Effects of Dipolar Scatterer Orientation beside a Plasmonic Nanosphere in Excitation Rate Enhancement

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Light scattering by plasmonic nanoparticles for enhancing the optical interactions, such as absorption, fluorescence, and Raman scattering have been under fervent study from different aspects. However, the scattering mechanism of a dipolar scatterer (DS) like a dye molecule or a quantum dot in the excitation regime is almost neglected in previous work for being very small. Stressing that scattering though small cannot be neglected in a system involving coupled components, we consider this mechanism in excitation rate evaluation of a generally oriented DS beside a plasmonic nanosphere (PN). In particular, we compare the two cases of radially and tangentially oriented DSs with respect to the surface of the PN. In this regard, the DS is assumed to express the polarizability only along its main axis, thus the induced dipole moment orientation is constant for a given DS with fix orientation (i.e. not rotating in the host medium). Furthermore, the polarizability of the DS is assumed to have a Lorentzian shape versus frequency.

Applying a semi classical model using the dyadic Green's function formalism, we have shown that in the case of a radially oriented DS, located in the hot spot of a PN, there are specific critical conditions under which this scattering process may result in very large field enhancement through a constructive coupling of the DS to itself via the PN (self-coupling). We investigate the self-coupling for a tangentially oriented DS and discuss the conditions under which such DS can be effectively excited. This strong excitation which is accompanied by a high scattering of the DS might be useful as a new feature for imaging and spectroscopy at the excitation wavelength for the tangentially oriented DS.