Studying dipole moment modification in a single fluorescent dye beside metallic Nano-Particle based on the Green's function theory

Faezeh Tork Ladani, Caner Guclu, Salvatore Campione, Filippo Capolino*
Department of Electrical Engineering and Computer Science,
University of California Irvine, CA, 92697, USA
http://capolino.eng.uci.edu

Enhancement of dipolar scattering can be achieved by locating the emitting dipole near a resonant nanosphere. In this study the dipole represents a fluorescent dye or an emitting quantum dot, and the nanosphere exhibits a plasmonic resonance at optical frequencies. It has been shown several times that a dipole excitation and emission can be greatly affected by the presence of a nanosphere at nanomener distance. This was considered for example in (J. Gersten, A. Nitzan, J. Chem. Phys. 73(7), 1980) in the case of Raman scattering, and in many other experimental works.

In this paper, we investigate the emission of a fluorescent dye analytically, using the electric dyadic Green's function in a semiclassical electrodynamic model accounting for the nanosphere scattering, which is evaluated according to Mie theory. The dye is modeled as a dipole, illuminated by an incident wave and the one from the nearby nanosphere. We compare our results with previous ones, based on different approximations. More specifically, assuming the dipolar dye is located beside the NP, we analyze when the latter, in turn, modifies the dye dipole moment since the dye has a certain polarizability and hence responds to the local electric field. We report when this contribution is important for the determination of the dye emission rate and scattering. We use the Lorentzian oscillator model for calculating the polarizability of the dye and investigate excitation rate enhancements in various cases. As results show when the polarizability of the dye becomes comparable to that of the plasmonic nanosphere we have to consider the change in the dipole moment of the dye, as in our electrocynamic model.