Electron polarization function and plasmons in metallic armchair graphene nanoribbons

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Abstract

Plasmons, i.e. collective charge density oscillations of free carriers, have attracted considerable fundamental and practical interest for several decades. Plasmons in graphene exhibit a number of extraordinary new features such as a high degree of optical field confinement and gate-tunability, which implies a great application potential. Particularly, achieving electric control of light is one of the key challenges to efficient plasmonics technology.

In this work [1] we calculate the polarization function of Dirac fermions in metallic armchair graphene nanoribbons for an arbitrary temperature and doping. The previous works on this system neglect either the intra-band contribution to the finite temperature polarization function [2] or the inter-band contribution to the zero temperature polarization function [3], [4]. Here we take into full account both the inter-band and intra-band parts of the polarization function for an arbitrary temperature and position of the chemical potential within the lowest subband of transverse quantization. We find that at finite temperatures due to the phase space redistribution among inter-band and intra-band electronic transitions in the conduction and valence bands, the full polarization function becomes independent of the temperature and the position of the chemical potential. As a result, for a given width of nanoribbons there exists a single plasmon mode, with the energy dispersion determined by the graphene's fine structure constant. In Coulomb-coupled nanoribbons, this plasmon splits into the basic in-phase and out-of-phase plasmon modes, with the splitting energy determined additionally by the inter-ribbon spacing.

References

[1] A. A. Shylau, S. M. Badalyan, F. M. Peeters, and A.-P. Jauho, arXiv:1501.02704 [cond-mat.mes-hall].
[2] L. Brey and H. A. Fertig, Phys. Rev. B **75**, (2007) 125434.
[3] C. E. P. Villegas, M. R. S. Tavares, G.-Q. Hai, and P. Vasilopoulos, Phys. Rev. B **88**, (2013) 165426.
[4] M. Bagheri and M. Bahrami, J. of Appl. Phys. **115**, (2014) 174301.

Figure

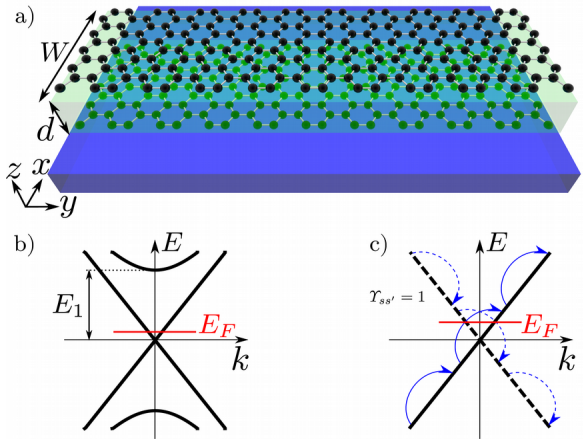

Figure 1:
a) Schematic representation of a metallic armchair graphene nanoribbon of the width *W* and the inter-ribbon spacing *d*. b) Single-electron energy spectrum of the metallic aGNR. Various inter-band and intra-band electronic transitions for a given bosonic momentum *q* at arbitrary temperature and chemical potential are depicted in c).