Acoustic plasmons in extrinsic free-standing graphene

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The realization of an acoustic plasmon, in addition to a conventional two-dimensional (2D) plasmon, is predicted to occur for carriers in the very same two-dimensional (2D) band of extrinsic (doped or gated) graphene. The origin of such novel mode resides in the strong anisotropy that is present in the graphene band structure near the Dirac point. This fact allows for the coexistence of carriers moving with two distinct velocities along the ΓK direction, which leads to two modes of collective charge oscillation: one mode in which the two types of carriers oscillate in phase with one another [this is the well-known 2D graphene plasmon, which at long wavelengths ($q \rightarrow 0$) has the same dispersion, $\sim q^{1/2}$, as the conventional 2D plasmon [1] of a 2D free electron gas], and the other mode found here corresponds to a low-frequency acoustic oscillation [whose energy exhibits at long wavelengths a linear dependence on the 2D wave number q] in which the two types of carriers in the very same energy band oscillate out of phase. Note, that the former mode was predicted to exist in doped graphene theoretically some time ago [2-4] and observed in numerous experiments on different substrates [5-11]. On the other hand, if the prediction of the latter mode is confirmed experimentally, it will represent the first realization of acoustic plasmons originated in the collective motion of a system of two types of carriers exited within the very same band. The properties of this novel mode like strong in-plane anisotropy in its dispersion, variation in its group velocity upon variation in doping and others will be discussed.

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