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Phonon dispersion in graphene

Leonid Falkovsky
Landau Institute for Theoretical Physics, Kosygina 2, 119334 Moscow, Russian Federation

Taking into account constraints imposed by the lattice symmetry, we calculate analytically [1] the phonon dispersion for graphene with interactions between first and second neighbors. We find that the out-of-plane (bending) modes are not coupled with in-plane modes and described only with two force constants, one of which is determined by the corresponding Raman frequency and another by the smallest elastic constant C44. In contrast to calculations by Saito et al, we find the linear dispersion of the bending (out-of-plane) mode around the Γ point with a small but finite sound velocity =1.57 km/s. The sound velocity of this mode is very sensitive to small variations of the force constants. The sound velocities of in-plane modes are = 20.3 km/s and =13.1 km/s. Because of the lack of information for graphene, we compare the present theory with experiments on graphite. The low phonon frequencies in the critical points turn out less than their values in graphite, since the atoms in graphene are more free to move in the out-of-plane direction in comparison with graphite. Accuracy of the comparison can be estimated using the value of the observed splitting of the ZA and ZO' modes in graphite which is around 130 1/cm.
[1] L.A. Falkovsky, cond-mat/0702409.