



Experiment title:

Phonon dispersion in electron-doped cuprate superconductor

Experiment number:

HS-1748

Beamline:

ID16

Date of experiment:

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Shifts:

30

Local contact(s):

Dr. Paola GIURA

Received at ESRF:

Names and affiliations of applicants (* indicates experimentalists):

*Dr. Matteo D'ASTUTO - ESRF,

*Mr. Patrick K. MANG - Dep. Appl. Physics, Stanford Univ. USA,

Dr. Markus BRADEN - LLB - CE-Saclay, 91191 Gif sur Yvette cedex FRANCE,

*Dr. Paolo GHIGNA - Dip. Chimica Fisica, Univ. Pavia ITALY,

*Dr. Paola GIURA - ESRF.

Report:

The experiment HS-1748 we report here is the continuation of the experiment HS-1501 (1,2).

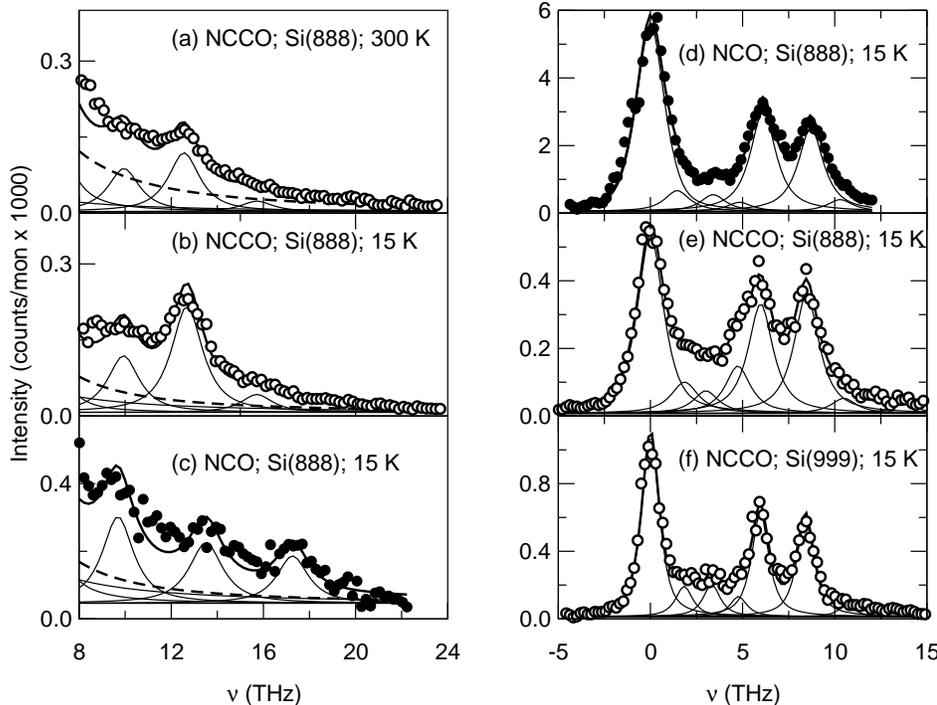


fig.1: IXS phonon spectra. Left panel: for $\mathbf{q} = (0.1, 0.1, 0)$ in $\text{Nd}_{1.86}\text{Ce}_{0.14}\text{CuO}_{4+\delta}$ (\circ) at (a) 300 K and (b) 15 K and (c) $\text{Nd}_2\text{CuO}_{4+\delta}$ (\bullet) at 15 K. Right panel: (d) at the reduced wave-vector $\mathbf{q} = (0.5, 0.5, 0)$ in $\text{Nd}_2\text{CuO}_{4+\delta}$ (\bullet) at 15 K with a resolution of $\Delta\nu = 1.6$ THz, and at the reduced wave-vector $\mathbf{q} = (0.45, 0.45, 0)$ in $\text{Nd}_{1.86}\text{Ce}_{0.14}\text{CuO}_{4+\delta}$ (\circ) at 15 K with a resolution

of (e) $\Delta\nu = 1.6$ THz and (f) $\Delta\nu = 1.1$ THz. Lines indicate a best fit with a harmonic oscillator model. The dashed line in the left panels emphasise the contribution from the LA mode.

For a general description of the scientific background we refer to (1,2). A large part of the data collected in the second experiment (HS-1748) has been described in (3). Here we present a brief report of the main experimental results. In the present experiment we have explored the second direction of high symmetry in the plane: $[\xi, \xi, 0]$. Some energy scans are compared in Fig. 1 for both the pure insulating parent and for the doped superconducting system, at $T = 15$ K and 300 K, and for two resolution set-ups. The frequencies of the peak positions extracted from these and many other scans are summarised in Fig. 2, along the main *in-plane* symmetry directions $\Delta = (\xi, 0, 0)$ and $\Sigma = (\xi, \xi, 0)$. The IXS results for $\text{Nd}_{1.86}\text{Ce}_{0.14}\text{CuO}_{4+\delta}$ (\circ) and $\text{Nd}_2\text{CuO}_{4+\delta}$ (\bullet) are shown together with the INS data for the highest Cu-O bond-stretching mode (Δ) (4). The lines show the results of a numerical calculation (2) based on a shell model. For the insulating parent compound, the results reproduce very well the experimental dispersion measured by INS (4). We observe anomalies in the frequencies of the two higher energy phonon modes in the superconducting system (see Ref. (2,3) for an extensive discussion of the observed anomalies).

We note that, due to the long counting times required for an inelastic measurement, our study was only performed at two temperatures (300 and 15 K), and for the two x dopings ($x=0$ insulating, and $x=0.14$ optimally doped superconductor).

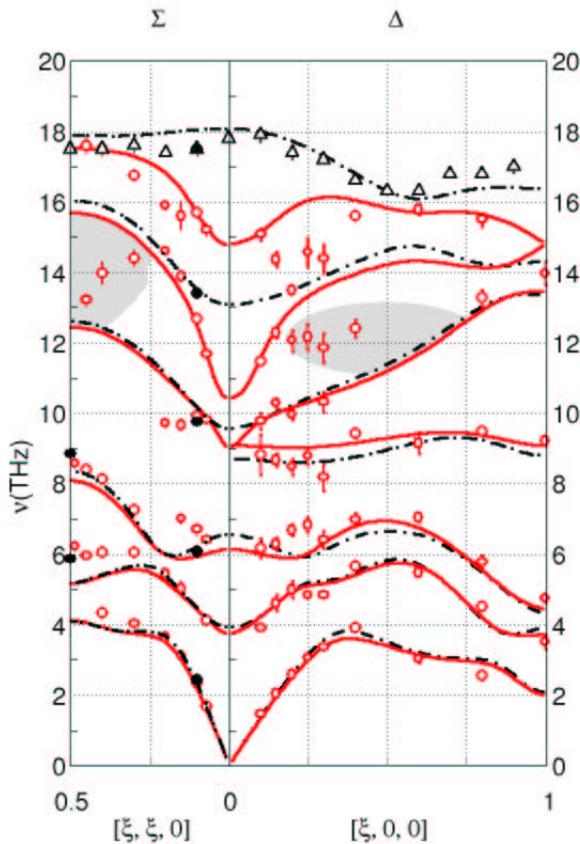


Fig. 2 :

Phonon dispersion of the longitudinal modes in $\text{Nd}_{1.86}\text{Ce}_{0.14}\text{CuO}_{4+\delta}$ (\circ) and $\text{Nd}_2\text{CuO}_{4+\delta}$ (\bullet) measured by IXS, compared with the highest-energy LO mode in $\text{Nd}_2\text{CuO}_{4+\delta}$ (Δ) as measured by INS (from Ref. 4). Solid (dot-dashed) lines indicate lattice dynamics calculation with a screened (unscreened) Coulomb interaction. The shaded areas indicate regions where the dynamic structure factor is very weak and the details of the second highest mode can not be determined.

References.

- 1) d'Astuto *et al.*, *ESRF Report* HS-1501. 2) M. d'Astuto *et al.* *Phys. Rev. Lett.* **88** 167002 (2002). 3) M. d'Astuto *et al.* accepted for publication *Int. J. Mod. Phys. B*.
- 4) L. Pintschovious *et al.*, *Phys. Rev. B* **60** (1999) 15039