Mn-substitution effect on spin correlations in $La_{1.90}Sr_{0.10}CuO_4$

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A recent finding that magnetic fluctuations both in an insulating $La_{1.875}Ba_{0.125}CuO_4$ (LBCO)[1] and in a superconducting $YBa_2Cu_3O_{6.6}$ (YBCO)[2] have a similar fascinating hour-glass-shape dispersion has attracted much attention in regard to the nature of magnetic fluctuations in high-T_c superconductors: with increasing energy ω, two incommensurate branches disperse inwardly toward (π, π) and finally merge at (π, π) at a so-called resonance energy ω_r=40-50 meV. Upon further increasing energy, the excitations exhibit an outward dispersion, which results in an hourglass-shape excitation. It seems that understanding the origin of the novel spin excitations holds the key to understanding the role of the spin correlations in the high-Tc superconducting mechanism[3, 4].

Quite recently, we have studied the low-energy spin fluctuations in $La_{1.90}Sr_{0.10}CuO_4$ with and without Mn doping into Cu sites[5]. We found that the incommensurate spin fluctuations observed in $La_{1.90}Sr_{0.10}CuO_4$ become commensurate when 3% Mn ions are doped. This results suggests that the dispersion changes into conventional spin-wave like one and a reduction of ω_r by Mn-doping.

To gain further insight into this problem, we performed neutron-scattering measurements on the intermediate Mn doping sample $La_{1.90}Sr_{0.10}Cu_{0.99}Mn_{0.01}O_4$. Figure 1 shows observed constant-energy spectra for ω=(a) 2 meV, (b) 3 meV, (c) 4 meV and (d) 6 meV at 40 K. The excitations are incommensurate at low energies. However, they emerge into the commensurate (π, π) point as the energy is increases to 3 meV. At energies higher than 3 meV, the excitations again become incommensurate. This feature strikingly resembles the hourglass-shape excitations observed in the LBCO and YBCO systems. The substitution of Mn ions with large magnetic moment may strongly affect the spin correlations and reduce the energy scale of the excitations.

References

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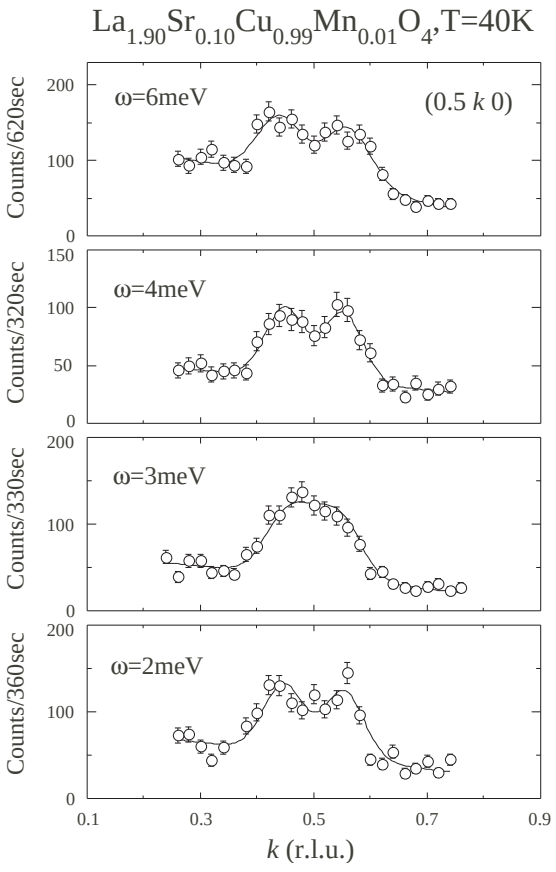

Fig. 1. Low-energy spin fluctuations for the 1% Mn-doped $La_{1.90}Sr_{0.10}CuO_4$.