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Strong coupling of exciton in organic material and plasmonic WGM localized on the surface of silver nanoparticles

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The current research explores the interaction between plasmonic whispering gallery modes (WGM) on silver nanospheres' surfaces and an exciton in the surrounding organic medium. The study aims to explore the potential for achieving strong coupling between plasmon modes localized on spherical metal particles' surfaces and an exciton in an organic material. Considering a microsphere of radius r_0 with permittivity ε_1 surrounded by a medium with permittivity ε_2, matching the tangential field components at the media interface results in an equation for eigenmodes. The interaction between the obtained plasmon modes and excitons in the organic material is described by a Hamiltonian, which involves exciton and plasmon creation and annihilation operators and coupling between plasmon and exciton. The study takes into account that the organic exciton will interact with several plasmon modes.

Silver was chosen as the material for spherical metal particles in this study, with its refractive index described by the Drude model that takes plasma oscillations of electrons into account. For the organic material, DPAVBi (4, 4′-bis[4-(di-p-tolylamino)styryl]biphenyl) [1] was used due to its high oscillator strength. The investigation involved solving the problem for different metal particle radii, which resulted in obtaining a collection of WGMs for each radius considered. Field distribution demonstrate that the fields focus on the metal surface, suggesting potential for a strong interaction. Two special modes appear at the energy edges, where the dissipation tends towards that of the exciton mode, indicating an increase in exciton contribution to the polariton mode. This phenomenon is consistent with previous observations [2] and suggests that polariton modes with a larger exciton contribution produce more intense radiation, hence the potential for strong coupling. Spectra resulting from the interaction of an "absorbing" exciton in DPAVBi with plasmon modes localized on the metal sphere were calculated for various radii (Fig. 1). For larger radii, the Rabi splitting increases, and two main peaks appear. It was observed that as the radius increases, the intensity of the emitted radiation decreases, imposing constraints on finding the optimal sphere radius that provides both sufficient radiation intensity and a large Rabi splitting.

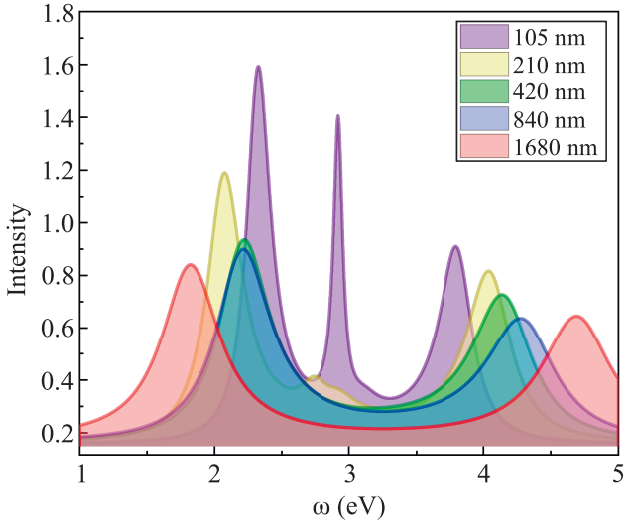

Fig. 1. (Color online) Theoretical spectra formed as a result of the interaction of the "absorbing" exciton mode in the organic material DPAVBi and plasmon modes formed on the surface of a silver spheres of different diameters

Thus, for sufficiently large radii of metallic spheres, the dense spectrum of surface plasmon modes can effectively interact with excitons in the organic material surrounding the sphere. This can result in significant modification of both absorption and radiation characteristics of the system. These observations highlight the

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potential of such hybrid systems for a range of applications in optoelectronics and photonics.

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