A Numerical Model for Finite-Temperature Electron Self-Energy in Doped Graphene with Electron-Electron Interaction

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Abstract

We develop a numerical model for the electron self-energy in doped graphene due to the electron-electron interaction at finite temperatures. It numerically calculates the real and imaginary parts of the self-energy within the Hartree-Fock [1] and random phase approximations [2] taking into account the finite-temperature Fermi-Dirac distribution, so that effects of both the band renormalization and the band broadening on real graphene devices can be investigated. We showed that the calculated RPA dielectric function exhibits the peak broadening and blue shift in the plasmon dispersion as the temperature increases (Fig. 1). As a result, the imaginary part of the self-energy exhibits the broadening of peaks associated with plasmon excitation (Fig. 2). In addition, splitting of the peaks (leading to the formation of the so-called plasmaron band [2] aside from the normal band for electrons) at high temperature is found. These results indicate that the temperature plays a crucial role in the energy dispersion through the self-energy and, in turn, the carrier transport in real devices.

Reference

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[3] E. M. Lifshitz and L. P. Pitaevskii, *Physical Kinetics* Pergamon Press, Oxford (1981).

Figure

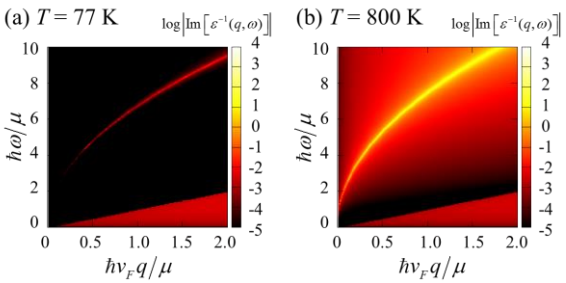

Fig. 1. Logarithmic expression of imaginary part of the RPA dielectric function ε in graphene as a function of the wavevector q and the frequency ω calculated at (a) T = 77 K and (b) 800 K. Axes are normalized by the Fermi level μ.

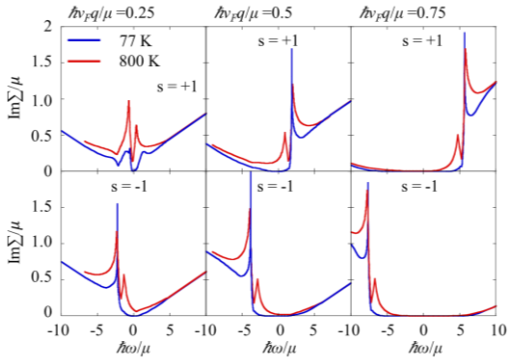

Fig. 2. Imaginary part of the self-energy Σ in graphene calculated at T = 77 and 800 K (red and blue lines, respectively). Columns from left to right correspond to $\hbar v_F q/\mu$ = 0.25, 0.5, and 0.75, respectively, while top and bottom rows correspond to s = 1 (the conduction band) and s = -1 (the valence band), respectively.