Incident Energy and Polarization Dependent RIXS Study of La_2CuO_4

Resonant Inelastic X-ray scattering (RIXS) is a novel technique used widely [1-5] to probe the valence structure of many classes of materials. When momentum selectivity is used in Cu *K* edge RIXS, one can follow the dispersion of particle-hole pair excitations. The nature of particle-hole excitations in charge-transfer insulators is of high interest to the field of high-temperature superconductivity.

La_2CuO_4 is an archetypal two-dimensional (2D) charge-transfer insulator. Strong Coulomb repulsion favors localization of carriers, and is responsible for insulating behavior. Meanwhile a small hopping integral prefers an antiferromagnetic state at temperatures below about T_N~320 K.

In comparison to non-resonant inelastic X-ray scattering, the RIXS process is poorly understood. Recent work [5] has emphasized the role of the incident photon energy to preferentially enhance particular excitations in the high-T_c superconductor $HgBa_2CuO_{4+d}$, but very little work has been reported on the polarization dependence of the momentum-selective RIXS cross section. With that in mind, in an international collaborative effort involving measurements at the Advanced Photon Source and SPring-8, we present a systematic study of the incident polarization and incident energy dependence of the RIXS cross section at the Cu *K* edge of La_2CuO_4.

Figure 1 shows the incident energy-dependent effect clearly in the context of La_2CuO_4 at a momentum transfer corresponding to the Brillouin zone center. Here we can identify clearly three peaks

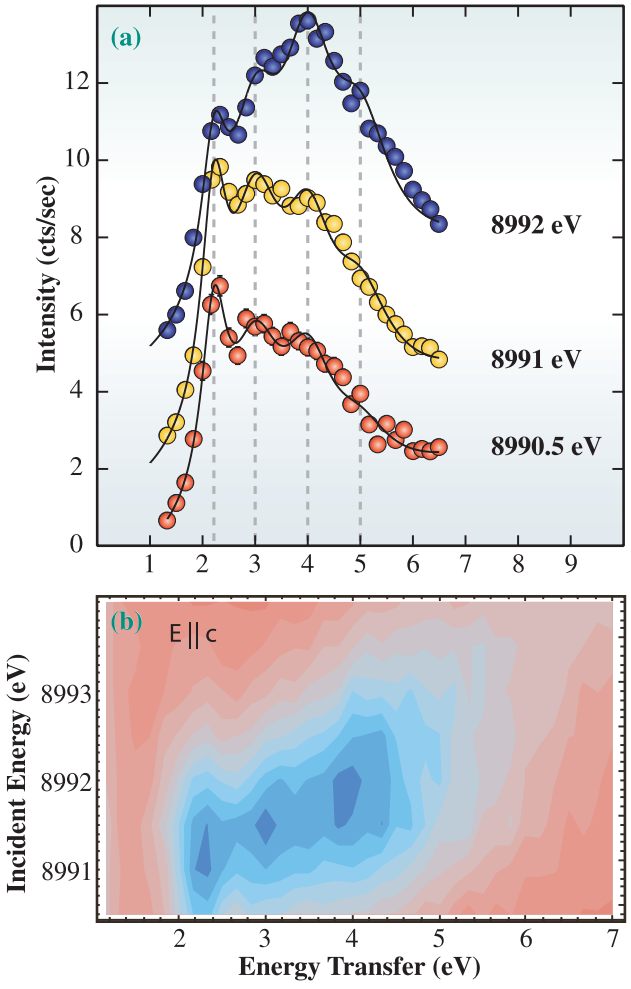

Fig. 1. **(a)** Three scans showing the incident energy dependent effect on the RIXS cross section of La_2CuO_4. **(b)** A contour plot constructed from seven such linescans. Features are clearly discernible at 2.25, 3.0, and 4.0 eV.

at 2.25, 3.0, and 4.0 eV, in contrast to previous studies on this system which could only resolve one [4] or two [2] features in this spectral range. We have extended this result to finite momentum and catalogued the appearance of features at select momentum transfers points throughout the 2D Brillouin zone of the CuO_2 plane. A similar analysis serves to identify a multiplet of weakly dispersive features.

Figure 2 summarizes the results of our analysis of the incident energy and momentum dependent RIXS spectra. Striking similarities and differences are present in the dispersive behavior of the particle-hole excitations. For example, a distinct softening of the 2.25 eV feature occurs when the polarization is chosen to lie in the CuO_2 plane. This effect is most likely either a result of the symmetry of the excitations involved or a resonance enhancement effect. This phenomenology indicates that, like the incident energy, the polarization degree of freedom is an important parameter of the RIXS process.

The appearance of multiple features in the 1-7 eV region of this charge-transfer insulator reveals the complexity of the energy structure in transition metal oxides. Positive identification Positive identification of the features eludes researchers at the moment, but theoretical modeling is likely to benefit our understanding of these excitations.

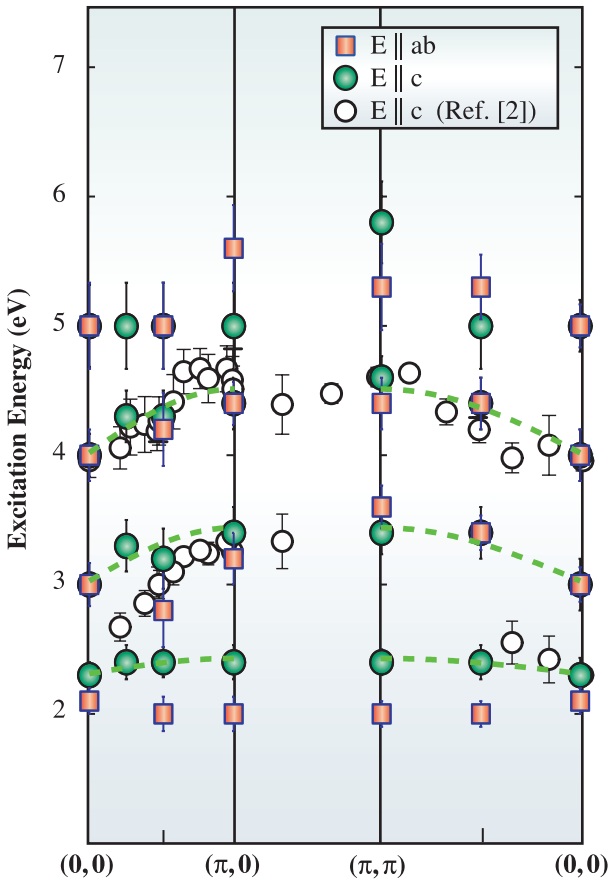

Fig. 2. Dispersion of identifiable features across the 2D Brillouin zone. This figure also shows the polarization dependence.

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