Electronic transport and optical properties of graphene near instabilities

K. Ziegler
Institut für Physik, Universität Augsburg, D-86135 Augsburg, Germany

Graphene, a genuine two-dimensional material formed by carbon atoms, has remarkable electronic and optical properties. It is a transparent semimetal with a minimal conductivity and it is colorless because its optical properties are independent of the frequency of the transmitted light. This is very different from the conventional Drude-type behavior of other materials. All these properties are strongly related to the existence of a quasiparticle spectrum which consists of two bands that touch each other at two Dirac nodes. This structure is associated with a number of interesting features, such as Klein tunneling and electron-hole pair creation. Recent experimental studies have revealed that the sublattice symmetry of the honeycomb lattice of graphene can be broken by chemical doping or by external gates in the case of bilayers. Here we will discuss the role of broken symmetries due to structural instabilities. This can lead to a random gap in the quasiparticle spectrum which may cause an insulating behavior. We discuss the gap opening and the related transition from a semimetal to an insulator in the case of disordered mono- and bilayers graphene and the effect of Coulomb and electron-phonon interaction on the gap formation. The discussion includes the role of dynamical symmetries and spontaneous symmetry breaking, and scaling laws in the form of a generalized Drude formula.

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