Resonant inelastic X-ray scattering study of novel electronic excitation in $La_{2-x}Sr_xCuO_4$

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Abstract: The temperature dependence of the Resonant Inelastic X-Ray Scattering spectra of La_2CuO_4 in the 0.2-0.8 eV range was measured. Inelastic scattering at 0.5 eV energy loss was observed to persist above the Neel temperature, with ~ 30% decrease in intensity.

Keyword: X-ray, Cuprate, La_2CuO_4, Superconductivity, Magnon, RIXS

Recently, an excitation of energy 0.5 eV, speculated to be of magnetic origin, was observed in the Resonant X-Ray Inelastic Scattering (RIXS) spectrum of La_2CuO_4 at the zone boundary. Although the Neel temperature for 3D antiferromagnetic ordering is T_N ~ 325 K, 2D AF order persists within the copper oxide planes well above T_N. The main purpose of this experiment is further investigate the 0.5 eV excitation, in particular its temperature dependence.

Our b-face, La_2CuO_4 sample was mounted at SPring-8's BL11XU inelastic scattering spectrometer. With horizontal scattering geometry, the momentum transfer Q was set to $(3.5\ 0\ 6)_{tet}$, such that the scattering angle is 90°. In this geometry, the polarization of the scattered light is rotated by 90° with respect to the incident beam's. The resulting background contribution from the tail of the elastic line is expected to be dramatically reduced, allowing observation of the 0.5 eV excitation with proper subtraction of the background. Indeed the elastic line at 300 K was not more than an order of magnitude higher than high-energy charge-transfer (CT) excitations. The background is taken as the spectrum when the incident energy E_i is well below the resonant 8.9925 keV. The combined resolution of the Si (1 1 1) main and Si (4 0 0) secondary monochrometers, and spherically bent Ge analyzer used was ~ 440 meV.

Our main result, in figure 1, shows intensity in the difference curve at 0.5 eV energy loss (while the difference at 0.5 eV on the energy-gain side is zero within error, as expected). The excitation persists above T_N, although is reduced by more than 10% at 400 K. Previous 2-magnon Raman scattering experiments by other groups, as well as a theoretical model for a 2-D Heisenberg antiferromagnet , showed a similarly small intensity drop across T_N, due to a large exchange energy J in this 2-D Heisenberg system.

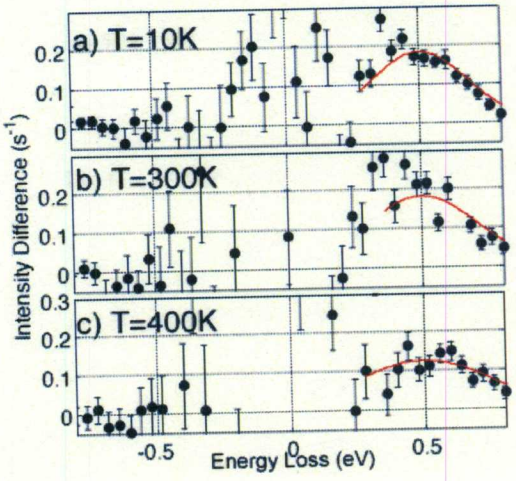

Figure 1: Intensity difference between spectra taken at on-resonance E_i = 8.9925 keV and off-resonance E_i = 8.9845 keV, at three temperatures, a) 10K , b) 300 K and c) 400 K. Gaussian fits to the energy-loss side data, with center energy fixed at 0.5 eV, are shown by the lines.