Excited quantum coherence: From plasmonically induced transparency to quantum correlation

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Spectroscopy of materials can be enhanced by the quantum coherent effects [1,2]. Quantum coherent effects are demonstrated to have an all-optical control, on ultrafast time scales, over the photonic topological transition [3]. Localized plasmon interaction in quantum confined structures strongly modify the optical and electronic properties with potential for manipulating light on the nanoscale [4]. Transient pump-probe spectroscopy demonstrate that the coherent absorption in quantum dots is modified by phonon-assisted plasmon induced transparency. A theoretical model has been developed to quantitatively demonstrate that the dark states can be still formed at ultrashort time scale corresponding to the dephasing time of the carriers in the quantum dots. The demonstrated results are important for developing new sensors based on high nonlinearities and their applications to optoelectronic devices. Another approach to demonstrate quantum coherent and cooperative effects is to study the Bi-exponential decay of dye fluorescence near the surface of plasmonic metamaterials and core-shell nanoparticles that has been shown to be an intrinsic property of the coupled system [5]. Our theory shows that the relaxation leads to the population of the sub-radiant states by dephasing the super-radiant Dicke states giving rise to the bi-exponential decay in agreement with the experiments. We use a set of metamaterial samples consisting of gratings of paired silver nanostrips coated with Rh800 dye molecules, having resonances in the same spectral range. We have demonstrated the spectroscopy of nanomaterials and metamaterials, where the quantum coherent effects are able to have an all-optical control, on ultrafast time scales, over the photonic topological transition, for applications as varied as quantum sensing, quantum information processing, and quantum simulations using metamaterials.

[1] Nikolai G Kalugin, Yuri Rostovtsev, Journal of Nanoelectronics and Optoelectronics, 2009, 4, 302-306.

[2] Suman Dhayal, Yuri Rostovtsev, Physical Review A, 2016, 93, 043405.

[3] Meg Mahat, et al., ACS Photonics, 2017, 5, 614-62.

[4] Pankaj K Jha, et al., Physical Review Letters, 2016, 116, 165502.

[5] David P Lyvers, et al., Journal Scientific Reports, 2018, 8, 9508.