



Lecture5 (spin) Rabi oscillation

- Rabi oscillation
- decoherence

W center
Zeeman shifts

NV-qubit

$\vec{H} = -\vec{\mu} \cdot \vec{B} = g\mu_B \left(\frac{m}{\hbar}\right) \cdot \vec{B}$
 $\vec{\mu}_0 = -g\mu_B \frac{\vec{S}}{\hbar}$ $S_0 = \hbar m$ $m = \pm \frac{1}{2}$
 $|\vec{\mu}| = g\mu_B \frac{1}{2} = \mu_B$
 $E_m = g\mu_B B_0 m$
 $\Delta E = g\mu_B B_0 \begin{cases} E_{+m} = g\mu_B B_0 \frac{1}{2} \\ E_{-m} = -g\mu_B B_0 \frac{1}{2} \end{cases}$

(Color-center qubit) NV-qubit

$m=+1$
 $m=0$
 $m=-1$

$|e\rangle$
 $|g\rangle$

$\hbar\omega = \hbar\omega$

Einstein AB Coefficient

A: incoherent interaction (spontaneous emission)
B: coherent interaction (absorption + stimulated emission)

$|e\rangle$
 $|g\rangle$
 $|g\rangle$





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Spontaneous

Stimulated

Vacuum fluctuation $\langle E \rangle = 0$ $\langle E^2 \rangle \neq 0$

Virtual photon (short time) Real photon (long time)

Rabi model solution (Semiclassical)

$E = E_0 \cos(\omega_0 t)$

$i\hbar \frac{\partial}{\partial t} |\psi\rangle = H |\psi\rangle$

$|\psi\rangle = a_g |g\rangle + a_e |e\rangle$

$= a_g |g\rangle + C e^{-i\omega_0 t} |e\rangle$

$\rightarrow i\hbar \frac{\partial}{\partial t} \begin{pmatrix} a_g \\ C \end{pmatrix} = \begin{pmatrix} 0 & \hbar \Omega_R \\ \hbar \Omega_R & 0 \end{pmatrix} \begin{pmatrix} a_g \\ C \end{pmatrix}$

Where $\Omega = \sqrt{|\chi|^2 + \Delta^2}$, $\chi = e \vec{r}_0 \cdot \vec{E}_0$, $\Delta = \omega - \omega_0$

At frequency $\omega_0 = \omega_0 \pm \Omega$

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$G(t) = \langle e | \psi(t) \rangle$

$P_g = 1 - \frac{1}{\Omega^2} \sin^2(\frac{\Omega t}{2})$

$P_e = \frac{1}{\Omega^2} \sin^2(\frac{\Omega t}{2})$

$\Omega = \sqrt{|\chi|^2 + \Delta^2}$

$|\chi| \propto E_0$

$\chi \propto E_0$



