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Broadband Optical Plasmonic Antennas Using Fano Resonance Effects

Authors : Siamak Dawazdah Emami, Amin Khodaei, Harith Bin Ahmad, Hairul A. Adbul-Rashid

Abstract : The Fano resonance effect on plasmonic nanoparticle materials results in such materials possessing a number of unique optical properties, and the potential applicability for sensing, nonlinear devices and slow-light devices. A Fano resonance is a consequence of coherent interference between superradiant and subradiant hybridized plasmon modes. Incident light on subradiant modes will initiate excitation that results in superradiant modes, and these superradient modes possess zero or finite dipole moments alongside a comparable negligible coupling with light. This research work details the derivation of an electrodynamics coupling model for the interaction of dipolar transitions and radiation via plasmonic nanoclusters such as quadrimers, pentamers and heptamers. The directivity calculation is analyzed in order to qualify the redirection of emission. The geometry of a configured array of nanostructures strongly influenced the transmission and reflection properties, which subsequently resulted in the directivity of each antenna being related to the nanosphere size and gap distances between the nanospheres in each model's structure. A well-separated configuration of nanospheres resulted in the structure behaving similarly to monomers, with spectra peaks of a broad superradiant mode being centered within the vicinity of 560 nm wavelength. Reducing the distance between ring nanospheres in pentamers and heptamers to 20~60 nm caused the coupling factor and charge distributions to increase and invoke a subradiant mode centered within the vicinity of 690 nm. Increasing the outside ring's nanosphere distance from the centered nanospheres caused the coupling factor to decrease, with the coupling factor being inversely proportional to cubic of the distance between nanospheres. This phenomenon led to a dramatic decrease of the superradiant mode at a 200 nm distance between the central nanosphere and outer rings. Effects from a superradiant mode vanished beyond a 240 nm distance between central and outer ring nanospheres.

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