Quantum magnetooscillations in the ac conductivity of disordered graphene

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We present the results of calculations of the dynamic magnetoconductivity $\sigma(\omega)$ of disordered graphene [1] and make connections to recent experiments [2]. Analytic expressions for $\sigma(\omega)$ are obtained in various parametric regimes ranging from the quasiclassical Drude limit corresponding to strongly overlapping Landau levels (LLs) to the extreme quantum limit where the conductivity is determined by the optical selection rules of the clean graphene.

The nonequidistant LL spectrum of graphene renders its transport characteristics quantitatively different from conventional 2D electron systems with parabolic spectrum. Since the magnetooscillations in the semiclassical density of states are anharmonic and are described by a quasi-continuum of cyclotron frequencies, both the ac Shubnikov-de Haas oscillations and the quantum corrections to $\sigma(\omega)$ that survive to higher temperatures manifest a slow beating on top of fast oscillations with the local energy-dependent cyclotron frequency. Correspondingly, both types of quantum oscillations possess nodes at characteristic frequencies. In the quantum regime of separated LLs, we study both the cyclotron-resonance transitions, which have a rich spectrum due to the nonequidistant spectrum of LLs, and the disorder-induced transitions violating the clean selection rules of graphene. The strongest disorder-induced transitions can be identified in recent magnetotransmission experiments [2]. We also compare the temperature- and chemical potential-dependence of $\sigma(\omega)$ in various frequency ranges: from the dc limit (allowing intra-LL transitions only) to the universal high-frequency limit (where the Landau quantization provides a small B-dependent correction to the universal value of the interband conductivity of the clean graphene).

The obtained results also form a basis for future studies of nonequilibrium magnetotransport phenomena [3] in graphene driven by strong ac and dc fields.

[1] U. Briskot, I. A. Dmitriev, and A. D. Mirlin, arXiv:1301.7246 (2013).
[2] M. Orlita, C. Faugeras, R. Grill, A. Wysmolek, W. Strupinski, C. Berger, W. A. de Heer, G. Martinez, and M. Potemski, Phys. Rev. Lett. 107, 216603 (2011).
[3] I.A. Dmitriev, A.D. Mirlin, D.G. Polyakov, and M.A. Zudov, Rev. Mod. Phys. 84, 1709–1763 (2012).