POLIMA
Center for Polariton-driven Light-Matter Interactions

SDU
Mads Clausen Institute

PROJECT TITLE

Position-dependent molecular fluorescence in high-index dielectric clusters

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PROJECT DESCRIPTION

Single-molecule fluorescence enhancement or quenching opens tremendous possibilities for (bio)sensing, quantum optics, and telecommunications [1]. Bringing light-emitting atoms/molecules close to a structured photonic environment drastically affects their lifetimes, allowing to create templates that control when, and how fast photons can be emitted. In the past 20 years, the most explored template has been found in metallic nanoparticles (NPs), where free-electron oscillations (plasmons) create strong electromagnetic (EM) fields localised around the NP. Since the interaction of an emitter with EM radiation is proportional to the product of its dipole moment with the EM field it experiences, controlling that field allows to precisely tailor light–matter interactions.

While plasmonic systems are dominated by strong EM field enhancement, they are also accompanied by considerable Ohmic losses. At the same time, the response of a plasmonic NP to incident EM radiation usually creates a dipole aligned to the incident electric field, requiring a molecular dipole moment to be aligned to it as well. Recently, it was shown that high-index dielectric (HID) NPs, made e.g., from silicon, provide an efficient alternative, with lower field enhancement but also lower losses, while the field scattered by the NP has components in all directions, allowing for better coupling [2].

This project will build on Ref. [2] and theoretically explore optimal architectures, combining multiple Si NPs, for the better control and enhancement of molecular fluorescenec. The student will use an in-house Matlab numerical tool (OpenMUSTANC [3]) to explore different kinds of NP clusters interacting with point dipoles, in a quest for position-independent fluorescence enhancement.

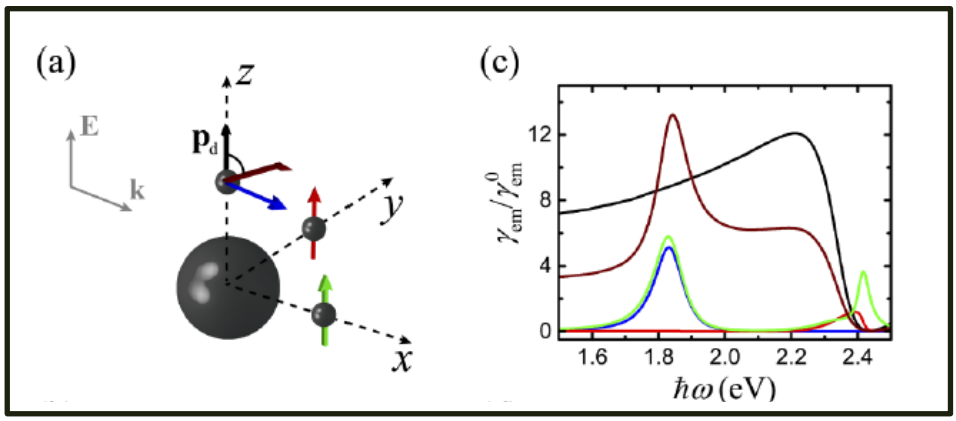


Figure 1: Fluorescence enhancement for a point dipole placed near a silicon sphere, at different dipole positions and orientations [2].

[1] P. Anger et al., *Enhancement and quenching of single-molecule fluorescence*, Phys. Rev. Lett. **96**, 113002 (2006).
[2] P. E. Stamatopoulou et al., *Role of emitter position and orientationon silicon nanoparticle-enhanced fluorescenec*, OSA Cont. **4**, 918 (2021).
[3] X. Zheng et al,, *OpenMUSTANC: a Matlab toolbox for the simulation of plasmonic sphere aggregates*, arXiv 2608.30565.