Quantum theory of the plasmon enhanced Raman scattering effect in hybrid nanotube systems

Igor Bondarev

North Carolina Central University

Contact e-mail: *ibondarev@nccu.edu*

The quantum theory of resonance Raman scattering is developed for a dipole emitter, the two-level system (TLS), coupled to an interband plasmon resonance of a carbon nanotube (CN) [1]. The model used belongs to a broad class of driven four-level quantum systems [2], with an important distinction that instead of being driven by an external periodic field, scattering by the interacting TLS-CN system is controlled by plasmon-induced quasi-static electric fields in the CN near-surface zone. The analytical expression obtained for the Raman cross-section covers both weak and strong TLS-plasmon coupling, and shows a dramatic enhancement due to the formation of hybridized (dressed) states when two subsystems, the TLS and the CN, enter the strong coupling regime. The theory applies to atomic type species such as atoms, ions, molecules, or semiconductor quantum dots that are physisorbed on the nanotube walls. The model provides a unified description of the near-field plasmon enhancement effects, and can be used in designing nanotube based electromagnetic sensing substrates for single atom detection, precision spontaneous emission control, and manipulation.

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[1] I.V.Bondarev, Optics Express 23, 3971 (2015).
[2] V.Delgado & J.M.Gomez Llorente, PRA 68, 022503 (2003).