# Anomalous Dispersion of Optical Phonons in High-Temperature Superconductors I

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High-temperature superconductivity was discovered in certain complex oxides in 1986, but after nearly two decades of research the microscopic mechanism responsible remains a mystery. In conventional superconductors the coupling between electrons and phonons (collective lattice vibrations) is the mechanism that leads to superconductivity, but the role of this coupling in copper-oxide superconducting compounds has remained a unclear.

Using high-resolution inelastic x-ray scattering (IXS), we measured the phonon dispersion in a single crystal of the electron-doped superconductor $Nd_{1.86}Ce_{0.14}CuO_4$ [1,2]. This was the first such measurement in a high-temperature superconductor using IXS. Our measurement reveals an anomalous softening in the dispersion of the upper phonon branches, similar to that observed in hole-doped superconductors by traditional neutron scattering techniques. This establishes an important commonality between the hole- and electron-doped materials, something that is lacking with respect to many other physical properties, and it provides valuable evidence for the importance of electron-phonon interactions in the high-temperature superconductors.

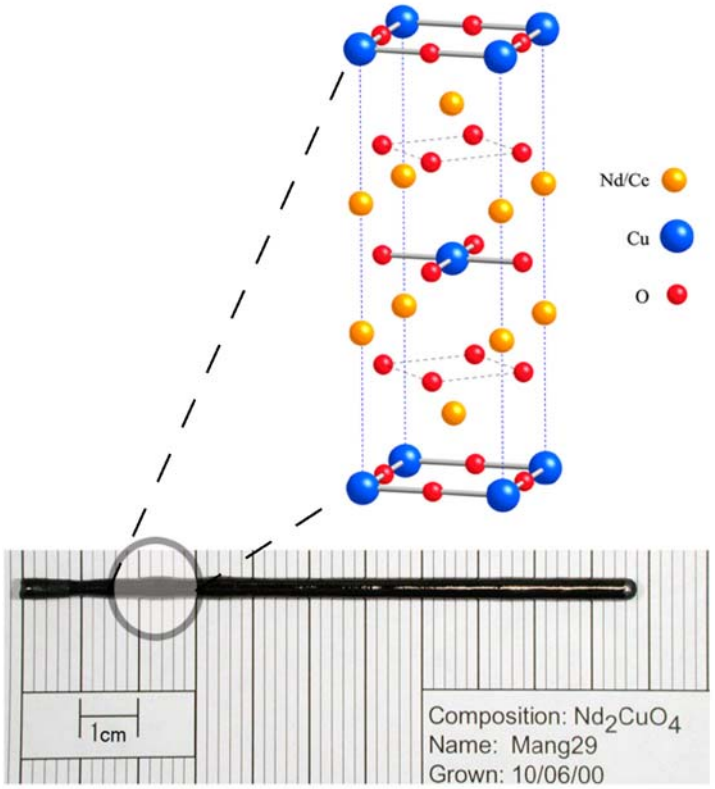


Figure : Example of a high-quality single-crystal sample with magnified schematic representation of the internal atomic structure. This crystal was grown in the T.H. Geballe Laboratory for Advanced Materials at Stanford University.

# Anomalous Dispersion of Optical Phonons in High-Temperature Superconductors II

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*References:*

[1] M. d'Astuto et al., Phys. Rev. Lett. **88**, 167002 (2002).
[2] M. d'Astuto et al., Int. J. Mod. Phys. B **17**, 484 (2003).

*Educational:*

2 undergraduate students

2 graduate students

A course for undergraduates and graduates has been developed which discusses the important experimental tools of x-ray and neutron scattering and emphasizes current "hot topics" in materials physics. Student tours of the Stanford Synchrotron Radiation Laboratory have been organized.

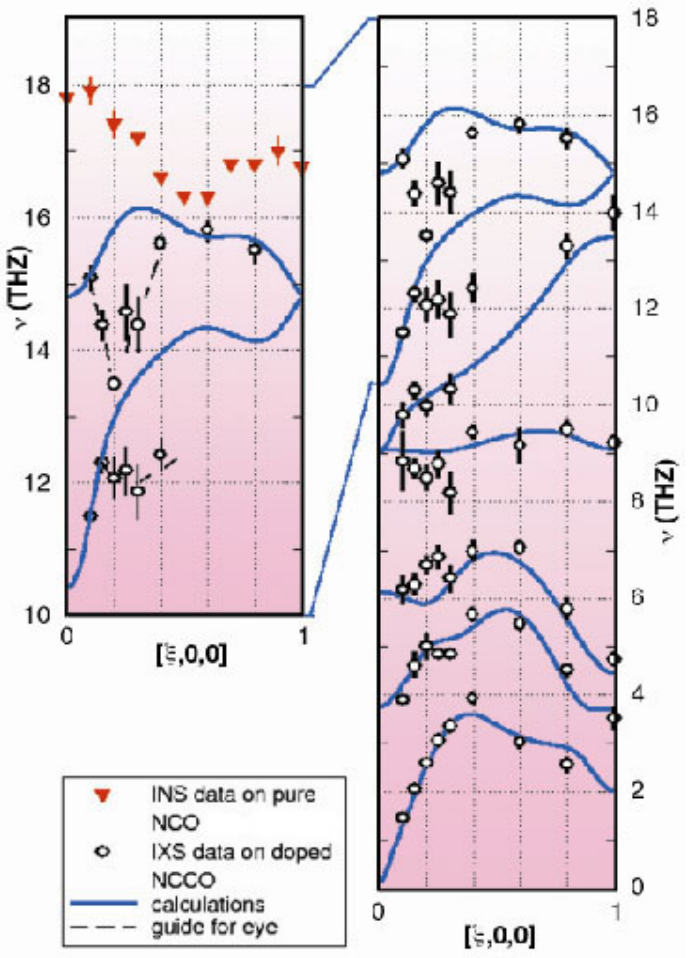


Figure 2: Phonon dispersion measured using IXS in $Nd_{1.86}Ce_{0.14}CuO_4$ (open circles). Anomalies (strong deviations from the calculated solid lines) were discovered between ν = 12 and 16 THz.