Geometrical frustration effects on the Mott transition in two-dimensional Hubbard models

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Geometrical frustration has attracted much interest in the field of strongly correlated electron systems. In particular, recent experiments on the triangular lattice organic materials κ-BEDT-TTF_2X have revealed various interesting physics, such as a novel spin liquid state in the Mott insulating phase. Geometrical frustration effects on the finite-temperature Mott transition is also very interesting. Another interesting frustration effects is reentrant Mott transition observed in the frustrated organic material κ-BEDT-$TTF_2Cu[N(CN)_2]Cl$. Motivated by these interesting phenomena, we have studied the finite-temperature Mott transition in the Hubbard model on the anisotropic triangular lattice by means of the cellular dynamical mean field theory and demonstrated that the reentrant behavior is characteristic of the Mott transition with intermediate geometrical frustration, which is due to the competition between Fermi-liquid formation and magnetic correlations under geometrical frustration.

Another interesting system with strong geometrical frustration is the kagome lattice system. We have also investigated the Mott transition in the kagome lattice Hubbard model with hopping anisotropy. We have determined the phase diagram in the interaction strength versus temperature plane. It has been confirmed that the reentrant behavior of the Mott transition appears when the strength of geometrical frustration is intermediate and in the isotropic kagome lattice system and the reentrant behavior does not appear down to very low temperatures. In the anisotropic systems, we have found the dramatic change in the quasiparticle and magnetic properties around the Mott transition and clarified that it is due to the enhancement of anisotropy associated with the relaxation of frustration around the Mott transition. We have also investigated the effects of an applied magnetic field and demonstrated that the relaxation of frustration due the field drives the Mott transition.

In order to study the Mott transition in the weakly frustrated system, we need other proper treatments for the effects of almost perfect nesting. In the square lattice Hubbard model, it has been suggested that the infinitesimal Hubbard interaction drives the insulating phase at zero temperature due to the perfect nesting but it is known that the cellular dynamical mean field theory gives the finite Mott transition point. We have studied the square lattice Hubbard model with weak next-nearest neighbor hopping by means of the dynamical cluster approximation and determined the phase diagram at zero temperature, which is in good agreement with the previous path integral group results. We have also applied this method to the Honeycomb lattice Hubbard model and found that the infinitesimal interaction drives the Mott insulator, which indicates the existence of the spin liquid phase, within our approximation.

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