Plasmon assisted non-radiative energy transfer between two fluorescent emitters

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The Local Density of States (LDOS) is a quantity that drives the interaction between a fluorescent emitter and its environment at the nanometer scale. The LDOS counts the number of modes in which the fluorescent emitter can decay, either by emitting a fluorescent photon coupled to the far field (radiative modes), or by giving its energy to the environment (coupling to a dark mode or absorption losses) [1]. Depending on the targeted application (e.g. an efficient single photon source or an efficient absorber), it can be interesting to characterize and optimize the radiative and the non-radiative contributions to the local density of states separately. We have recently developed a novel method allowing to measure these two contributions of the local density of states [2]. The method, as it will be shown in this presentation, is based on the simultaneous mapping of the fluorescence intensity and decay rate of an emitter grafted on the apex of an AFM tip, brought in the near field of a plasmonic nanoantenna [3]. A rigorous confocal geometry allows us to apply the reciprocity theorem, on which the analytical calculation relies. The obtained experimental results are shown in Fig.1a-d, and are in a good quantitative agreement with numerical simulations.

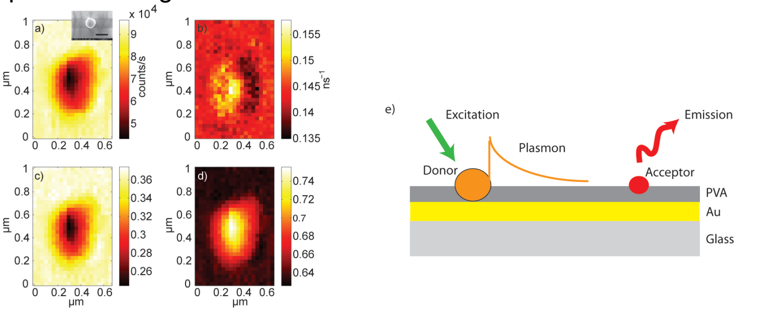

Figure 1: From a) to d): maps of the fluorescence intensity, total decay rate, radiative and non-radiative decay rate (normalised by the total decay rate map) of a fluorescent bead on the top of a gold disc (SEM image in the inset). e) Sample for the observation of long-range FRET.

The ability of mapping the radiative and non-radiative contributions to the LDOS, lays the foundations for study the influence of the environment on the interaction between two emitters. A particularly interesting phenomenon based on the non-radiative dipole-dipole coupling between two fluorescent emitters (called donor and acceptor) is the Förster Resonant Energy Transfer (FRET), which occurs over ranges of few nanometers. The influence of the environment on FRET efficiency and in particular to what extent the environment can be used to enhance both the efficiency and the range of the energy transfer, is still a question open to debate. In the second part of this talk, we will report on a first demonstration, recently achieved by our group [4], of FRET occurring between two fluorescent emitters located at a distance of several microns. This is achieved by using plasmons to transfer the energy from the donor to the acceptor. As depicted in Fig.1e, donors (fluorescent nanobeads) and acceptors (dye molecules) are dispersed on a metallic thin film. The donor, in the excited state, decays to the ground state by exciting a plasmon. The latter, after propagation, transfers its energy to the acceptor, which goes to the excited state and then decays by emitting a fluorescence photon, which is detected. This experiment paves the way for the study of the influence of the environment on the energy transfer and will have very interesting applications going from long-range quantum entanglement or strong coupling, to light harvesting and sensing.

References

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