Tight-binding minimal substitution in doped Dirac semimetals

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Abstract

The conduction electrons in doped Dirac semimetals are generally described by the anisotropic 4x4 3D Dirac Hamiltonian with a finite Dirac mass [1]. In most recent studies, however, quantitative analyses of measured reflectivity data are based on oversimplified 2x2 3D Dirac models [2,3], which usually do not possess the proper symmetry of the crystal under consideration. In this work, we reconsider this question. The tight-binding minimal substitution from Ref. [4] is used to describe the coupling of conduction electrons in the 4x4 Dirac model to external electromagnetic fields. The resulting dynamical conductivity obtained in the relaxation-time approximation is found to have the structure which is a simple generalization of the dynamical conductivity of doped graphene. Not only the Bloch energies, but also the current vertex functions are simple functions of the Dirac mass and the related electron group velocities, in both cases. Therefore, there is no need to use oversimplified 2x2 Dirac models for conduction electrons in Dirac semimetals. It is also shown that the same approach can be used to include the relaxation processes beyond the relaxation-time approximation.

References

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