Phys 551 Homework 3

1. Complex atomic polarizability

Consider atoms with a transition at frequency ω_0 having an oscillator strength f and lorentzian half-width Γ, which is a combination of collisional broadening and natural lifetime. The atoms are contained in a cell with length l and have number density N. Calculate the atomic polarizability as a function of frequency ω near the resonance and consider propagation of the light through the cell. Find the attenuation and phase shift of the light exiting the cell assuming it is optically thin. Verify that attenuation agrees with the number of photons per second absorbed in the cell.

2. Light shift far off-resonance

Calculate the ground state light shift for a transition between $^2S_{1/2}$ and $^2P_{1/2}$ states at frequency ω_0 with an oscillator strength f illuminated with light of intensity I and frequency ω. Do not make rotating wave approximation, but you can ignore the finite lifetime of the excited state. Show that the light shift can be divided into a scalar shift independent of light polarization which is the same for both ground state sublevels and vector light shift proportional to the degree of circular polarization that splits the Zeeman levels in the ground state. How do these lightshifts behave as the frequency ω of the light approaches zero? Hint: For arbitrary (complex) light polarization ε you can write the electric field as $E = E_0(\varepsilon e^{-i\omega t}+\varepsilon^* e^{i\omega t})/2$