Homework #7

1A In class we derived, both in perturbation theory and for dressed atoms, the light shift:

$$\Delta = \frac{\Omega^2}{4\delta} \quad \text{valid for } \delta \gg \Gamma, \Omega.$$

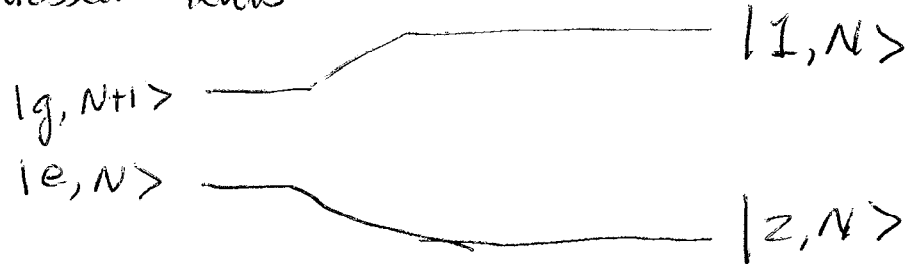
Using the dipole force calculated from optical Bloch eqns., treating the potential from which it derives as a light shift, write an expression for the "lightshift". (Valid for all δ, Γ, Ω.) Simplify the expression when $\Omega \ll \Gamma$, and compare it to the expression above.

1B. Discuss the situation $\Omega \gg \Gamma$, $\delta \lesssim \Gamma$, comparing the optical bloch eqn. picture and the dressed atom picture.

Homework #7

2. In class we calculated the dipole force on an atom in a non-uniform optical field, using the optical Bloch eqns. (valid for all δ, ie. not necessarily large.) Here we will do that using the dressed atom picture, by considering rate eqns. between dressed states.

2A. In class we calculated eigenvalues of the dressed levels.



to be $E_{1,2} = \pm \frac{1}{2}(\delta^2 + \Omega^2)$,

Expressing the Eigenvectors as

$$|1,N\rangle = \sin\theta\,|g,N+1\rangle + \cos(\theta)\,|e,N\rangle$$
$$|2,N\rangle = \cos\theta\,|g,N+1\rangle - \sin\theta\,|e,N\rangle$$

derive these expressions for the eigenvectors, giving explicit forms for $\sin\theta$, $\cos\theta$

2B. Assuming well separated levels ($\Omega \gg \Gamma$ or $\delta \gg \Gamma$) calculate the rate at which the dressed levels $|1,N\rangle + |2,N\rangle$ decay by spontaneous emission to the manifold $|1,N-1\rangle, |2,N-1\rangle$ Express in terms of Γ (the $|e\rangle \to |g\rangle$ rate). What are the partial decay rates $1\to1$, $2\to2$, $1\to2$, $2\to1$? Express in terms of Γ, θ, discuss.

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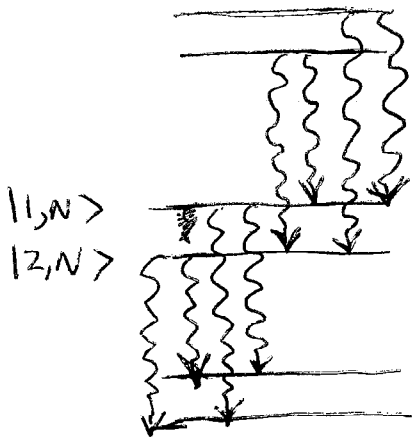
2c. Assume an infinite ladder of dressed states

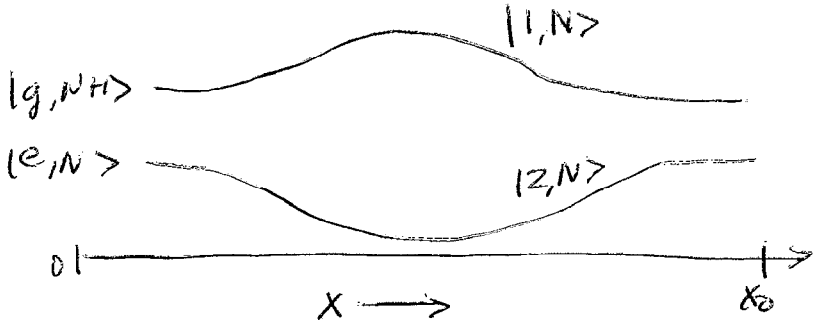


Write a rate equation for the populations (i.e. ignore the off-diagonal terms in the dressed atom density matrix) of $|1,N\rangle$ and $|2,N\rangle$ based on the rates calculated in 2B and in terms of the populations P_1 and P_2 of $|1,N\rangle$ & $|2,N\rangle$. Solve in steady state for these populations.

Homework #7

2D

Now consider a laser field with a gradient of intensity, but no phase gradient. Consider the dressed levels for $\delta > 0$ as a function of position where the field goes to 0 at $X = 0$ and $X = X_0$



Find the force on each dressed level by taking the gradient of its potential.

Find the average force by weighting the dressed level forces according to their populations

Compare this to the dipole force calculated in class using the Optical Bloch eqns.