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Realistic model for electron-electron interactions in graphene¹ JOAO N. B. RODRIGUES, HO-KIN TANG, JIA NING LEAW, National University of Singapore, PINAKI SENGUPTA, Nanyang Technological University, FAKHER F. ASSAAD, Universitt Wrzburg, SHAFFIQUE ADAM, National University of Singapore — We study the effects of realistic electronic interactions in undoped graphene. Using projective quantum Monte Carlo simulations of tight-binding electrons on a honeycomb lattice interacting through a realistic effective Coulomb potential, we compute the phase diagram and renormalized Fermi velocity as a function of the strength of the short- and long-range components of the Coulomb potential. The short-range part of the interaction drives the semi-metal to antiferromagnetic Mott insulator transition, which is consistent with the Gross-Neveu-Yukawa critical theory. Far from the critical point, the Fermi velocity renormalization is dominated by the long-range part of the interaction, agreeing with the predictions from perturbative theory. In contrast, close to the antiferromagnetic Mott insulator transition, the Fermi velocity renormalization is modified by a competition between spin density wave and charge density wave fluctuations. Real graphene samples are typically halfway between these two limits. Since finite system sizes restrict the QMC results to large momentum scales, we perform a phenomenological reconstruction of the renormalization group flow of the Fermi velocity to make predictions that can be tested against current experimental observations.

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