1 Nanoparticles as Nanoscale Resonators

Consider a quantum emitter in proximity to a gold metal nanoparticle of radius 40 nm with dielectric constant $\epsilon_{NP} = -5.9311 + i2.0970$ surrounded by air ($\epsilon_1 = 1$). The wavelength of the emitted photons is 550 nm.

- Calculate the modification of the spontaneous emission rate for the quantum emitter as a function of distance from the nanoparticle and of the dipole orientation in the quasistatic approximation.
- When a photon is emitted, estimate the probability that the photon is radiated to the far field (external quantum efficiency) as a function of distance from the nanoparticle and of the dipole orientation.

2 Nanoparticles as Nanoantennas

Consider a Hertzian dipole in proximity to a gold metal nanoparticle of radius 40 nm with dielectric constant $\epsilon_{NP} = -9.3875 + i1.5292$ surrounded by air ($\epsilon_1 = 1$). The Hertzian dipole radiates at a wavelength of 600 nm.

- Calculate the modification of the radiation pattern by the metal nanoparticle as a function of distance and dipole orientation using the dipole approximation.
- Conceive an optical antenna made of gold nanoparticles that can direct radiation into a preferential direction (optical Yagi-Uda antenna). Use the dipole approximation.