Electron-phonon interaction anomalies in graphene and other layers

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Abstract Phenomena related to particular layers (e.g. graphene, phosphorene) reveal specific behavior inferred by (quasi) two-dimensionality, attracting attention of the condensed matter physics. Here we report another interesting feature. In some 2D layers particular electronic states associated to highly symmetric point in the Brillouin zone are within the first order perturbation theory uncoupled to the nuclear subsystem. This manifests a significant deficiency in the electron-phonon coupling. Some of the consequences are breaking of the Jahn-Teller theorem, complete or partial absence of the Kohn anomaly, symmetry based explanation and prediction of the flexural modes, etc. The conditions for total decoupling of phonons with a particular electronic state (independently of its degeneracy) are derived. They restrict the symmetry of the layer to the groups with spatial inversion, possessing dual maximal orbits. Then the nuclei of a layer being a combination of these orbits are decoupled from the dual electronic states. Besides this extreme situation, there are compounds, like graphene, with partly suppressed electron-phonon interaction [1]. This is observable through the Kohn anomalies. The effect is found within adiabatic harmonic model, and in quasi-one-dimensional structures it points to the symmetry breaking revealed without adiabatic approximation; as for the layered structures, this is not the case.

Detailed analysis of electron and phonon spectra of graphene is presented, and the mentioned anomalies are pointed out and discussed. Some conclusions are related to carbon nanotubes [2,3].

References

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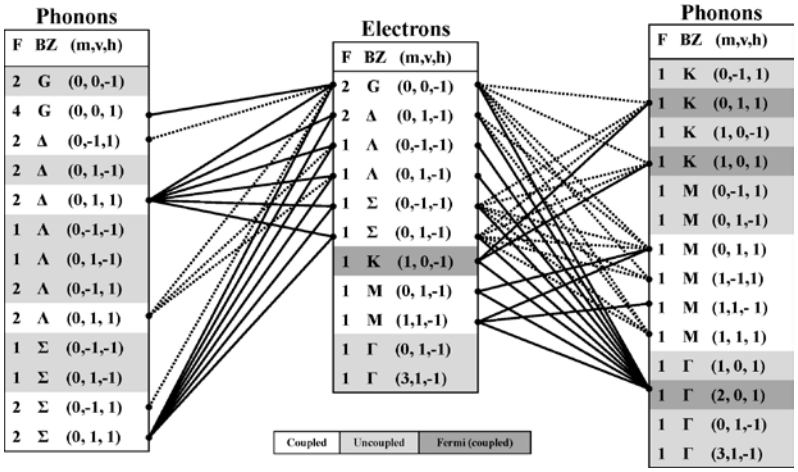
[2] S. Dmitrovic, I. Milosevic, M. Damnjanovic, T. Vukovic, J. Phys. Chem. C **119** (2015) 13922–13928.
[3] M. Milivojevic, N. Lazic, T. Vukovic, M. Damnjanovic, Phys. Rev. B **92** (2015) 165410.

Figures



Electron-phonon coupling in graphene. Electron states and phonons are classified by the quantum numbers (and labels of the position in the Brillouin zone), and the coupled ones are joined.