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Surface plasmons in a massless Dirac plasma

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The propagation of surface (electrostatic or electromagnetic) waves in conducting solids or plasmas has been a topic of important research over the last many years [1-3]. Because of the peculiar features, and amazing electronic and optical properties of graphene, the exciattion of plasmons in graphene has attracted a huge interest in recent years owing to their applications in optics, electronics, metamaterials, light harvesting, energy storage, THz technology etc. [4-9]. The dense honeycomb arrangements of carbon atoms with photon-like massless energy relation have made it possible for the charge carriers in graphene to mimic both relativistic and quantum effects at the same time. Such massless electrons can move with an effective Fermi speed of about 10^6 m/s, which is independent of the carrier number density.

We investigate the collective excitation of surface plasmons in a massless Dirac plasma half-space (bounded by air) using a relativistic quantum fluid model [5-7]. The unique features of such surface waves are discussed and compared with those in a Fermi plasma. It is found that in contrast to Fermi plasmas, the long-wavelength surface plasmon frequency in massless Dirac plasmas is explicitly nonclassical. Besides some apparent similarities between the surface plasmon frequencies in massless Dirac plasmas and Fermi plasmas, several notable differences are also found and discussed.

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