Plasmons and single-particle excitations in single and double coupled graphene stripes

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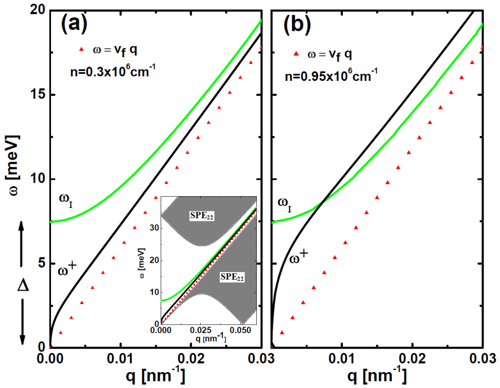

Fig. 1: The Plasmon modes for (a) $n=0.3x10^6$ cm^{-1} and (b) $n=0.95x10^6$ cm^{-1}. The inset shows the electron-hole continuum associated to the intrasubband transitions in the first excited state (hiperbolic relation dispersion).

The graphene electronic properties are unusual and arise as a direct consequence of the linear low-energy dispersion relation at the corners of the Brillouin zone, so that the low-lying excitations can be studied through the 2D Dirac Hamiltonian within a reliable approximation. The development of new experimental techniques, regarding control in growth and fabrication of nanostructures, have led to the design of new promising devices with potential applications in electronics, optoelectronics and photovoltaics. Nevertheless, despite the breakthroughs reached, further detailed studies concerning the single-particle excitations and plasmons in graphene-based nanostructures are required.

In this sense, we theoretically study the single-particle (SP) and collective excitations (plasmons) of Dirac Fermions confined in single and *double parallel nanostructures* formed by applying electric-magnetic barriers and also through patterning the graphene edges. We discuss the effects of the variation of controlled parameters, such as: i) induced gap; ii) barrier high and iii) width; and iv) doping, might have on the electronic properties of the system. Concerning the SP excitations, our results indicate that the character of the bound states is highly sensitive to the substrate induced gap. We also show that, through an adiabatic variation of the barrier intensity and nanostructure width, one might be able to control the current flux along the nanostructure. In addition, we study the plasmon modes of *double coupled* metallic armchair graphene nanoribbons (AGNRs) separated by distance L_b. For a single metallic AGNRs, we further show the plasmon dispersion dependence with the Fermi wavevector. Furthermore, we study the static dielectric function and found the absence of the logarithmic divergence at $q=2k_F$, which clearly suggests that plasmons in metallic AGNRs might be the most robust charge density oscillations occurring in quasi-one-dimensional electron systems. We also study the influence of L_b as well as the carrier densities over the acoustical and optical plasmon modes when double stripes are considered. Finally we address the dynamical screening properties of Fermion gas by considering a Fermi energy which fill out up to the second allowed state in the conduction band. We also found novel and interesting phenomena related to the Landau damped regions. Such effects arise as a direct consequence of the interaction of the linear dispersion (first state) with the hyperbolic dispersion (second state). Moreover, we found a strong influence of doping over the in-phase plasmon mode, whereas the out-phase plasmon mode remains robust, as shown in Fig.1.

[1] Marcos R.S. Tavares and Cesar E.P. Villegas, to be published.
[2] C.E.P. Villegas and M.R.S. Tavares, Appl. Phys. Letters, **101**, p. 163104, (2012); C. E. P. Villegas, and M. R. S. Tavares, et al., New J.Phys. **15** 023015 (2013).