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Competing order in the fermionic Hubbard model on the hexagonal graphene lattice

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We study the phase diagram of the fermionic Hubbard model on the hexagonal lattice in the space of on-site and nearest neighbor couplings with Hybrid-Monte-Carlo simulations. With pure on-site repulsion this allows to determine the critical coupling strength for spin-density wave formation. We compare the standard approach of introducing a small mass term, explicitly breaking the sublattice symmetry, with a purely geometric mass, i.e. using lattices and boundary conditions such that the Dirac points fall in between the grid points inside the Brillouin zone without explicit sublattice-symmetry breaking. For the first method we extrapolate the corresponding susceptibility peaks towards zero mass and infinite volume in the usual way, while with the geometric mass only infinite volume extrapolation is needed. An added bonus is that it can be used with nearest neighbor repulsion and charge-density wave formation where the corresponding mass term would introduce a sign problem. The geometric mass thus provides a promising method to study the competition between these different types of order and the resulting phase diagram with ab-initio simulations.

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