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M2 Quantum, Light, Matter, Nanosciences

Fundamentals of Nanophotonics - Tutorial 3

Spontaneous Emission engineering

Rabi oscillations of a molecule coupled to a plasmonic nanoantenna

Rabi oscillation of a molecule with a nanoantenna. In this exercise, we aim to derive a condition for observing the Rabi oscillation regime for a molecule coupled to a plasmonic cavity. A necessary condition is $2g > \kappa$. We estimate $\hbar g = dE$ using

$$E = \sqrt{\frac{\hbar\omega}{2\varepsilon_0\varepsilon_r V}}$$

and we introduce the oscillator strength f using $d^2 = f\frac{\hbar e^2}{2m\omega}$. Show that

$$\frac{2g}{\kappa} = Q\sqrt{f\frac{\lambda^3}{V}}\sqrt{\frac{r_e}{\pi\epsilon_r\lambda}}$$

, where $r_e = \frac{e^2}{4\pi\epsilon_0 mc^2}$ is the classical electron radius. Show that for $\lambda = 600\,\mathrm{nm}$, a Q-factor on the order of 10, a volume of $30\mathrm{nm}^3$ and a permittivity of 2, the strong coupling condition is satisfied.