Towards graphene Plasmonics: electric dipole radiation in graphene

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While the electronic properties of graphene have recently been extensively studied [1], the photonic properties are much less known. In the present work, the interaction of a point electromagnetic emitter and a graphene sheet will be theoretically considered (see Fig. 1). This problem reduces to finding the Green's function corresponding to an electric dipole in graphene, which is fundamental for description of electromagnetic effects in graphene.

We describe the electromagnetic fields using Maxwell's equations, and the graphene is represented by a conductivity surface with the conductivity depending upon the temperature, chemical potential and frequency. Applying adequate mathematical techniques [2,3] we find an analytical representation of the electromagnetic propagator for the graphene sheet. We identify every term in the analytical solution and discuss its origin with respect to the peculiarities on the density of electromagnetic states. We find that an electric dipole can hardly couple to transverse electric surface modes, but at certain frequencies do strongly couples to transverse-magnetic ones (long-range surface plasmon-polariton modes) essentially increasing the amplitude of the field in the vicinity of the emitter. The field patterns are drastically different for different values of chemical potential and frequency ranges and orientations of the dipole.

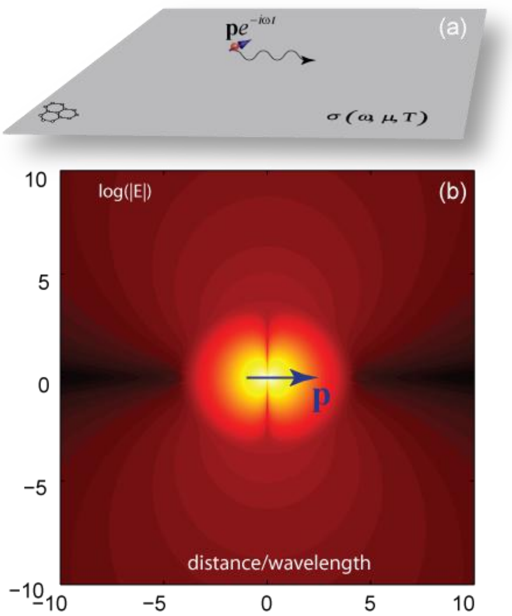

Figure 1. Schematic illustration of the system under study (a) and the distribution of the electric field modulus in the graphene plane (b) for T=300 K, μ=0.2 eV, ω=0.08 eV.

References

[1] A. H. Castro Neto, F. Guinea, N. M. R. Peres, K. S. Novoselov and A. K. Geim, Rev. Mod. Phys. 81, 109 (2009).
[2] L. P. Felsen and N. Marcuvitz, Radiation and Scattering of Waves (IEEE Press, Piscataway, NJ, 1994).
[3] A. Yu. Nikitin, F. J. García-Vidal, and L. Martín- Moreno, Phys. Rev. Lett. 105, 073902 (2010).