Spin Excitations in Doped Mott insulators

Takami Tohyama
Department of Applied Physics, Tokyo University of Science, Tokyo 125-8585, Japan

Metallic states generated by introducing carriers into Mott insulator show various anomalous properties such as psedugap, nematic state, and high-temperature superconductivity as realized in hole-doped high-temperature cuprate superconductors. Magnetic properties also exhibit unusual behaviors. One of the most prominent behaviors in hole-doped cuprates is an hourglass-type spin excitation centered at the magnetic zone center in the Brillouin zone observed by inelastic neutron scattering [1]. One of possible origins of the hourglass-type excitation is the formation of charge stripes in hole-doped cuprates. This indicates strong coupling between spin and charge degrees of freedom in doped Mott insulators.

In order to understand such a coupling of spin and charge in doped Mott insulator, we theoretically investigate dynamical spin and charge structure factors, $S(\mathbf{q},\omega)$ and $N(\mathbf{q},\omega)$, in the t-t'-J model that is a canonical model for doped Mott insulator in two dimsnsions. Using dynamical density-matrix renormalization group (DDMRG), we first examine the geometry dependence of $S(\mathbf{q},\omega)$ in the t-t'-J model. With increasing the number of leg in ladder systems from four with 24×4 sites [2] to eight with 12×8 sites, we find the decrease of excitation energy at $\mathbf{q} = (\pi,\pi)$ [3] approaching to the observed value in inelastic neutron scattering in various cuprates. At the same time, $N(\mathbf{q},\omega)$ changes with changing the number of leg due to strong coupling between spin and charge. This provides important clue to the mechanism of incommensurate spin excitations in cuprates. We also find that doping dependence of $S(\mathbf{q},\omega)$ is qualitatively consistent with Cu L-edge resonant inelastic x-ray scattering (RIXS) data in hole-doped cuprate [4].

[1] For a review, see M. Fujita, H. Hiraka, M. Mstsuda, M. Matsuura, J. M. Tranquada, S. Wakimoto, G. Xu, and K. Yamada, J. Phys. Soc. Jpn. **81**, 011007 (2012) and references therein.

[2] T. Tohyama, M. Mori, and S. Sota, Phys. Rev. B **97**, 235137 (2018).

[3] T. Tohyama, in preparation.

[4] D. Meyers *et al.*, Phys. Rev. B **95**, 075139 (2017).