Efectos mecánicos de luz sobre átomos II.

- Fuerza dipolar

En la clase pasada:

$$\langle F\rangle = \langle F_{rad}\rangle + \langle F_{dip}\rangle$$

$$\langle F_{dip}\rangle \longrightarrow V_{dip} \approx \frac{\hbar\Omega^2}{4\delta}$$

$\sqrt{1+x} \simeq 1+\frac{x}{2}$

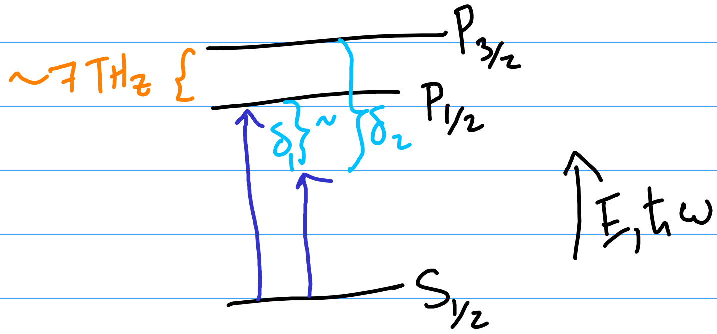
Usando edos. vestidos

$$E_\pm = -\frac{\hbar\delta}{2} \pm \frac{\hbar\delta}{2}\sqrt{\frac{|\Omega|^2}{\delta^2}+1} \underset{\delta\gg|\Omega|}{\approx} -\frac{\hbar\delta}{2}\pm\frac{\hbar\delta}{2}\left(1+\frac{|\Omega|^2}{2\delta^2}\right)$$

Para $\delta \ll -|\Omega|$

$$E_+ \simeq E_e \sim +\frac{\hbar\Omega^2}{4|\delta|} \qquad E_- \simeq E_g \sim -\frac{\hbar|\Omega|^2}{4|\delta|}$$

• Múltiples niveles



Si $\delta \sim \omega_0/2$

$\omega-\omega_0 \sim \omega+\omega_0$

- Generalizando

$$\Delta E_g = \frac{|\langle g|\hat{\epsilon}\cdot\vec{d}|e\rangle|^2 |\mathcal{E}_0^{(+)}(\vec{r})|^2}{\hbar(\omega-\omega_0)} \underset{\substack{\uparrow\\ \text{quitando la RWA}}}{=} |\langle g|\hat{\epsilon}\cdot\vec{d}|e\rangle|^2 |\mathcal{E}_0^{(+)}(\vec{r})|^2 \underbrace{\left(\frac{1}{\hbar(\omega-\omega_0)} - \frac{1}{\hbar(\omega+\omega_0)}\right)}_{\frac{-2\omega_0}{\hbar(\omega_0^2-\omega^2)}}$$

Para el edo base o excitado:

$$\Delta E_\alpha = -\frac{2\omega_{\beta\alpha}|\langle g|\hat{\epsilon}\cdot\vec{d}|e\rangle|^2 |\mathcal{E}_0^{(+)}(\vec{r})|^2}{\hbar(\omega_{\beta\alpha}^2-\omega^2)}$$

- Agregando más niveles

$$\Delta E_\alpha = -\sum_\beta \frac{2\omega_{\beta\alpha}|\langle\beta|\hat{\epsilon}\cdot\vec{d}|\alpha\rangle|^2 |\mathcal{E}^{(+)}(\vec{r})|^2}{\hbar(\omega_{\beta\alpha}^2-\omega^2)}$$

- Derivaciones de expresiones con múltiples niveles (Steck 7.5.1).

$$H_A = \hbar\omega_0 |e\rangle\langle e| \longrightarrow d_q = \mathbb{1}\, d_q\, \mathbb{1} = \langle e|d_q|g\rangle + \langle g|d_q|e\rangle$$

Base $|g\rangle, |e\rangle$ $\qquad\qquad$ $|g\rangle\langle g| + |e\rangle\langle e|$

Incluyendo estructura angular

$$H_A = \hbar\omega_0 \sum_{m_e} |J_e\, m_e\rangle\langle J_e\, m_e| + \hbar 0 \sum_{m_g} |J_g\, m_g\rangle\langle J_g\, m_g|$$

Base $\{|J_e, m_e\rangle, |J_g, m_g\rangle\}_{m_e, m_g}$

$$\langle J_e M_e | d_q | J_e M_e' \rangle$$

$$d_q = \mathbb{1}\, d_q\, \mathbb{1} = (P_e + P_g)\, d_q\, (P_e + P_g) = \cancel{P_e d_q P_e} + \cancel{P_g d_q P_g} + P_e d_q P_g + P_g d_q P_e$$

$$= d_q^{(+)} + d_q^{(-)}$$

$$\mathbb{1} = \underbrace{\sum_{m_e} |J_e m_e\rangle\langle J_g m_g|}_{P_e} + \underbrace{\sum_{m_g} |J_g m_g\rangle\langle J_g m_g|}_{P_g}$$

⋮

haciendo la RWA y en el marco rotante

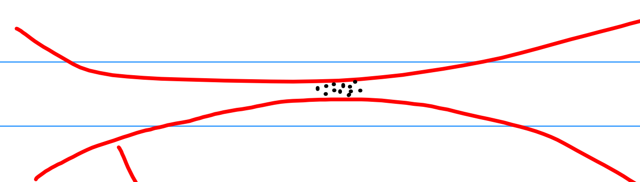
⋮

$$H_{AF} = \frac{\hbar}{2} \sum_{m_e m_g} \left[\Omega^*(m_g, m_e)\, \sigma(m_g, m_e) + \Omega(m_g, m_e)\, \sigma^\dagger(m_g, m_e) \right]$$

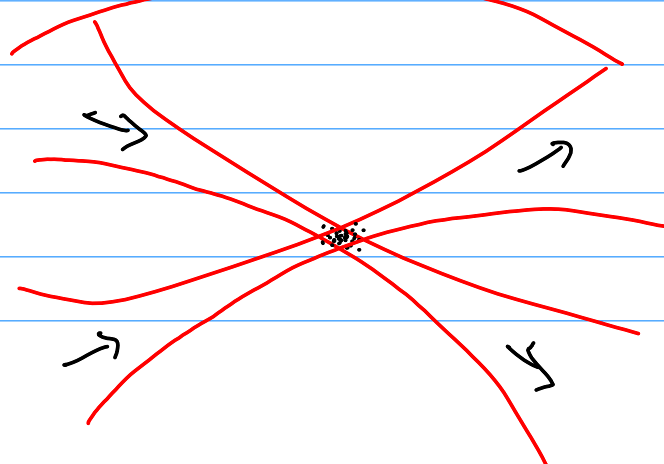
$$|J_g m_g\rangle\langle J_e m_e|$$

Aplicaciones

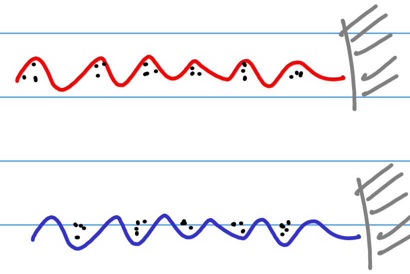
Haz Gaussiano



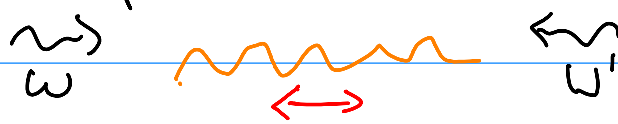
Cruzada



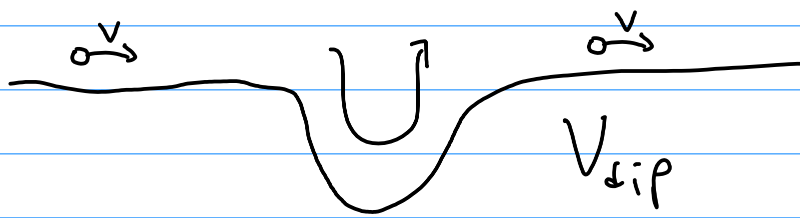
Redes ópticas
(onda estacionaria)

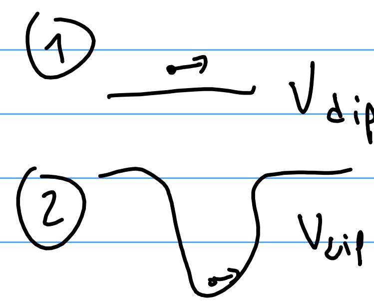


Banda transportadora



Carga de prampa óptica





– Fuerza Radiativa.

$$\bar{F}_{rad} = \langle F_{rad} \rangle = \Gamma \rho_{ee}(\vec{x}, t \to \infty)\hbar \overbrace{\nabla \phi(\vec{x})}^{\vec{K} \text{ para onda plana}}$$

tasa de decaimiento

población edo. excitado

fase de campo $\vec{E}$

Para onda plana:

$$\bar{F}_{rad}(\delta) = \hbar \vec{K} \frac{\Omega^2/\Gamma}{1 + \frac{4\delta^2}{\Gamma^2} + 2\frac{\Omega^2}{\Gamma^2}}$$

Efecto Doppler

Hay dependencia en la velocidad por $\delta_{eff} = \delta - \vec{K}\cdot\vec{v}$

$$\vec{F}_{rad}(\delta - \vec{k}\cdot\vec{v}) \underset{\substack{\uparrow \\ k\cdot v \ll \Gamma}}{=} \vec{F}_{rad}(\delta) - \vec{k}\vec{v}\,\frac{\partial F_{rad}}{\partial \delta}(\delta)$$

$$\sim \delta \vec{v}$$