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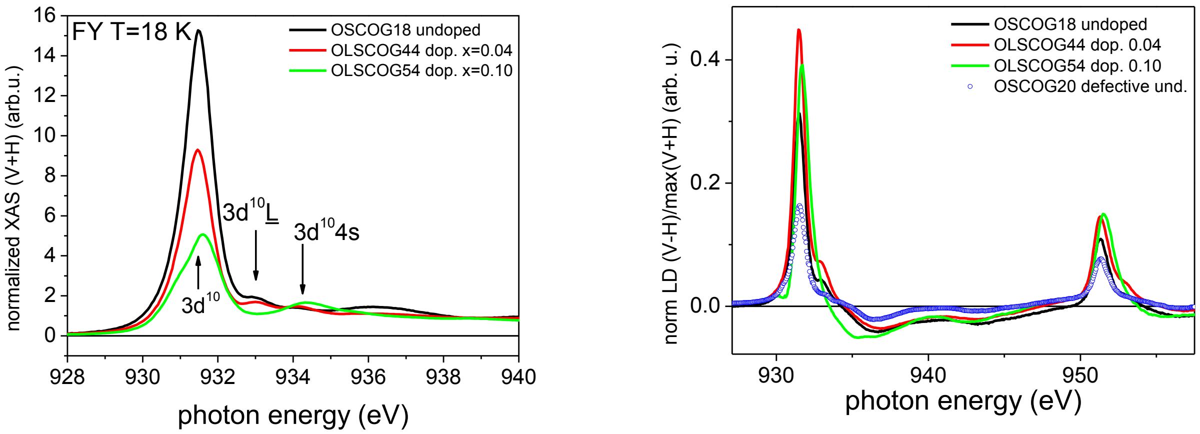
Report:

The aim of the experiment is the study of magnetic excitations (i.e. magnons and/or paramagnons) in electron (e-)doped $Sr_{1-x}La_xCuO_2$ (SLCO) infinite layer cuprate superconductors. It has been recently proven that single magnons can be probed by resonant inelastic x-ray scattering (RIXS), as long as the spin quantization axis has a projection in the xy plane, a condition fulfilled in cuprates. We can then exploit the unique capability of RIXS of measuring magnons (and paramagnons) and their dispersion in thin film samples. Indeed single crystals of SLCO cannot be easily produced in bulk form, as their synthesis requires high pressure (6-8 GPa), then techniques requiring large sample mass (such as inelastic neutron scattering) cannot be employed. Furthermore RIXS allows at the same time to probe the d-d orbital excitations of Cu, giving us information about Cu coordination and doping. The thin film samples have been grown by molecular beam epitaxy on $GdScO_3$ substrates, chosen in order to exert tensile strain on the samples, that helps in stabilizing the infinite layer structure with variable doping and limits the amount of extra-planar oxygen impurities.

In order to select the best samples to be measured by RIXS, x-ray absorption spectra have been collected in the AXES spectrometer with linearly polarized light, and compared with literature results on infinite layer cuprates. Undoped samples and doped samples with doping (i.e. La content) x ranging from 0.04 to 0.13 have been examinated.

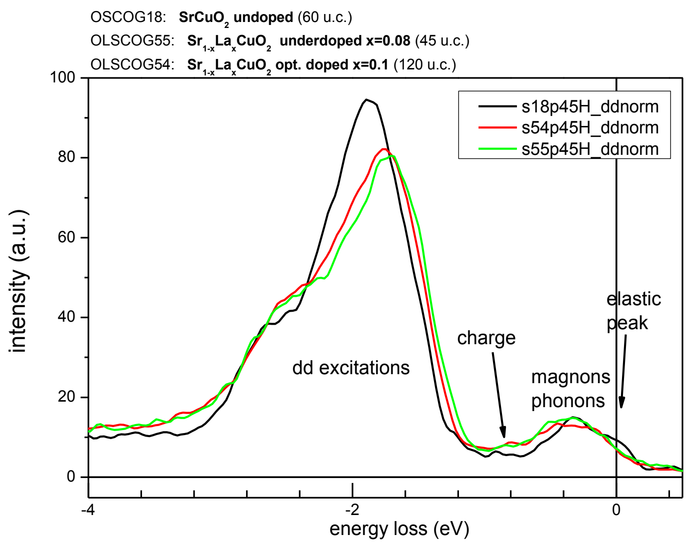
We performed XAS measurements at the Cu $L_{2,3}$ edge in grazing incidence (30°) by tuning the radiation polarization vertical (V, in the plane of the film xy) and horizontal (H, nearly perpendicular to the film plane, z). The isotropic XAS spectra, obtained by summing the V and H polarization spectra normalized to unity edge jump, are reported in Fig.1 for three samples with different doping.



1.(left) isotropic XAS spectra around Cu L_3 line of three samples with doping x=0,0.04,0.10. The measurements have been performed at low temperature(18 K), and the absorption signal has been detected by fluorescence yield (FY), to limit and prevent the detection of surface damage. The peaks are attributed to absorption in the final states indicated by the labels.(right) LD spectra normalized to maximum of absorption for the three samples of Fig.1 plus an undoped defective samples showing a reduced LD.

According to other XAS investigation on SLCO samples, the peak associated to Cu $3d^9 \rightarrow 2p^5 3d^{10}$ transition decreases with doping as electrons occupy the Cu^{2+} 3d levels. The peak attributed to $3d^9\underline{L} \rightarrow 2p^5 3d^{10}\underline{L}$ originates by ligand holes, that may be introduced in the samples by oxygen defects in the infinite layer structure (such as apical oxygens). This peak is absent in the optimally e-doped sample, that is superconducting with T_C=28K. At the same time a peak attributed to presence of Cu^+ ($2p^5 3d^{10} 4s$ final state) arises in the doped samples, according to the e-doping.

Because of the square planar coordination of the Cu ion, the lone hole in Cu^{2+} resides in the very high energy x^2-y^2 orbital. Consequently a strong linear dichroism (LD) is observed at $L_{2,3}$ edge in infinite layer compounds. Comparable LD (normalized to the maximum of the isotropic absorption signal, in the left part of Fig.1) is observed for the three samples in Fig.1. Conversely in a defective undoped sample, the LD normalized intensity is reduced by about a factor of 2 (see Fig.1 right, symbols).

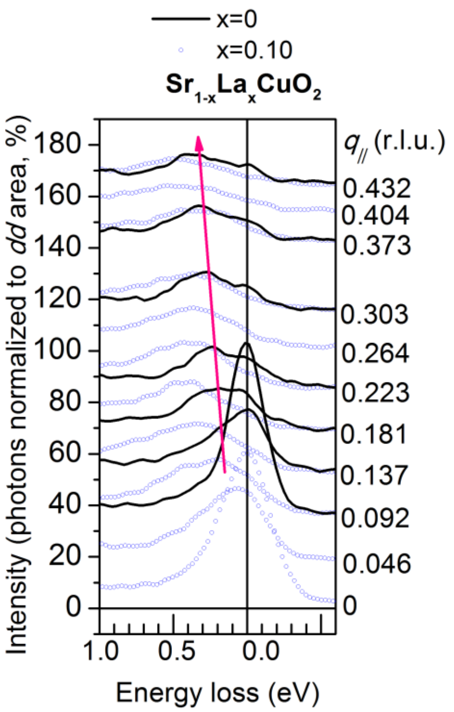


2. RIXS spectra collected at δ=45° for samples with different doping level. The modification of the orbital d-d excitation and the intensity rise of the charge excitation is observed in the doped samples.

RIXS measurements have been performed at the L_3 edge for the following samples

SAMPLE	La doping x	Thickness (unit cells)	Lattice parameter (nm)	T_C (K)
OSCOG18	0	60	0.345	-
OSCOG20	0	120	0.344	-
OLSCOG54	0.10	120	0.340	28
OLSCOG55	0.08	45	0.340	28

The RIXS spectra have been collected by varying the polarization and the incidence angle of the incoming photon. In this way the angle δ between the scattering vector **q** (fixed in the AXES spectrometer) and the sample surface normal can be varied from -45° to 55° in our measurements. In this way the in plane transferred momentum $q_{||}$ is varied so that the dispersion of the magnetic excitation can be measured. In Fig. 3 the main features of the RIXS spectra for 3 samples are reported. The d-d excitation of the undoped sample are similar to the one reported for $CaCuO_2$ infinite layer samples and successfully reproduced by simulations, but some differences, especially in the relative intensity of the peaks, are present.



3. *Low energy loss part of RIXS spectra in H polarization with different $q_{||}$, showing a similar dispersive magnetic excitation in the undoped and doped SLCO samples.*

In Fig. 3 we report the RIXS spectra of a SCO and of an optimally doped SLCO sample, focusing on the low energy part where magnetic excitations are expected. Indeed, a dispersive excitation, identified with a magnon or paramagnon, is observed in both samples. Similar dispersion is observed for the two cases. For energy loss larger than 0.5 eV, a $q_{||}$ independent contribution is found in the doped sample, and can be attributed to charge excitations. The charge excitation in the e-doped sample is found to be more intense than the ones observed in the hole doped counterpart.

We are presently analizing and elaborating the data, in order to decompose the low energy excitation in the elastic, phonononic, single magnon and multi-magnon components. The d-d excitations of the undoped sample can be analized by means of single-ion model cross section calculations, but more sophisticated theoretical approaches are necessary to understand the effect of doping. Also for the magnetic excitation theoretical calculations will be performed in order to understand the dispersion in the doped samples and its analogies and differences with the undoped ones and with the hole doped compounds.

By considering the original proposal, all the aimed goals were successfully achieved.