APPPHYS383 Thursday 25 February 2010

Summary points

- (Atom + Laser) couples to Reservoir, $\Omega \gg \Gamma$
- $\langle N \rangle, V \to \infty$ with $\langle N \rangle / V$ constant
- $\langle N \rangle \gg \Delta N \gg 1, \Gamma T$
- $V_{AL} = g(\sigma_+ + \sigma_-)(a + a^\dagger), \quad g = -\boldsymbol{\varepsilon}_L \cdot \boldsymbol{d}_{ab} \sqrt{\hbar\omega_L / 2\varepsilon_0 V}$
- Ignore nonresonant couplings
- $v_N \approx g\sqrt{\langle N \rangle} \to \hbar\Omega_1/2$
- Figure 4; dipole force
- Figure 5; anti-crossing and ac Stark shifts; adiabatic passage

$$
\begin{aligned}
V_{AL} &= g(\sigma_+ a + \sigma_+ a^\dagger + \sigma_- a + \sigma_- a^\dagger), \\
(H_A + H_L)|b, N\rangle &= \hbar(\omega_0 + N\omega_L)|b, N\rangle, \\
(H_A + H_L)|a, N+1\rangle &= \hbar(\omega_L + N\omega_L)|a, N+1\rangle \\
(V_{AL})_N &= \frac{\hbar}{2}\begin{pmatrix} -\delta & \Omega_1 \\ \Omega_1 & \delta \end{pmatrix}, \\
(V_{AL})_N &= \frac{\hbar}{2}\begin{pmatrix} 1 & 1 \\ \frac{1}{\Omega_1}\left(\delta - \sqrt{\delta^2 + \Omega_1^2}\right) & \frac{1}{\Omega_1}\left(\delta + \sqrt{\delta^2 + \Omega_1^2}\right) \end{pmatrix} \\
&\quad \times \begin{pmatrix} -\sqrt{\delta^2 + \Omega_1^2} & 0 \\ 0 & \sqrt{\delta^2 + \Omega_1^2} \end{pmatrix} \begin{pmatrix} \frac{1}{2}\frac{\delta}{\sqrt{\delta^2+\Omega_1^2}} + \frac{1}{2} & -\frac{1}{2}\frac{\Omega_1}{\sqrt{\delta^2+\Omega_1^2}} \\ \frac{1}{2} - \frac{1}{2}\frac{\delta}{\sqrt{\delta^2+\Omega_1^2}} & \frac{1}{2}\frac{\Omega_1}{\sqrt{\delta^2+\Omega_1^2}} \end{pmatrix}.
\end{aligned}
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Discussion points

- Single-mode versus multi-mode picture of laser excitation
- Difference w.r.t. Jaynes-Cummings model
- Mollow triplet
- Autler-Townes doublet
- Dipole force fluctuations: free space, intracavity
- Optical amplification, on- and off-resonance