

**Experiment title:**

Study of effect of isotope substitution on local lattice of high T_c superconductors by XANES and EXAFS.

Experiment number:
HS1514**Beamline:**

BM29

Date of experiment:

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Date of report:

30.08.02

Shifts:

21

Local contact(s):

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Report:

The proposal was motivated by our own measurements at BM29, on the isotope effect on local lattice displacements and the stripe formation temperature in the cuprate superconductors, revealing large oxygen isotope on the local lattice displacements and charge stripe ordering temperature in the $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ superconductor by temperature dependent high resolution Cu K-edge x-ray absorption spectroscopy. Observation of such a large isotope effect was followed by other groups, focussing on the oxygen and copper isotope effect. Indeed, a similar magnitude of isotope effect was found also by neutron scattering experiments in an independent study by other groups, confirming our experiments and further enlightening the importance of local lattice fluctuations in the charge inhomogeneous state of the high T_c superconductors.

During the assigned beamtime, we focussed on a systematic study of evolution of the isotope effect as function of doping in $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$. We could measure temperature dependent high resolution Cu K-edge XANES spectra on four pairs of samples with O¹⁶ and O¹⁸ isotopes. These samples are with x=0.04, 0.06, 0.08 and 0.15 (O¹⁶ and O¹⁸ samples making it 8 samples used for the study). The measurements were made at about 10 different temperatures in average within the temperature range of 15K to 300K. A 13 element fluorescence detector was used for the measurements. The emphasis was to

obtain the experimental spectra with high signal to noise ratio and several scans were collected to limit the noise level to the order of 10^{-4} in order to pin point small changes introduced by the isotope substitution in the system.

A part of the beamtime was used to study doping dependence of the stripe formation temperature in the $\text{La}_{2-x}\text{Sr}_x\text{Cu}_{1-y}\text{Zn}_y\text{O}_4$ ($x=0, 0.07, 0.115, 0.15, 0.2$ and $y=0, 0.01$) using temperature dependent Cu K-edge XANES measurements. Fig. 1 shows evolution of doping dependence of the stripe formation temperature in the $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ system. In addition, we find that even a very small Zn substitution ($\sim 1\%$) has significant influence on the local lattice displacements. The results suggest that the local geometry around the Cu atom becomes rigid and the temperature dependent lattice anomaly (earlier identified due to formation of charge stripe ordering in the copper oxide superconductors) appears with smaller magnitude. The results on the doping dependent isotope effect and the effect of Zn on the local lattice displacements are to be interpreted with respect to the inhomogeneous state of the high T_c superconductors, and the results are being communicated for the publication.

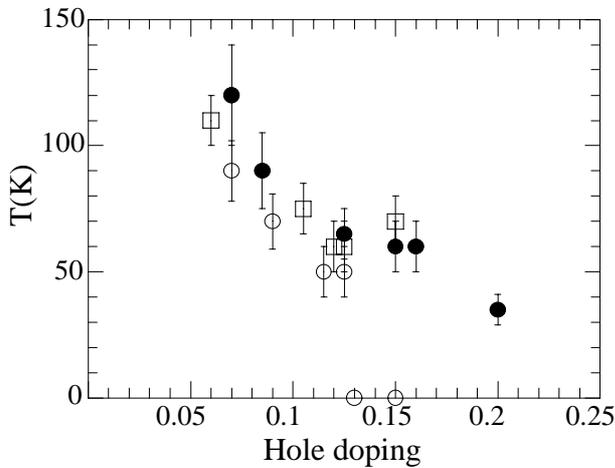


Fig. 1. Doping dependence of the stripe formation temperature obtained by the Cu K-edge XANES peak intensity ratio R (squares) plotted with the one obtained by wipeout fraction of Cu NQR (circles). The open circles are for the $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ while the closed circles represent the one obtained for $\text{La}_{1.6-x}\text{Sr}_x\text{Nd}_{0.4}\text{CuO}_4$ system.

During the allocated beamtime we could only make the measurements for the Cu K-edge XANES region with variable doping concentration on pairs of samples with different isotopes and pairs of Zn and non-Zn samples to investigate the charge inhomogeneous state versus local lattice displacements in the studied system. The temperature dependent Cu K-edge EXAFS is the object of future work and still to be performed to quantify the local displacements related with the effect of isotope substitution on the charge inhomogeneity and the superconductivity of the studied material.