Anomalous lattice dynamics in $La_{2-x}Sr_xCuO_{4+y}$ (LSCO): The role of static or mobile dopants

T. Tejsner[a,b*], M. Boehm,[a], A. Piovano[a], A. Ţuţueanu[a,b], L. Udby[b]

a. Institut Laue-Langevin, 38000 Grenoble, France

b. Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen, Denmark

* tejsnertb@ill.fr

The cuprate $La_{2-x}Sr_xCuO_4$ (LSCO) is an interesting model system for high-temperature superconductivity (HTSC) due to its relatively simple crystal structure and differences in the superconducting transition as function of Sr and Oxygen doping. Hole-doping with Sr^{2+} creates a superconductor where the superconducting transition temperature T c varies monotonically with doping. Doping with highly mobile, excess O^{2-} by contrast, results in a bulk superconductor separated into two unique phases: 1) An optimally doped, bulk superconducting phase (T_c = 40K)[1] with low pinning[2] and a 2) long-range modulated antiferromagnet with period $\approx$ 8 similar to the striped cuprates[3].

While both optimally doped LSCO and LSCO+O appear to have similar superconducting properties, the specific role of the dopant ions on a microscopic scale is still unknown. Recently, an anomaly in the Cu-O bond stretching phonon was found to correlate with T c in Sr-doped LSCO, indicating a coupling to a novel charge mode possibly related to stripes[4,5]. In order to distinguish between a lattice effect driven by the superconducting transition or a lattice anomaly introduced by Sr doping, we concentrated our research on samples that are strongly underdoped in terms of Sr (x $\leq$ 0.06), but optimally superconducting (T c = 40K) due to excess Oxygen. Our preliminary measurements with x = 0.06 shows a phonon anomaly with similar strength to optimally doped LSCO as reported in literature[6]. Expanding on these results, we will measure the phonon anomaly in LCO+O in spring this year and compare our experimental results with DFT calculations.

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