Global Phase Diagram of the 1D Triangular-Lattice Hubbard Model

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Motivated by the recent discovery of spin-triplet superconductivity in a variety of materials such as organic conductors $(TMTSF)_2X$ and some transition-metal oxides, we study the one-dimensional (1D) Hubbard model with nearest-neighbor t_1 and next-nearest-neighbor t_2 hopping integrals, i.e., 1D triangular-lattice Hubbard model, over a wide parameter and doping regions. We use the density-matrix renormalization group (DMRG) method as well as the Hartree-Fock approximation to calculate the Tomonaga-Luttinger-liquid parameter K_ρ and the spin gap of the system. Based on the calculated results, we determine the ground-state phase diagram in the strong-coupling regime as shown in Fig. 1. We find that, in contrast to the weak-coupling phase diagram which predicts a spin-gapped liquid phase for a Fermi surface with four points, the spin gap vanishs in a substantial region of the strong-coupling phase diagram. We argue that this result occurs because the ferromagnetic spin fluctuation is induced by the Nagaoka mechanism near half filling and by the three-site ring-exchange interaction for $t_2 > t_1$ away from half filling. We also find that the spin-singlet superconducting correlation is enhanced near the critical boundary at which the Fermi surface splits from two into four points. Details are given in Refs. [1]-[3].

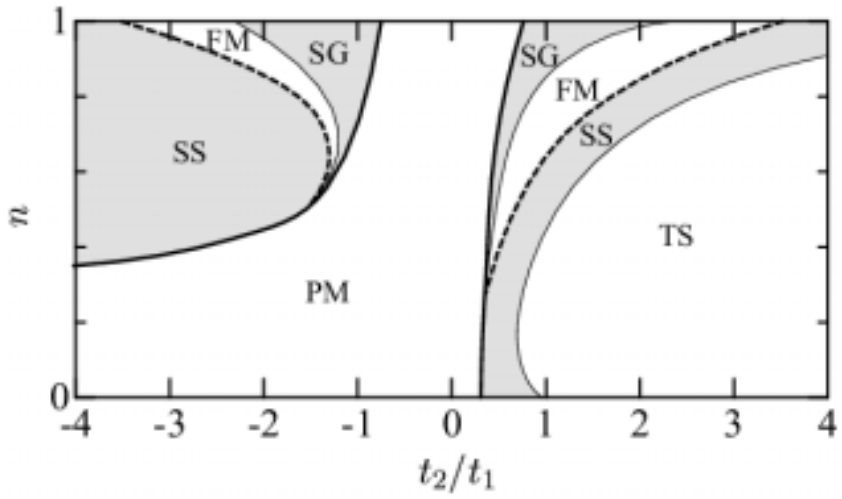

Fig. 5: Calculated phase diagram of the 1D $t_1 - t_2 - U$ Hubbard model at $U/t_1 = 10$. SG: aspin-gapped liquid with incommensurate spiral correlations, FM: a paramagnetic metal with strongferromagnetic fluctuations, SS: spin-singlet superconductivity, TS: spin-triplet superconductivity.

[1] Y. Ohta, S.Nishimoto, T. Shirakawa, and Y. Yamaguchi, Phys. Rev. B **72**, 012503 (2005).
[2] S. Nishimoto, T. Shirakawa, and Y. Ohta, Phys. Rev. B, in press (2007).
[3] S. Nishimoto, K. Sano, and Y. Ohta, in preparation.