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Microscopic theory of plasmon-enabled resonant terahertz detection in bilayer graphene

The electron gas hosted in a two-dimensional solid-state matrix under external driving supports the propagation of plasma waves.[1] Nonlinear interactions between plasma waves generate a constant density gradient which can be detected as a dc potential signal at the boundaries of the system. This phenomenon is at the heart of a plasma-wave photodetection scheme which was first introduced by Dyakonov and Shur for electronic systems with a parabolic dispersion [2] and then extended to the massless Dirac fermions in graphene.[3] Motivated by a recent experimental breakthrough in the resonant detection of plasma waves in double-gated bilayer graphene, [4] we develop the theory of plasma-wave photodetection in such geometry, [5] where the dispersion relation depends locally and dynamically on the intensity of the plasma wave. We show that quantum capacitance effects, arising from the local fluctuations of the electronic dispersion, modify the intensity of the photodetection signal. An external electrical bias, e.g. induced by top and bottom gates, can be used to control the strength of the quantum capacitance corrections, and thus the photoresponse.

References

[1] A.N. Grigorenko, M. Polini, and K.S. Novoselov, Nature Photon. **6**, 749 (2012).
[2] M.I. Dyakonov and M.S. Shur, IEEE Trans. Electron Devices **43**, 380 (1996); *ibid.* **43**, 1640 (1996).
[3] A. Tomadin and M. Polini, Phys. Rev. B **88**, 205426 (2013).
[4] D.A. Bandurin et al., Nature Commun. **9**, 5392 (2018).
[5] A. Tomadin, M. Carrega, and M. Polini, arXiv:2012.11463.

Figures

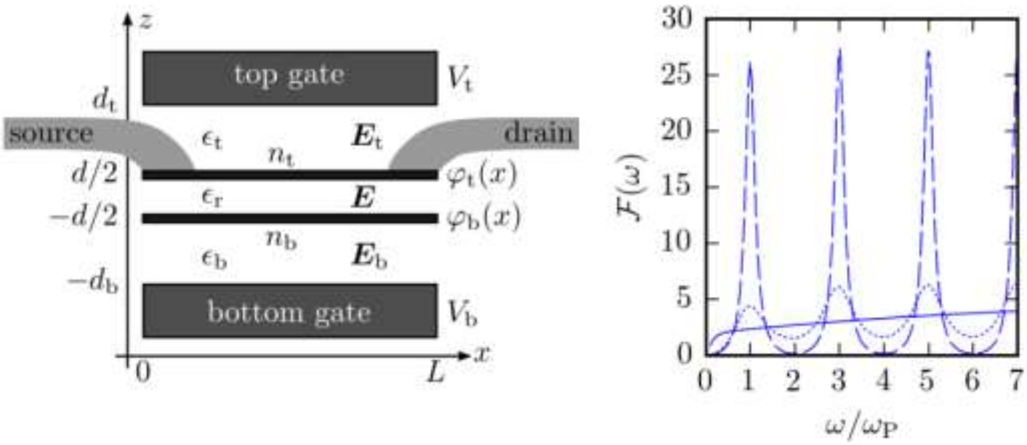

Figure 1: Schematics of the double-gated bilayer graphene setup (left) and photoresponse as a function of the driving frequency (right) for several carrier densities *n* = 0.1 (solid), 1.0 (dotted), and 5.0 (dashed) × 10^{12} cm^{-2}.