Graphene plasmons and quantum emitters: from plasmon blockade to temporal control

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Among the many extraordinary properties of graphene, its optical response allows one to easily tune its interaction with nearby molecules via electrostatic doping. The large confinement displayed by plasmons in graphene nanodisks makes it possible to reach the strong-coupling regime with a nearby quantum emitter, such as a quantum dot or a molecule. In this limit, the quantum emitter can introduce a significant plasmon-plasmon interaction, which gives rise to a plasmon blockade effect. This produces, in turn, strongly nonlinear absorption and modified statistics of the bosonic plasmon mode. In the first part of this work [1], we characterize these phenomena by studying the optical absorption cross section and he equal-time second-order correlation function $g^{(2)}(0)$, which plunges below a value of 1, thus revealing the existence of nonclassical plasmon states.

The plasmon-emitter coupling can be efficiently controlled by tuning the doping level of the graphene nanodisks. Therefore, the time modulation of the doping opens the possibility of achieving full temporal control of the quantum emitter dynamics. In the second part of this work [2] we explore such possibility, analyzing the temporal evolution of a single quantum emitter placed in the vicinity of a graphene nanodisk, under different doping profiles. We also demonstrate theoretically the possibility of temporal controlling the coupling of two quantum emitters mediated by the graphene plasmons.

The proposed systems based on graphene nanostructures emerge as a new promising platform to realize quantum plasmonic devices [3] capable of commuting optical signals at the single-photon/plasmon level with full temporal control.

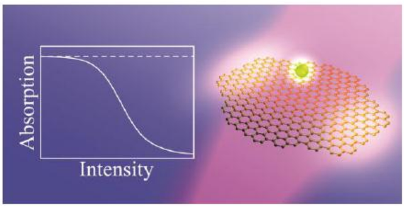
References

[1] A. Manjavacas, P. Nordlander, and F. J. García de Abajo, ACS Nano. 6, (2012) 1724.

[2] A. Manjavacas, F. J. García de Abajo, and P. Nordlander, Nano Lett. 11, (2011) 2318.

[3] A. Manjavacas, S Thongrattanasiri, D E Chang, and F. J. García de Abajo, arXiv:1207.5903, (2012).

(a)



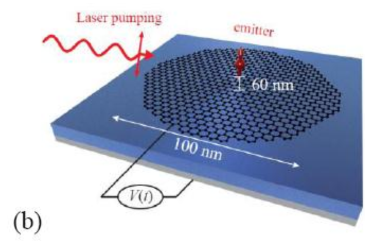


Figure 1: (a) Artistic view of the system under study composed of a quantum emitter placed near a graphene nanodisk, and plot of the absorption cross section as a function of the illumination intensity showing the non-linear optical response of the system. (b) Schematic view of the system considered to study the temporal control of a quantum emitter.