# Fluorescence enhancement for quantum emitters near a plasmonic nanoparticle

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Project Type: Bachelor, Semester project (or a combination or all)

Context: The interaction between light and matter stands as a fundamental and pivotal phenomenon in the natural world. In plasmonic systems, the coupling of surface plasmon polaritons with quantum emitters (e.g., semiconducting quantum dots, fluorescent molecules) is a notable instance. This coupling occurs when the emitter is positioned in close proximity to the plasmonic nanostructure, leading to significant effects including enhancement of fluorescence and Raman scattering. These effects demonstrate the profound impact of the nanostructure. The potential benefits extend to applications such as bio-sensors, light-emitting diodes and lasing, increasing the sensitivity and efficiency.

Project overview: To understand the effects arising due to light-matter interaction in these plasmonic systems, the underlying mechanisms should be explored. Under certain conditions, we adapt an electromagnetic approach to study the enhancement of fluorescence. The emitter is modelled as a classical dipole moment and placed in the vicinity of a plasmonic nanostructure. The near-field interaction results in the enhancement of the radiative decay rate of the emitter. We want to study the impact of different properties of the nanoparticle and emitter on this fluorescence enhancement.

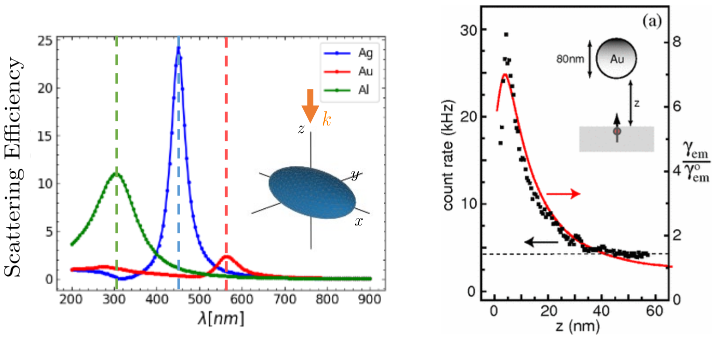


Figure. Left: The scattering efficiency of a plasmonic nanoparticle with an ellipsoid geometry for different materials, obtained from electromagnetic simulations. Right: Fluorescence rate as a function of the distance of the emitter from the nanoparticle. Adapted from [2].

What the student will do: The student will engage in activities related to the field of plasmonics, with emphasis on the theory and modelling of nanostructure-quantum emitter systems. The impact of the plasmonic nanostructure on the optical properties of the quantum emitter will be examined using electromagnetic simulations, and we wish to vary several parameters of the system such as the geometry and material of the nanoparticle. Furthermore, the study will involve placing specific optical species near the nanoparticle such as a fluorescent molecule (dye) or a semiconducting quantum dot. At the same time, the student will contribute to the development of a Python interface designed for conducting diverse simulations, and which it will be greatly beneficial in this study.

Benefits: The student will have the opportunity to employ electromagnetic theory in systems of interest using computational methods available in the lab, thereby enhancing their understanding and intuition in the subject. Moreover, valuable insights will be gained through hands-on experience in numerical simulations and Python programming, along with the chance for close collaboration with experiments.

References:

1. Kern A. et al, ACS Nano 2012, 6, 11, 9828–9836 (2012)
2. Anger P. et al, Phys. Rev. Lett. 96, 113002 (2006)
3. Kern A. et al, J. Opt. Soc. Am. A 26, 732-740 (2009)