Friction force on slow charges moving near graphene

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Dynamic effects in the polarization of graphene by external moving charges play an important role in several techniques for probing graphene systems using particle beams, such as high-resolution reflection electron-energy-loss-spectroscopy with slow electrons [1]. In addition, dynamic polarization of graphene can affect the kinetics of chemical reactions on graphene as well as ion transport in an aqueous solution adjacent to graphene, e.g., when top-gating with an electrolyte is implemented [2].

It is therefore of interest to investigate how low-energy excitations of charge carriers in graphene affect the motion of slow charged particles near graphene. It is well known that in the linear response regime, such excitations are dominated by the intra-band electron-hole excitations which give rise to a friction force proportional to the particle speed [3]. In this respect, graphene is particularly interesting because such excitations are strongly suppressed in the limit of intrinsic graphene, which is characterized by zero or very low levels of doping [4,5].

We shall use the expression for the dielectric function of graphene in the random phase approximation, which is available for a wide range of doping levels [4,5], and amend it with a non-zero decay rate for electron excitations using Mermin's procedure [6]. Deriving the low-frequency limit of such a modified dielectric function will allow us to calculate the friction coefficient on a charged particle moving close to graphene [3]. In particular, we shall investigate the effects of particle distance as well as the effects of doping level and decay rate in graphene on the friction coefficient.

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