MAR14-2013-020415

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Mott Transitions of Correlated Dirac Fermions from SU(2) to SU(N)

THOMAS C. LANG, Boston University

The rise of graphene and topological insulators has sparked countless investigations of interacting electrons on the honeycomb lattice. We present recent advances in the study of the evolution from the weak-coupling semimetal into the strong-coupling, insulating regime by means of unbiased quantum Monte Carlo simulations of the Hubbard and related models on the honeycomb lattice at half filling. Employing a novel approach to quantum phase transitions, we perform non-equilibrium imaginary time quenches of the Hubbard model in (zero temperature) projective quantum Monte Carlo simulations. This allows us to efficiently access order parameters on a finite size lattice for a wide range of coupling values in a single run. We extract reliable estimates for the scaling properties and critical exponents of the semimetal-insulator quantum phase transition. Furthermore, we investigate the extension of the Hubbard model with an explicit SU(N)-symmetric, Heisenberg-like nearest-neighbor flavor exchange interaction. From the large-N regime down to the SU(6) case, the insulating state is found to be a columnar valence bond crystal, with a direct transition to the semimetal at weak, finite coupling, in agreement with the mean-field result in the large-N limit. At SU(4) however, the insulator exhibits a subtly different valence bond crystal structure, stabilized by resonating valence bond plaquettes. Furthermore, we discuss the new possibility to efficiently access the Renyi entanglement entropy within the auxiliary field quantum Monte Carlo algorithm. Using the example of a correlated topological insulator we present the development of the stable computation of higher order Renyi entropies, in order to access the entanglement spectrum.