Magnetic Correlations in the Pseudogap Phase of Optimally Doped Bi2212

M. Matsuura[1], Y. Yoshida[2], H. Eisaki[2], N. Kaneko[2], C.-H. Lee[2] and K. Hirota[1]
[1] *Department of Earth and Space Science, Faculty of Science, Osaka University, Toyonaka, 560-0043.*
[2] *AIST, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568*

In the underdoped region of high-T_c system, a partial gap structure in the charge or spin excitation spectra has been observed universally though its origin is still controversial. Recent inelastic neutron scattering study of underdoped $YBa_2Cu_3O_{6.6}$ has shown that the dispersion relations of spin excitations in the superconducting and pseudogap states are qualitatively different; unusual vertical dispersion is observed in the pseudogap state instead of the hour glass shape of the magnetic dispersions in the superconducting state[1]. This important difference in the magnetic excitation between the pseudogap and superconducting state should be studied in other high-T_c system. Therefore, we explored the magnetic spectrum in the pseudogap state of optimally doped $Bi_{2.1}Sr_{1.9}CaCu_2O_{8+\delta}$ (Bi2212).

Neutron scattering experiments were performed on the triple-axis spectrometer PONTA with horizontal collimations of 48′-80′-80′-120′ and E_f of 30.5 meV. The single crystals were grown by floating zone method and T_c is determined to be 86 K from a shielding signal. We have aligned 9 single crystals on Al plates. The total mass of aligned crystals is 4.6g (0.71cc). The momentum transfer (Q_x, Q_y, Q_z) is denoted in units of reciprocal lattice vectors $a^* \sim b^* = 1.64$ Å^{-1} and $c^* = 0.20$ Å^{-1}.

Figure 1 shows the contour map of the scattering intensity near (π, π) measured in the pseudogap state ($T = 100$ K). The single commensurate peak at center, that is (π, π), and $\omega = 26$ meV splits and disperses outwards with increasing energies, which is similar to the dispersion observed in the pseudogap state of underdoped YBCO[1]. Note that the scattering intensity is especially large at $\omega = 34$ meV, where the resonance peak at (π, π) ($q = 0$) appears in the superdonducting state. This suggests coupling between spin-wave mode and the other excitation at $\omega = 34$ meV. Interestingly, the same value of the superconducting gap Δ has been reported from an STS study of optimum Bi2212[2], indicating pre-formed singlet pairs in the pseudogap phase could be the origin of such enhancement of the spin-wave intensity.

References

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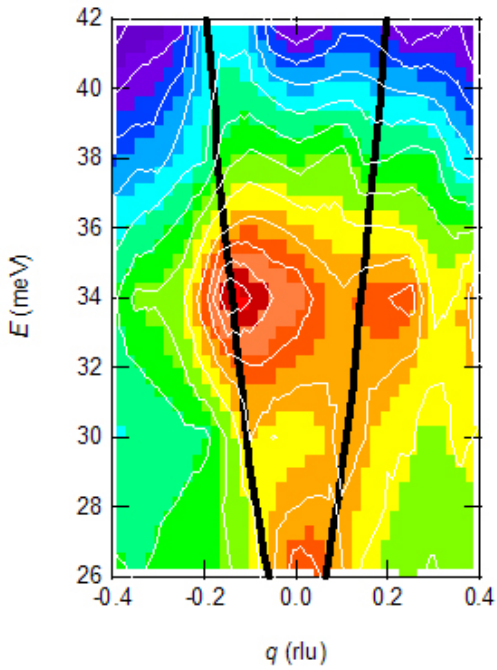

Fig. 1. Intensity contours of the inelastic scattering near (π, π) measured at $T = 100$ K ($> T_c$). The thick black line shows spin-wave dispersion of two-leg spin ladder with gap of 24 meV and zone boundary energy of 80 meV.