Competing many-body instabilities and unconventional superconductivity in graphene

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The band structure of graphene exhibits van Hove singularities (VHS) at doping \( x = \pm 1/8 \) away from the Dirac point. Near the VHS, interactions effects, enhanced due to the large density of states, can give rise to various many-body phases at experimentally accessible temperatures. We study the competition between different many-body instabilities in graphene using functional renormalization group (FRG). We predict a rich phase diagram, which, depending on long range hopping as well as screening strength and absolute scale of the Coulomb interaction, contains a \( d + id \)-wave superconducting (SC) phase, or a spin density wave phase at the VHS. The \( d + id \) state is expected to exhibit quantized charge and spin Hall response, as well as Majorana modes bound to vortices. In the vicinity of the VHS, we find singlet \( d + id \)-wave as well as triplet \( f \)-wave SC phases.

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