Fano resonances and the fluorescence enhancement of a dipole emitter near a plasmonic nanoshell

Tiago José Arruda, John Weiner, Philippe Wilhelm Courteille
Instituto de Física de São Carlos - Universidade de São Paulo - Brasil

Romain Bachelard
Departamento de Física - Universidade Federal de São Carlos - Brasil

Sebastian Slama
Eberhard Karls Universität Tübingen - Alemanha

We analytically study the spontaneous emission of a single dipole emitter in the vicinity of a plasmonic nanoshell in the framework of classical electrodynamics. We show that the fluorescence enhancement due to the coupling between optical emitter and sphere can be tuned by the shell thickness of the core-shell nanosphere and by the distance between the quantum emitter and its surface. In particular, we demonstrate that both the enhancement and quenching of the fluorescence response are associated with plasmonic Fano resonances induced by near- and far-field interactions. These Fano-like resonances have asymmetry parameters whose signs depend on the orientation of the dipole with respect to the spherical nanoshell. This effect is explained by the different role played by the induced electric dipole moment in the plasmonic nanoshell for both atomic dipole orientations. We also show that if the atomic dipole is oriented tangentially to the plasmonic nanoshell, the interaction exhibits saddle points in the near-field energy flow. This results in a Lorentzian luminescence response in the near field and a Fano lineshape in the far field. The signatures of this interaction may have interesting applications for sensing the presence and the orientation of optical dipole emitters in close proximity to plasmonic nanoshells.