Electromagnetically Induced Transparency (EIT)

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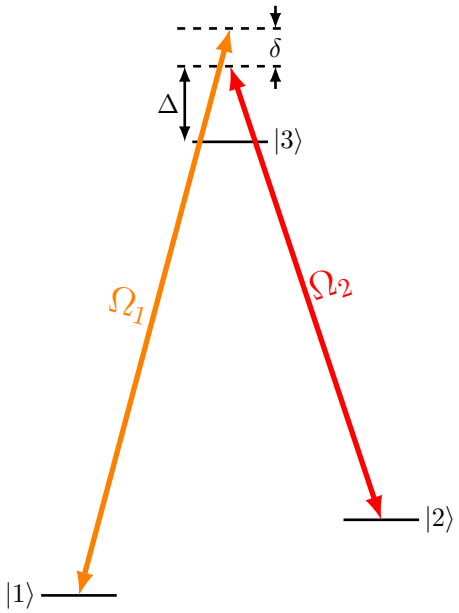

With Ω_2 coupling $|2\rangle$ and $|3\rangle$ together, the energies of the coupled states are (relative to the original energy of $|3\rangle$)

$$E_\pm = \frac{\Delta \pm \sqrt{\Delta^2 + \Omega_2^2}}{2}$$

The eigenstates are

$$|\pm\rangle = \frac{\sqrt{\sqrt{\Delta^2 + \Omega_2^2} \pm \Delta}}{\sqrt{2}\sqrt[4]{\Delta^2 + \Omega_2^2}}|2\rangle + \frac{\Omega_2}{\sqrt{2}\sqrt[4]{\Delta^2 + \Omega_2^2}\sqrt{\sqrt{\Delta^2 + \Omega_2^2} \pm \Delta}}|3\rangle$$

The Rabi frequencies from the $|1\rangle$ state to the $|\pm\rangle$ states are

$$\Omega_\pm = \frac{\Omega_1 \Omega_2}{\sqrt{2}\sqrt[4]{\Delta^2 + \Omega_2^2}\sqrt{\sqrt{\Delta^2 + \Omega_2^2} \pm \Delta}}$$

and the detunings,

$$\begin{aligned}\delta_\pm =& \delta - E_\pm \\ =& \delta - \frac{\Delta \pm \sqrt{\Delta^2 + \Omega_2^2}}{2}\end{aligned}$$

Lifetime of the $|\pm\rangle$ states

$$\Gamma_\pm = \frac{\Gamma\Omega_2^2}{2\sqrt{\Delta^2+\Omega_2^2}\left(\sqrt{\Delta^2+\Omega_2^2}\pm\Delta\right)}$$

Scattering rate

$$\begin{aligned}\gamma =& \left(\frac{\sqrt{\Gamma_+}\Omega_+}{\sqrt{\Gamma_+^2+4\delta_+^2+2\Omega_+^2}}+\frac{\sqrt{\Gamma_-}\Omega_-}{\sqrt{\Gamma_-^2-4\delta_-^2-2\Omega_-^2}}\right)^2 \\ =& \Gamma\Omega_1^2\Omega_2^4\left(\frac{1}{2\sqrt{\Delta^2+\Omega_2^2}\left(\sqrt{\Delta^2+\Omega_2^2}\pm\Delta\right)}\frac{1}{\sqrt{\Gamma_+^2+4\delta_+^2+2\Omega_+^2}}+\frac{1}{2\sqrt{\Delta^2+\Omega_2^2}\left(\sqrt{\Delta^2+\Omega_2^2}\pm\Delta\right)}\frac{1}{\sqrt{\Gamma_-^2-4\delta_-^2-2\Omega}}\right.\end{aligned}$$