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Sequential coupling in plasmon–exciton–plasmon ternary nanoparticles

A Alemahmud ardehaei, E Yaghooti, and F Babaei,

Department of Physics, Faculty of Science,University of Qom

E-mail: a.alemahmud@stu.qom.ac.ir

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Abstract
In this study, the optical response of plasmon–exciton–plasmon (PEP) hybrid structures was investigated using the finite-difference time-domain (FDTD) simulation method. The structures were composed of disk-shaped metallic nanoparticles made of silver and gold, combined with molecular excitons originating from J-aggregated cyanine dyes. As an initial step, the extinction spectra of the individual metallic components and dye molecules were analyzed separately to identify the intrinsic resonance characteristics of each component. Subsequently, the influence of structural parameter variations on the coupling strength between the constituents was evaluated. The resulting spectra exhibited three distinct hybrid branches, namely the lower (L), middle (M), and upper (U) branches, indicating the interaction between the fundamental plasmonic and excitonic modes. By tracking the variations in detuning frequency, the coupling pathways between the plasmonic and excitonic resonances were identified.The results clearly demonstrate the pivotal role of nanoparticle size and detuning in Rabi splitting and the anti-crossing behavior of the hybrid modes. This study provides a comprehensive framework for spectral engineering of PEP hybrid structures and highlights their high potential for developing advanced nanophotonic devices and PEP-based biosensors.

Keywords: Plasmon, Excitons, Plexcimon, Sequential coupling, Rabi splitting.

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