

ESRF

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Phase separation in cuprate superconductors

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Report:

We have measured the x-ray absorption-fine-structure (EXAFS) at the Y-K edge of $\text{YBa}_2\text{Cu}_3\text{O}_x$ for $x=6.806, 6.886, 6.947, 6.986, 6.984$ at $T=20-300$ K. Optimum doping is found to be a notable point in the x-T phase diagram, also concerning the c-axis related displacements of the planar $\text{O}_{2,3}$ and Cu_2 atoms. The $\text{O}_{2,3}\text{-Cu}_2$ spacing along c is found to be largest at x_{opt} . In the underdoped regime doping reduces the $\text{Cu}_2\text{-O}_{2,3}$ spacing by displacing the $\text{O}_{2,3}$ layer towards the Cu_2 layer. In the overdoped regime doping reduces the $\text{Cu}_2\text{-O}_{2,3}$ spacing by displacing the $\text{O}_{2,3}$ layer towards the Cu_2 layer [1,2]. Further we wish to emphasise the following details of the local structure and its vibrational dynamics:

- 1.) The Y-Cu_2 bondlengths are independent on doping. In the normal phase the Y-Cu_2 pairs vibrate harmonically, but in the superconducting phase the Y-Cu_2 vibrations freeze out. On doping the Cu_2 atoms shift along the c directions towards the Ba layer.
- 2.) The $\text{Y-O}_{2,3}$ pairs exhibit strong anharmonicities. The degree of non-Gaussian disorder and the strong anharmonic vibrational dynamics depend significantly on the oxygen concentration. The $\text{Y-O}_{2,3}$ mean squared deviations do not freeze out in the superconducting phase as the Y-Cu_2 vibrations. But the mean-cubic deviations of the

Y-O_{2,3} pairs are large, depend on doping, and exhibit a clear singularity at T_c.

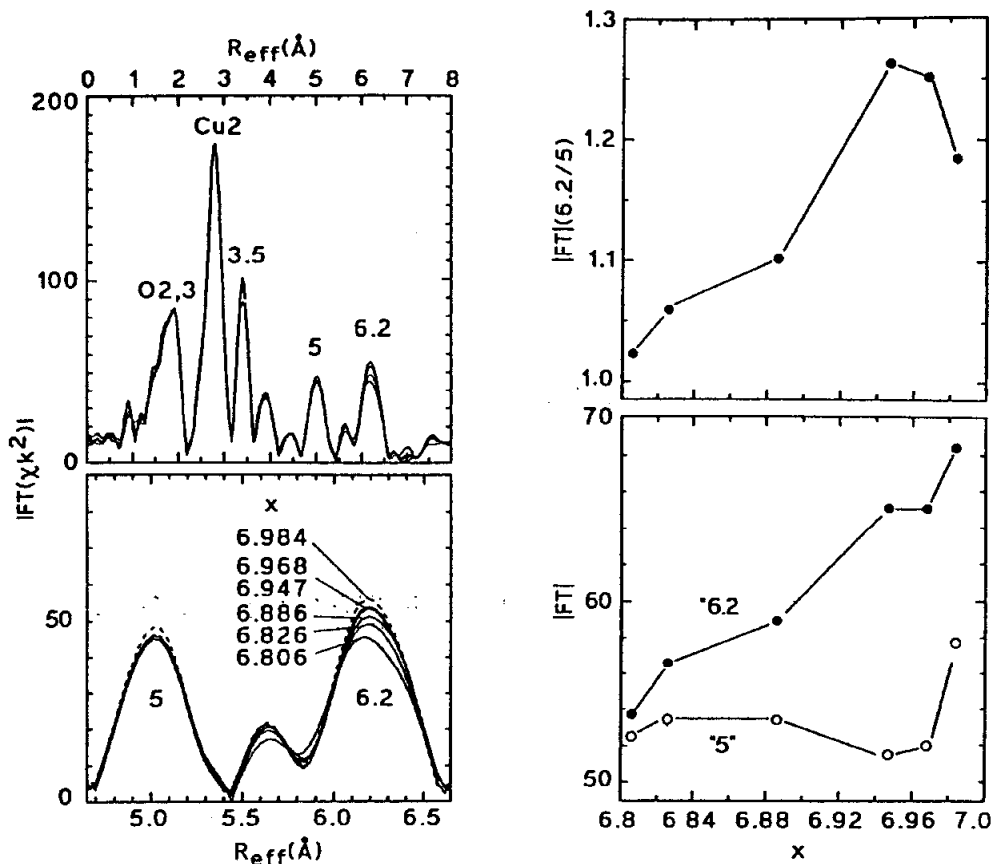


Fig 1. The underdoped-overdoped transition in $YBa_2Cu_3O_x$. Left: Fourier transform spectra of the Y-K EXAFS as a function of oxygen concentration at 90 K. Zoomed are the important Y-O_{2,3}-Ba (“5”) and Y-Cu₂-Ba (“6.2”) multiple scattering peaks, which yield the O_{2,3}-Cu₂ spacing of the dimpled CuO₂ planes. Right: The peak heights “6.2” and “5” monitor the c-axis related displacements of the Cu₂ and O_{2,3} layers, respectively. Its ratio clearly exhibits the O_{2,3}-Cu₂ spacing to be largest at optimum doping.

References

- [1] J. Röhler, P.W. Loeffen, S. Müllender, K Conder, E. Kaldis in: “Material Aspects of High T_c Superconductivity: 10 years after the Discovery”, NATO Advanced Study Institute (ASI Series), Eds. E Liarokapis, E. Kaldis. Kluwer (Dordrecht) 1997. 33 pages, 20 Figs. In the press. Also available as electronic preprint: **COND-MAT/9701208**
- [2] J. Rohler, P.W. Loeffen. K. Conder, E. Kaldis, in: Proc. of the 5th Int. Conf. on Materials and Mechanisms of Superconductivity (Beijing), Physica C, 1997 (invited).

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