Controlling fluorescence resonant energy transfer with a magneto-optical nanoantenna

R. Vincent and R. Carminati
Institut Langevin, ESPCI ParisTech, CNRS, 10 rue Vauquelin, 75231 Paris Cedex 05, France

Energy transfer between a molecule in an excited state (donor) and a molecule in the ground state (acceptor) underlies many significant photophysical and photochemical processes, from photosynthesis to fluorescence probing of biological systems. Depending on the separation between the donor (D) and the acceptor (A), the process can be described accurately by various theories accounting for the electromagnetic interaction between the two species. For a D-A distance range on the order of 2-10 nm, which is relevant for photochemical studies and nanophotonics, the well established Förster theory [1] based on quasi-static dipole-dipole interaction has been very successful. It shows that while Förster Resonant Energy Transfer (FRET) is a very useful process which can be used, for example, as a ruler for spectroscopic measurements [2], it is a rather weak process which goes down as the inverse sixth power R^6 of the D-A separation [3].

In the present work, we use an established general framework for dipole-dipole energy transfer between an emitter and an absorber in a nanostructured environment [4]. The theory allows us to address FRET between a donor and an acceptor in the presence of a nanoparticle with an anisotropic electromagnetic response. Using Green function formalism [5], we show that the angular contribution, the distance behavior and the influence of the polarizability tensor of the nanoparticle can be identified and separated.

We also compare the contribution of the different non-radiative energy transfer channels: The direct (standard) Förster transfer and the energy transfer mediated by the nanoparticle. In this comparative study a new distance arise, in the spirit of the Förster radius, named polarization coupling radius Rp, which depends of the polarization properties of the nanoparticle.

We illustrate the formalism for the well known metallic nanoparticle, showing that this formalism could furnish insight in the understanding of the good quantities controlling this process and also for nanoparticle with anisotropic dielectric responses [6], e.g., nanoparticle made of a ferromagnetic material exhibiting a magneto-optical response. For which the degree of anisotropy can be controlled by an external static magnetic field. We discussed potential application for FRET tuning.

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