ESRF	**Experiment title:** The origin of phonon anomalies in $YBa_2Cu_3O_y$	**Experiment number:** HC-1400
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Report:

X-ray diffraction experiments [1,2] on the high-temperature superconductor $YBa_2Cu_3O_y$ have demonstrated the existence of a charge density wave (CDW) phase for underdoped compositions y ~ 6.54-6.67). Recent inelastic x-ray spectroscopy (IXS) measurements [3,4] on these underdoped compositions have shown that the low-energy phonons with the CDW wavevector, q_{CDW}, become strongly damped as the temperature is lowered towards the superconducting transition temperature T_{SC}. This damping starts for temperatures greater than T_{SC} and it is important to establish its origin. One possible origin is the pseudogap, which can alter the charge susceptibility and hence charge the phonon damping.

To investigate this further, we have studied the temperature dependence of the phonons in an optimally doped sample of ortho-I $YBa_2Cu_3O_y$ (y ~ 6.92). For this composition, the pseudogap temperature T^* is comparable with T_{SC}. Thus, if the above hypothesis were correct large changes of damping would only occur near T_{SC}.

Inelastic spectra with an energy transfer of -5 to 25 meV were collected over a range of positions in reciprocal space, concentrated around the wavevector expected for CDWs in $YBa_2Cu_3O_y$ - note that no CDW has been observed in this composition. The chosen zone is the one that consistently shows the largest structure factor the CDW peak - (0 0+q 6.5). The spectra were collected at 1.8 K, 100 K (just above T_{SC}) and 300 K. Figure 1a shows an overview of the data collected at 100 K in the (9 9 9) backscattering setup.

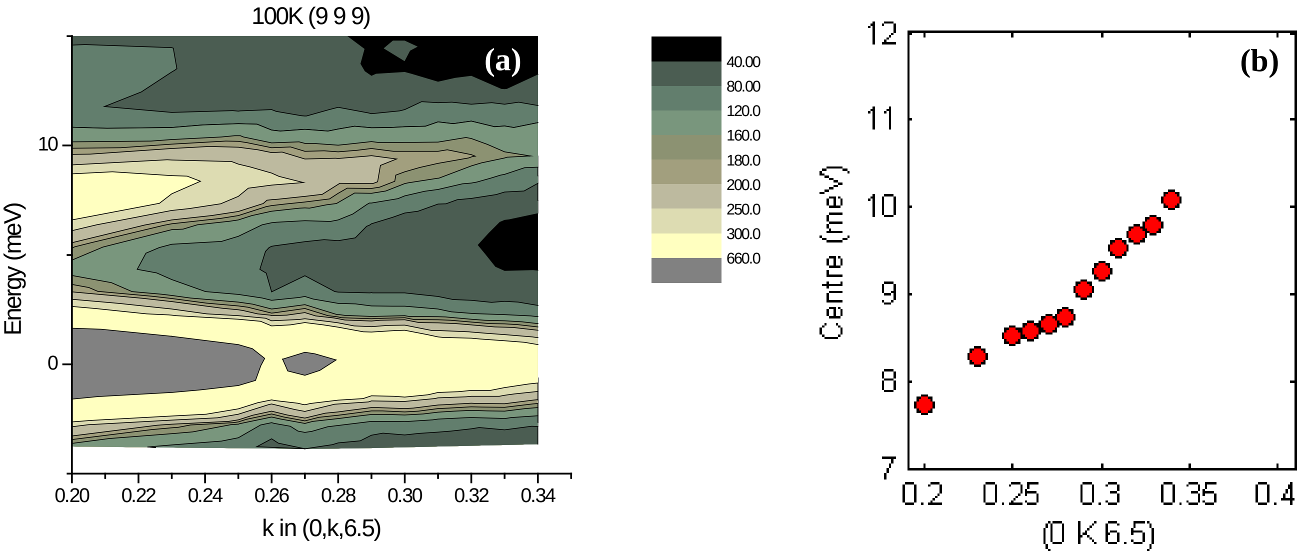

Figure 1: (a) Overview of inelastic spectra measured at 100 K in the (9 9 9) instrument configuration, clearly showing the elastic line and a strong acoustic phonon branch. (b) The peak centres for the phonon branch as a function of wavevector. The errors are standard deviations from a fit to the data of three pseudo-Voigt functions, and are smaller than the point size.

Extracting the phonon pole positions reveals an indication of an anomaly located at q = 0.28 r.l.u. To investigate this further, the instrument configuration was switched to the high resolution (12 12 12) setup, and points at (0 0.24 6.5), (0 2.8 6.5) and (0 0.30 6.5) were measured at 1.8 K, 100 K and 300 K. The point at K = 0.30 was selected, as opposed ot 0.34, due to constraints on achievable scattering angles brought about by the change in energy of the incident beam.

The high resolution measurements were inconclusive. At K = 0.28 r.l.u., a sharp drop in the pole energy was observed at 100 K, when compared with the energy at 1.8 K and 300 K, accompanied by some increases in width at higher temperatures (Figure 2a). However, at K = 0.30 r.l.u. the variation in peak positions obtained showed a wide spread (Figure 2b). We are therefore unable to confirm the anomaly; further measurement is necessary to answer this question. Only one of the analyzer channels has been studied to date; this work is ongoing.

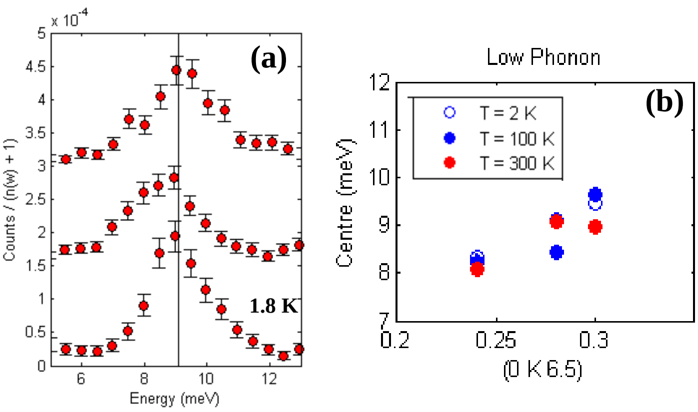

Figure 2: (a) Bose corrected energy profiles at (0 0.28 6.5), measured in the (12 12 12) configuration. The vertical line is set at 9.1 meV. (b) Phonon pole positions fitted to uncorrected data taken in the (12 12 12) configuration.

References

[1] G. Ghiringhelli *et al.*, Science **337**, 821 (2012).
[2] J. Chang *et al.*,Nature Physics **8**, 871 (2012).
[3] M. Le Tacon *et al.*,Nature Physics **10**, 52 (2013).
[4] E. Blackburn *et al.*, Phys. Rev. B **88**, 054506 (2013).