Collective modes and screened interactions in double layers of massless Dirac fermions

Tohid Farajollahpour[1, 2]
Andrea Secchi[3], Iacopo Torre[4], Frank H.L. Koppens[4, 5] and Marco Polini[2, 4, 1]
1) Istituto Italiano di Tecnologia, graphene Labs, Via Morego 30, I-16163 Genova, Italy
2) Dipartimento di Fisica dell'Università di Pisa, Largo Bruno Pontecorvo 3, I-56127 Pisa, Italy
3) Centro S3, CNR - Istituto di Nanoscienze, via G. Campi 213/A, I-41125 Modena, Italy
4) ICFO-Institut de Ciències Fotòniques, The Barcelona Institute of Science and Technology, Av. Carl Friedrich Gauss 3, 08860 Castelldefels (Barcelona), Spain
5) ICREA-Institució Catalana de Recerca i Estudis Avançats, Passeig Lluís Companys 23, 08010 Barcelona, Spain
Tohid@iit.it
Marco.Polini@unipi.it

We present a detailed theoretical study of collective modes and screened interactions in double layers of massless Dirac fermions with tunable Fermi velocities. By fixing the Fermi velocity of the carriers of one of the two layers to a reference value, we study the dependence of all the relevant response functions and their poles on the ratio between the Fermi velocity of the other layer and the reference value. We employ the random phase approximation to obtain all our results, finding in particular a compact analytical expression for the acoustic plasmon group velocity. We compare analytical results with numerical results for the loss function, finding excellent agreement. We also quantify the damping rate of acoustic modes, highlighting the role of a "pseudo gap" phase in which the acoustic plasmon lies inside the electron-hole continuum of the faster fermions, and outside the electron-hole continuum of the slow fermions. We finally illustrate the role of the acoustic plasmon in altering effective electron-electron interactions. We hope that this theoretical study will stimulate the experimental search of acoustic plasmons in systems of "slow" Dirac fermions, such as those that are hosted by twisted bilayer graphene.

Figure

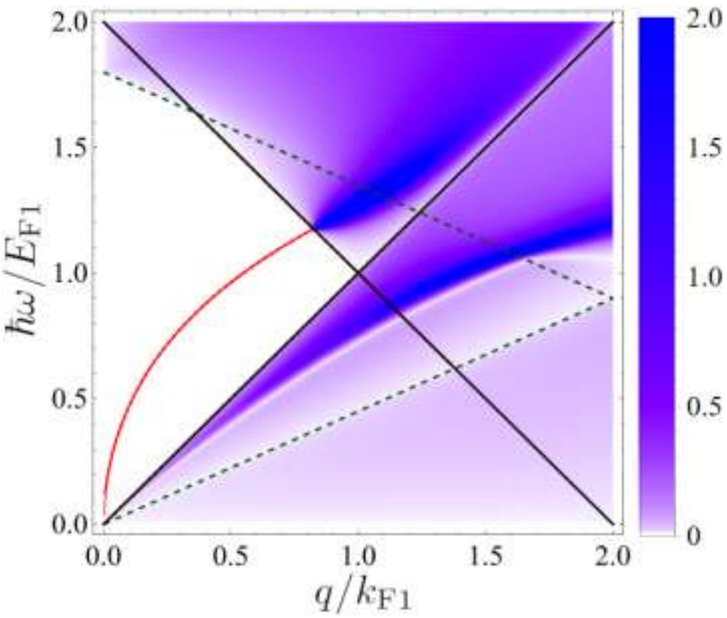

Figure 1: Optical and acoustic plasmon dispersions as functions of wave vector in a double layer system of graphene encapsulated by hexagonal Boron Nitride. The black solid lines illustrate the regions of reference layer while dashed dark green lines display the regions related to slow fermions. The acoustic plasmon lies inside the electron-hole continuum of the faster fermions, and outside the electron-hole continuum of the slow fermions.

References

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