Effects of disorder on vacuum interactions on graphene.

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Abstract:

Dispersive forces are interactions between neutral, but polarizable objects, and have their origin in fluctuations of the vacuum electromagnetic field. The Casimir–Polder force involves interactions between a macroscopic object and a microscopic particle. Recent advances in the understanding of dispersive interactions involving low-dimensional systems have shown the importance of a detailed characterization the electrical response for the control and tailoring of dispersive forces.

In this work, the Casimir-Polder interaction energy between a rubidium atom and a disordered graphene sheet is investigated beyond the Dirac cone approximation [1]. A large graphene sheet is modelled by a tight-binding model of π-electrons on a honeycomb lattice with a small concentration of vacancies, as illustrated in Figure 1. To determine the Fermi energy dependence of its optical conductivity, we employ an accurate largescale quantum transport approach based on an exact polynomial representation of disordered Green functions [2]. This information is then used to compute the Casimir–Polder force between a defected graphene sheet and an atom in function of the charge doping, and compare it with the force calculated using the Drude model. Far from the Dirac point, the Casimir–Polder force varies linearly with the chemical potential. The Drude model is found in accord with numerical calculations in that regime, as expected, but fails to capture the behavior of the Casimir–Polder force close to the Dirac point. Furthermore, we find that the strength of the interaction is reduced in the vicinity of the Dirac point, following the trend of the dc conductivity and increases again above a certain Fermi energy scale, in contrast with the monotonic enhancement of interactions predicted by calculations based on perfect graphene models (see Figure 2)
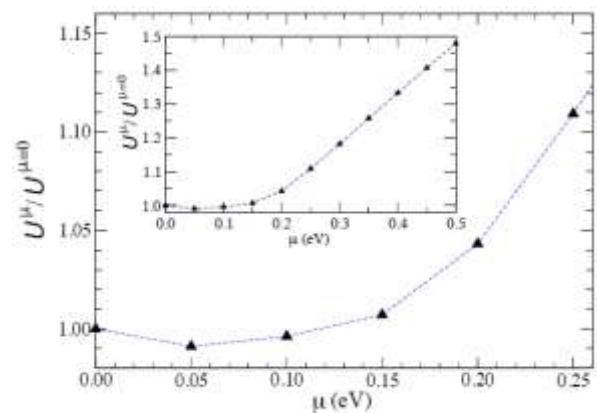
References

[1] T. P. Cysne, T. G. Rappoport, Aires Ferreira, J. M. Viana Parente Lopes, and N. M. R. Peres Phys. Rev. B **94**, 235405 (2016)

[2] N. Leconte, A. Ferreira, and J. Jung, 2D Materials, Elsevier, Vol. **95**, 35 (2016).

Figures
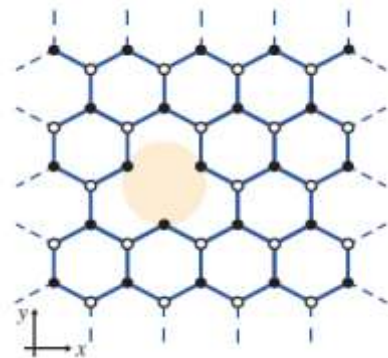
Figure 1: Model for defected graphene (vacancy).

Figure 2: Behaviour of Casimir-Polder interaction between a graphene sheet and a rubidium atom with chemical potential.