Plasmonics in Graphene Nanoribbons

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Graphene is a material that has undergone intense study in over the past several years [1,2]. The novel, Dirac-like linear bandstructure near the K points in the Brillioun zone gives rise to a variety of unique phenomena that may have wide applicability in various areas of electronic and optical technology. Specifically, studies of plasmon propagation in graphene and related material have shown that the plasmon dispersion relation persists to very small energies and long wavelengths [3], in distinct contrast to plasmonic propagation in other two-dimensional structures, *e.g.* the metal/dielectric interface [4]. Further, graphene plasmons can exhibit low-loss propagation due to the absence of absorption in the metallic half-space [5].

Recently, the bandstructure of quasi-one-dimensional graphene nanoribbons has been investigated as well [6]. Transverse confinement of the electronic wavefunctions in the nanoribbon causes the bandstructure to split, giving rise to many more bands. This richer electron spectrum modifies the plasmonic dispersion. The new plasmon dispersion characteristics are where we focus our attention now.

In this paper, we discuss our recent calculations of the dielectric function and plasmon dispersion in armchair graphene nanoribbons. Using a 2N-band p_z tight-binding model, where N is the width in atoms of the nanoribbon, we calculate the dielectric function in the Lindhard [7] (random phase) approximation. Details of the plasmon dispersion are then obtained by examining the behavior of the inverse of the dielectric function following the method of Ref. [5].

Several interesting phenomena are observed in armchair nanoribbons of small-integer widths. In particular, for the semimetallic armchair nanoribbons, we find a linear plasmon dispersion for values of the plasmon energy below the onset of the second band absorption threshold. The group velocity for this plasmon is equal to the Fermi velocity in two-dimensional graphene. The dispersion relation calculated for plasmons in N = 8 armchair (acGNR8) nanoribbons is shown in Fig. 1. Semiconducting nanoribbons (*e.g.* acGNR9,10) are found to exhibit near-parabolic plasmon dispersion in the low-energy limit.

The small group velocity of these plasmons, coupled with their localization in the direction normal to the graphene layer suggest the possibility that they may be suitable for inter-device communication in integrated circuit applications.

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References

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Figure

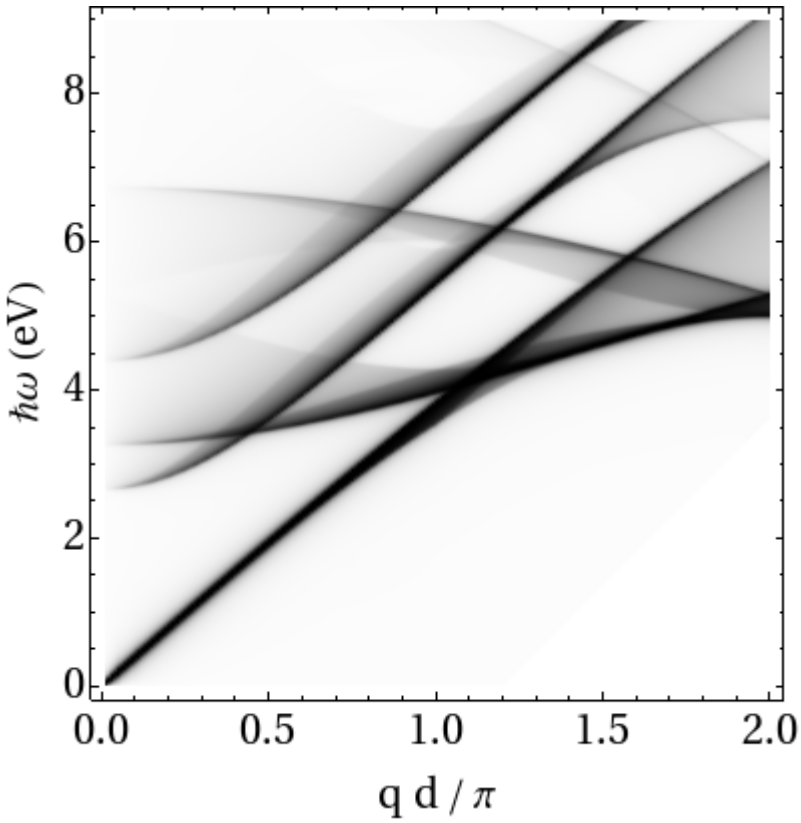

Fig. 1. Plasmon dispersion relation for intrinsic acGNR8 graphene nanoribbon. A linear dispersion characteristic is observed for plasmon energies below ~ 2.6 eV. Above this value, interband scattering of electrons introduces losses into the plasmon propagation, resulting in broadening of the additional branches in the dispersion curve.