Class discussion 3/22/2017

Concept questions:

Interacting photons:

Photons interact through a nonlinear medium. What Hamiltonian describes them.

A. The photons are now described by an anharmonic oscillator.

B. The photons are still a harmonic oscillator, but there is an interaction term with the medium.

C. Either description is correct in certain regimes. ✓

Representations for atom-light interactions

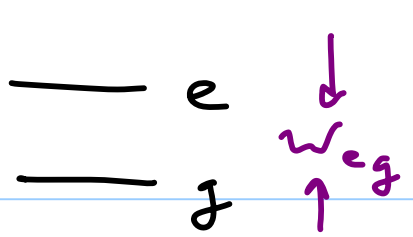
We assume a model atom which has only two energy levels, 1s and 2s. For this system, which of the operators dE, pA, A^2 have only zero matrix elements?

A. dE

B. pA

C. dE and pA ✓

Perturbation theory



Switch on external field (laser) at $\omega \neq \omega_{eg}$.
At what frequency does the population $|a_e|^2$ oscillate (neglect factors of 2)?

A. Rabi freq. $\omega_R = d \cdot E$

B. ω_e

C. ω_{eg}

D. Energy defect $\Delta = \omega_{eg} \pm \omega$ ✓

Schroedinger picture

What are the frequencies of the Fourier components of the Schroedinger Wavefunction?

A. ω_g, $\omega_g \pm \omega$ ✓

B. ω_g, ω_e

C. ω_g, $\omega_{eg} \pm \omega$

At what Frequency does the electron density $|\psi(r,t)|^2$ oscillate?

A. Not at all

B. ω_e

C. ω_{eg}

D. Δ

E. ω ✓

Time dependent perturbation theory
AC Stark effect
(Atomic Physics Wiki)

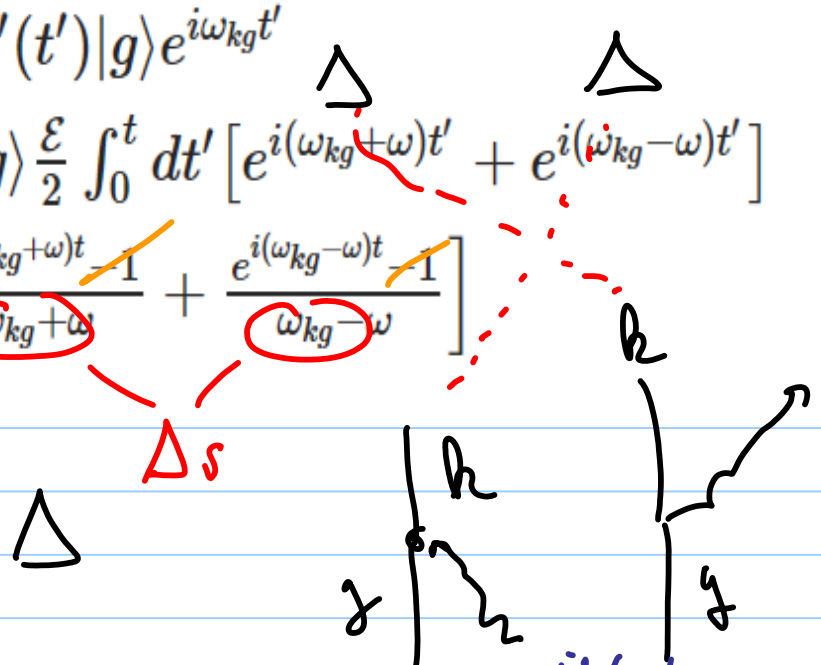
$$H' = -D \cdot \hat{e}\mathcal{E}\cos\omega t = -\frac{1}{2}(e^{i\omega t} + e^{-i\omega t})\mathcal{E}\hat{e} \cdot D$$

$$|\psi\rangle = \sum_n a_n e^{-i\omega_n t}|n\rangle$$

$$\begin{aligned} a_k^{(1)}(t) &= (i\hbar)^{-1}\int_0^t dt' \langle k|H'(t')|g\rangle e^{i\omega_{kg}t'} \\ &= -(i\hbar)^{-1}\langle k|\hat{e}\cdot D|g\rangle \frac{\mathcal{E}}{2}\int_0^t dt' \left[e^{i(\omega_{kg}+\omega)t'} + e^{i(\omega_{kg}-\omega)t'}\right] \\ &= \frac{\mathcal{E}}{2\hbar}\langle k|\hat{e}\cdot D|g\rangle \left[\frac{e^{i(\omega_{kg}+\omega)t}-1}{\omega_{kg}+\omega} + \frac{e^{i(\omega_{kg}-\omega)t}-1}{\omega_{kg}-\omega}\right] \end{aligned}$$

transient

Δs



$$|\psi\rangle = a_g e^{-i\omega_g t}|g\rangle + a_k(t) e^{-i\omega_k t}|k\rangle$$

ω_k

$\omega_g \pm \omega$

$$= a_g e^{-i\omega_g t}|g\rangle + (\quad) e^{-i\omega_g t} e^{i\omega t}|k\rangle + (\quad) e^{-i\omega_g t} e^{-i\omega t}|k\rangle$$

Concept questions

- VdW and Casimir Forces

Can the vdW force be regarded as the Lamb shift of two separated atoms?

A Yes ✓

B No

Casimir forces

For the Casimir force between two metal plates, which statement is incorrect. The force is due to

A. A lower zero point energy of the electromagnetic field, summed over all modes, due to the boundary conditions imposed by the metal plate.

B. Correlated dipole moments in the plates, induced by the vacuum fluctuations.

C. The result of the 1/R^6 van der Waals interactions between the atoms. 1/R^7 retarded ✓

D. Photon exchange between the atoms in the plates.

E. All statements are correct.