Abraham-Minkowski and the HMW phase

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Hey Duncan, just a small sample calculation I'd like you to look over. Thanks!

I. THE HMW TERM

From Cohen-Tannoudji, we find that

$$\langle \mathbf{d} \rangle = 2\mathbf{d}_{\mathrm{ab}} U \cos(\omega_L t) \tag{1}$$

where

$$U = \frac{\Omega_1}{2} \frac{\delta_L}{\delta_L^2 + \frac{\Gamma^2}{4} + \frac{\Omega_1^2}{2}} \tag{2}$$

Now we want to maximize U, so we set $\delta = \Omega_1$ which gives

$$\langle \mathbf{d} \rangle = \frac{2}{3} \mathbf{d}_{\mathrm{ab}} \cos(\omega_L t) \tag{3}$$

Now for Rubidium, the D2 transition matrix element $\mathbf{d}_{\mathrm{ab}}$ is approximately 3.6×10^{-29} C · m. We want to know the size of $\langle \mathbf{d} \rangle \cdot \mathbf{E}$, where $\mathbf{E} = E_0 \cos(\omega_L t)$. We first get rid of the $\cos^2$ term by integrating over time, which will yield a factor of 1/2. We now look at the value of the intensity and electric field needed. A power of 10 mW, focused to a spot size of diameter 10 μm yields an intensity of $I = 10^8$ W/m^2. We find the corresponding electric field amplitude is $E_0 = 2.7 \times 10^5$ V/m. Then we find that

$$\frac{1}{2} \langle \mathbf{d} \rangle \cdot \mathbf{E} = 4.9 \times 10^{-24} \mathrm{J} \tag{4}$$

We now can find the size of the HMW term over a 1 second period (t=1 s)

$$\frac{2\mathbf{d} \cdot \mathbf{E} n_r k t}{m} = 1.8 \tag{5}$$

Here we have used the mass of Rubidium (1.4×10^{-25} Kg). This number is large enough for us to see.

The corresponding Rabi frequency for these values are

$$\Omega_1 = \frac{\mathbf{d}_{\mathrm{ab}} E_0}{\hbar} = 97GHz \tag{6}$$

This is what suggested to me that we could not use $d = \alpha E$ as we are no longer in the weak field limit and can no longer treat this linearly. This is all done for a 2-level atom. Right now I'm working on the 3 level case to make sure we can get zero absorption.