Dual structure in spin excitations of La2-xSrxCuO4 studied through impurity effect

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Antiferromagnetism in the doped cuprate Mott-insulator has been extensively investigated due to its rich physics and close relation with the high transition temperature (high-Tc) supercoductivity. Recently, Vignolle and co-workers revealed the existence of two energy scales in the spin excitations of optimally doped $La_{1.64}Sr_{0.16}CuO_4$ exhibiting the sharp and broad intensity-maximum at 18meV and 45meV, respectively [5]. Furthermore, even in the optimally-doped region of Y-123 existence of high-energy dispersive magnon-like modes, which is not reproduced by the Fermi liquid theory was reported [6], while the low-energy spin dynamics including resonance feature is well explained by fermiological way. Such structure of spin excitation showing dual nature suggests the different origins for the hourglass-shape spectrum separated by energy. Indeed, phenomenological theory, which treats both itinerant fermions and local spins have well reproduced the overall spin susceptibility in Y-123 [7]. Therefore, two spin degrees of freedom of the itinerant spins and local spins would intrinsically exist in the high-Tc compounds. To make progress on above issue, we investigated the spin excitations in Fe-doped $La_{2-x}Sr_xCuO_4$ system, in which both spin and charge stripe order is significantly stabilized by Fe-doping.

In Fig. 1, the local spin susceptibility (χ'') is plotted for $La_{1.64}Sr_{0.16}Cu_{0.98}Fe_{0.01}O_4$. With decreasing the energy transfer (ω), χ'' below 6 meV decreases toward the minimum intensity at $\sim$2 meV and turn to increase, showing a gap-like structure. Compared to the Fe-free LSCO with the comparable hole concentration shown by dashed line, the low-energy component below 2 meV is strongly enhanced while the high energy component above 8 meV is suppressed. This result suggests that the spectral weight is shifted toward the low energy side by Fe-doping, and therefore, the low energy component is significantly affected by Fe-doping. To conclude the existence of dual nature of spin excitations, study of Fe-doping effects on the high-energy is required, and the neutron-scattering experiment is now under progress.

References

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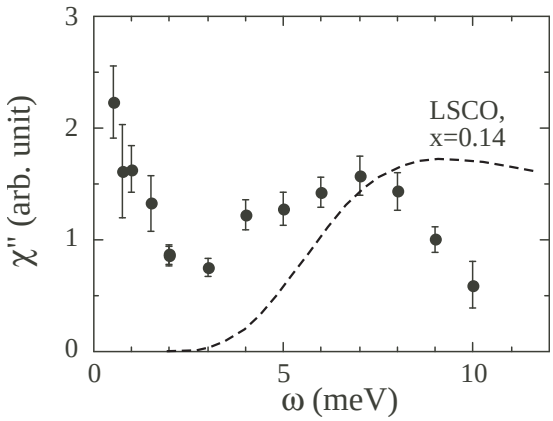

Fig. 1. Local spin susceptibility for $La_{1.94}Sr_{0.16}Cu_{0.98}Fe_{0.02}O_4$ measured at 14K. Dashed line represents the result for Fe-free LSCO with the comparable hole concentration.