Fermionic quantum criticality in Hubbard models

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We numerically investigate the critical behavior of Hubbard models which exhibits a direct transition from a Dirac semimetal to an antiferromagnetically ordered Mott insulator. We investigate the Hubbard model on the honeycomb and the π-flux lattice with a purely local screened repulsion, and the Hubbard model with a long-range Coulomb interaction on the honeycomb lattice. Long-range interactions are expected to play a role in honeycomb materials because the vanishing density of states in the semimetallic weak-coupling phase suppresses screening. We use projective auxiliary-field quantum Monte Carlo simulations and a careful finite-size scaling analysis that exploits approximately improved renormalization-group-invariant observables. This approach allows us to extract estimates for the critical couplings and the critical exponents for the Hubbard model on the honeycomb lattice. The results confirm that the critical behavior for the semimetal to Mott insulator transition in all the models analyzed belongs to the Gross-Neveu-Heisenberg universality class. In the presence of long-range Coulomb repulsion, nonlocal part of the interaction promotes short-range sublattice charge fluctuations, which compete with antiferromagnetic order driven by the onsite repulsion. Consequently, the critical interaction for the magnetic transition is significantly larger than for the purely local Hubbard repulsion.

References

[1] M. Hohenadler, F. Parisen Toldin, I. F. Herbut, F. F. Assaad, Phys. Rev. B **90**, 085146 (2014)

[2] F. Parisen Toldin, M. Hohenadler, F. F. Assaad, I. F. Herbut, Phys. Rev. B **91**, 165108 (2015)