number**: HC2196
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Shifts:	**Local contact(s)**: S.M. Souliou	*Received at ESRF:*

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Report:

The aim of the current proposal was to explore the effect of hydrostatic pressure on the charge density wave (CDW) instability and on its competition to superconductivity (SC) in the underdoped cuprates. Despite the intensive research activity on the subject over the last 3 years, this remains an open question due to the technical difficulties imposed by the use of high pressure equipment and the weak signatures of the CDW modulations.

Following our experience from previous energy integrated experiments (see [1]-[2]), we addressed this question using inelastic x-ray scattering to measure the underdoped $YBa_2Cu_3O_{6.6}$ superconductor in a diamond anvil cell. The energy-resolved nature of the technique allowed us to filter out the continuous background signal from the diamond anvils and to follow the quasi elastic central peak intensity as well as the phonon anomalies associated with the CDW formation.

The experiments were performed on high quality detwinned $YBa_2Cu_3O_{6.6}$ (p=0.12, T_c= 61 K) single crystals, from the same bunch as the ones measured in our ambient pressure study [2]. The samples were polished prior to the experiment to plates with dimensions of 80*80 μm and thicknesses of 30 μm. We followed the pressure and temperature dependence of the transverse acoustic and optical phonons along the (010) direction. The number of the accessible Brillouin zones was limited by the geometrical restrictions imposed by the opening of the diamond anvil cell. For every pressure we collected a reference spectrum at high temperature and then we cooled the cell below the CDW and the superconducting transition temperatures. Major complications and experimental time delays arose from the sample rotations/tilts inside the diamond anvil cell during the pressure and temperature changes.

We collected high quality inelastic spectra from -5 to 20 meV, like the ones shown in Figure 1 for P=3 kbar at T=298 K and 65 K. Already from the raw data of Figure 1 it is clear that at 65 K, unlike room temperature, there is a pronounced broadening of the acoustic phonon around the CDW ordering wavevector q_{CDW}=(0 0.31 0.5). The experimental data were fitted to damped harmonic oscillators lineshapes convoluted with the experimental resolution and the fit results for the phonon energy and linewidth at 65 K and 3 kbar is shown in Figure 1. Already at a hydrostatic pressure of 3 kbar the effect appears to be much suppressed, approximately to half, with respect to ambient pressure [2].

While the analysis of the large number of data collected from the 9 different analysers/detectors is still ongoing, we can already report some preliminary conclusions. In our hydrostatic pressure experiment we could identify phonon anomalies in the CDW and SC state around the ordering wavevector q_{CDW}, similar to the ones observed at ambient pressure. Our data clearly show that the amplitude of these anomalies is supressed under pressure. While this is not very surprising given the previously reported competition between the CDW and SC states and the pressure-induced increase of T_c (see [3]-[4]), our data however point out that it is a very rapid suppression and indicate a very delicate dependence of the CDW associated anomalies to the local structural details.

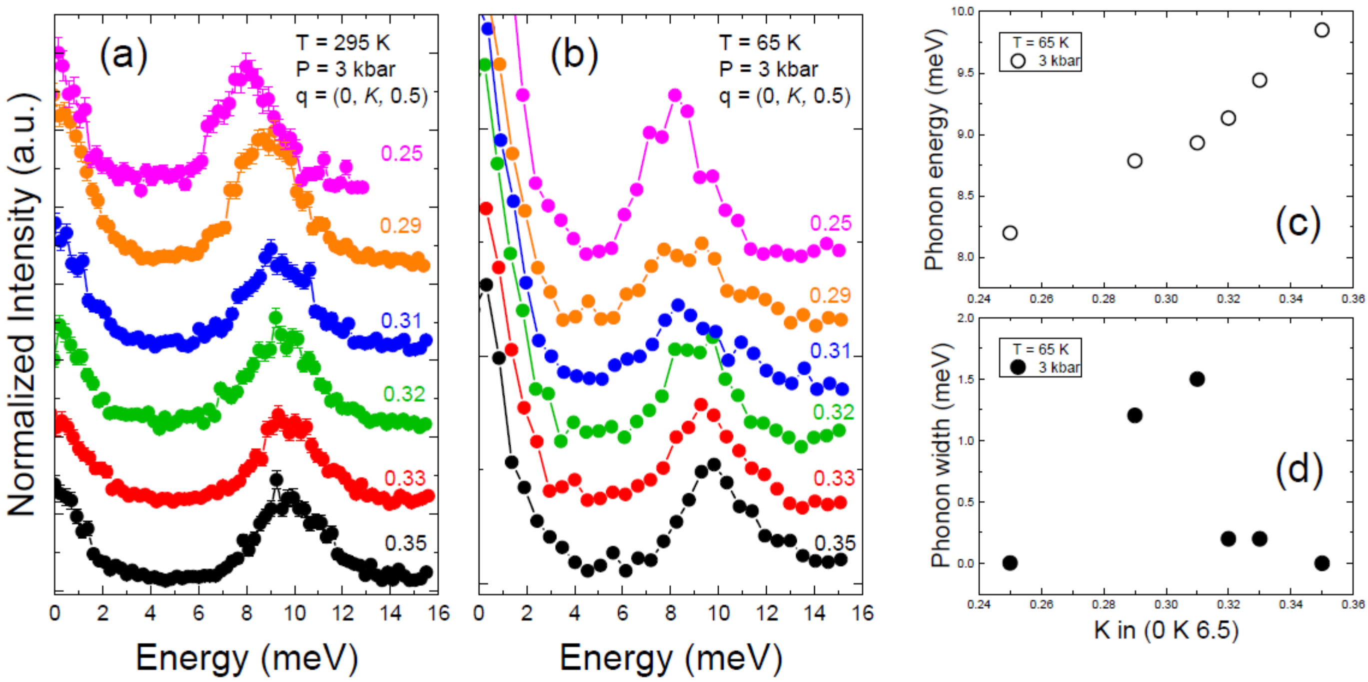

Figure 1: (a,b) Momentum dependence of the IXS spectra along the (010) direction at room temperature (a) and 65 K (b). (c,d) Fit results for the transverese acoustic phonon energy and linewidth at 3 kbar and 65 K.

References:

[1] see ESRF proposal HC-1681
[2] Le Tacon M., et al., Nature Physics, 10, 52-58 (2014)
[3] Ghiringhelli G., et al., Science, 337, 821-825 (2012), Blanco-Canosa S., et al., Physical Review B, 90, 054513 (2014)
[4] Sadewasser S., et al., Physical Review B, 61, 741-749 (2000)