Neutron Scattering Study of Magnetic Impurity-Fe Effect on hourglass-like magnetic dispersions in La-based high-Tc cuprate

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Recently, similar magnetic excitations have been observed in high-transition-temperature (high-Tc) cuprates by time-of-flight neutron spectrometer, namely, a characteristic hourglass-like magnetic excitation [1, 2]. The resonance peak appears at Q=(π,π) and $\omega \sim 40$ meV, which corresponds to the crossing point of upward and downward dispersions in the hourglass-like dispersion. The resonance peak in the YBCO and Bi2212 systems grows below T_c like an order parameter, and the resonance energy E_{res} is scaled by T_c ($5.8k_BT_c$). Although there is no clear enhancement of the intensity at the crossing point in the LSCO system, the energy of the crossing point (E_{cross}) scales with T_c ($E_{cross} \sim 12k_BT_c$) [3].

The impurity effects on Cu sites, particularly nonmagnetic Zn^{2+} ($S = 0$) and magnetic Ni^{2+} ($S = 1$), have been used to study the correlation between magnetism and superconductivity because impurity substitution can control T_c without changing the carrier number and lattice properties. Recently, we have studied magnetic excitations in impurity-doped $La_{1.85}Sr_{0.15}Cu_{1-y}Ni_yO_4$ by neutron scattering and have found that E_{cross} for Ni: $y = 0.029$ is decreased down to 15 meV, which is nearly the same ratio as the reduction in T_c. In order to establish the linear relation ship between E_{cross} and T_c upon Ni-doping, we performed systematic study of Ni-doping effect on magnetic excitation in optimally doped LSCO. Neutron scattering experiments were performed on the triple-axis spectrometer TOPAN installed at the JRR-3 Reactor of the JAEA.

Figure 1 shows magnetic dispersion observed in Ni 1.5% doped LSCO($x = 0.15$). Two incommensurate peaks around (π, π) merges at $E_{cross} = 30$ meV, which is 10 meV smaller than that in Ni-free LSCO ($x = 0.16$) [4]. The inset of Fig.1 shows T_c vs E_{cross} plot for Ni-doped LSCO ($x = 0.15$). Together with Ni 3% result, the E_{cross} monotonically decrease from 41 meV (Ni free) to 30 (Ni 1.5%), and 15 meV (Ni 3%) with holding linear relationship to T_c. Since Ni-doping changes magnetism without major change in carrer and lattice properties, this result indicates that magnetism plays important role on E_{cross} and T_c.

References

[1] J. M. Tranquada *et al.*, Nature **429**, 534 (2004).
[2] S. M. Hayden *et al.*, Nature **429** (2004) 531.
[3] M. Matsuda et al., Phys. Rev. Lett. 101 (2008) 19.
[4] B. Vignolle *et al.*, Nature Physics **3**, 163 (2007).

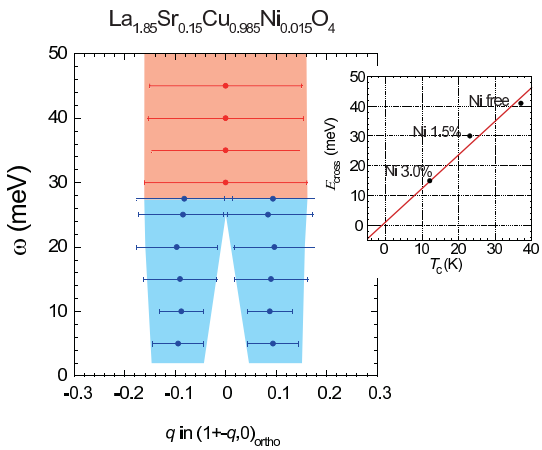

Fig. 1. Magnetic dispersion observed in $La_{1.85}Sr_{0.15}Cu_{0.985}Ni_{0.015}O_4$ at $T = 10$ K. The inset shows T_c vs E_{cross} plot for Ni-doped LSCO ($x = 0.15$)