MAR06-2005-002196

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Momentum Dependence of Charge Excitations in $YBa_2Cu_3O_{7-\delta}$ and $Nd_{2-x}Ce_xCuO_4$

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Resonant inelastic x-ray scattering (RIXS) studies at Cu K-edge on high-T_c superconducting cuprates, $YBa_2Cu_3O_{7-\delta}$ and $Nd_{2-x}Ce_xCuO_4$ are presented. The superconductivity occurs in the vicinity of the Mott insulating state and it is important to clarify the nature of the Mott gap and its doping dependence. Because RIXS has an advantage that we can measure charge excitation in a wide energy-momentum space, it gives a unique opportunity to study the electronic structure of materials. We apply this technique to high-T_c superconducting cuprates. In particular the electronic structure of strongly correlated metals is in the focus of our RIXS study. The experiments were performed at BL11XU of SPring-8, Japan, where a specially designed spectrometer for inelastic x-ray scattering is installed. In optimally doped $YBa_2Cu_3O_{7-\delta}$, anisotropic spectra are observed in the ab plane of a twin-free crystal. The Mott gap excitation from the one-dimensional CuO chain is enhanced at 2 eV near the zone boundary of the chain direction, while the excitation from the CuO_2 plane is broad at 1.5-4 eV and almost independent of momentum. Theoretical calculation based on the one-dimensional and two-dimensional Hubbard model reproduces the observed features in the RIXS spectra when smaller values of the on-site Coulomb energy of the chain than that of the plane are assumed. This means that the charge transfer gap of the chain is smaller than that of the plane. On the other hand, both interband excitation across the Mott gap and intraband excitation in the upper Hubbard band are observed in the electron-doped $Nd_{2-x}Ce_xCuO_4$. The intensity of the interband excitation is concentrated at $\sim$ 2 eV near the zone boundary while a dispersion relation with a momentum-dependent width emerges in the intraband excitation.
The author would like to acknowledge to his collaborators, K. Tsutsui, Y. Endoh, T. Tohyama, K. Kuzushita, T. Inami, K. Ohwada, M. Hoesch, M. Tsubota, Y. Murakami, J. Mizuki, S. Maekawa, T. Masui, S. Tajima, and K. Yamada. The crystal growth of $YBa_2Cu_3O_{7-\delta}$ was supported by the New Energy and Industrial Technology Development Organization (NEDO) as the Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.