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Waveguide QED quantum computing with graphene nanoribbon plasmons

Abstract

The study of surface plasmons – confined electromagnetic modes supported by collective oscillations of surface charge in a metal – has emerged over the last 20 years as the field of plasmonics. It is expected that plasmonics can have applications in intra-communication and in the development of bio and chemical sensors. In more recent years, graphene has emerged as a new platform for plasmonics in the terahertz to the mid-infrared frequency region [1]. Graphene is an ideal platform for plasmonics due to its reduced losses and the possibility of tuning the plasmon dispersion relation via doping. Due to the strong confinement of the electric field, plasmons will strongly interact with nearby fluorophores, such as quantum dots, which can lead to an increased decay rate of the fluorophore – superradiance [2]. Surface plasmons can also mediate strong interactions between two fluorophores, which lead to both energy exchange and assisted dissipation. This leads to the establishment of entanglement between the two fluorophores, which can lead to the reduction of the dissipation – subradiance [3]. If the plasmons are supported in 1 dimensional channels, then the mediated interaction will not decay over distance, and dissipation for some of the entangled states will be nearly zero. The entangled states with nearly zero decay rate form a decoherence free subspace (DFS) which can be used as a logic space for quantum computing. Recently, emergent DFS's in quantum dots coupled to 1D plasmonic waveguides (waveguide QED) wave been proposed as a platform for universal quantum computing [4]. In this work, we explore the possibility of using graphene nanoribbons as a basis for waveguide QED quantum computing.

References

[1] P. A. D. Gonçalves and N. M. R. Peres, "An Introduction to Graphene Plasmonics" (2016) World Scientific

[2] P. A. Huidobro et al, PRB, 85 (2012) 155438

[3] A. Gonzalez-Tudela et al, PRL, 106 (2011) 020501

[4] V. Paulisch et al, New Journal of Physics, 18 (2016) 043041

Figures

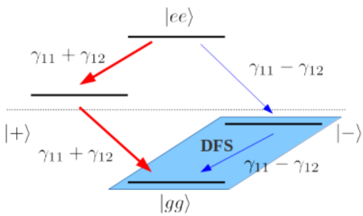

Figure 1: Energy diagram of 2 two-level quantum dots coupled via plasmons. γ11 and γ12 are, respectively, the decay rates of an isolated quantum dot and the decay rate assisted by the other quantum dot. If made equal, the ground state and the entangled antisymmetric superposition of excited and ground states become long lived states forming a DFS.

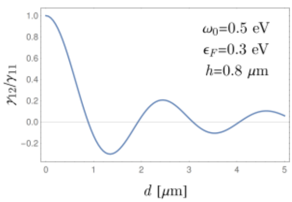

Figure 2: Isolated and assisted decay rate ratio for two quantum dots close to an infinite graphene layer.