PHYS598 AQG, Fall 2017
Homework Set #6, due by 4:30 pm on Friday 11/17

Note: this set will be graded out of 10 points, such that an extra 4 "bonus" points are available for your total course homework grade

Q1) [3 pts] ***Light shifts and scattering rates***

Consider that you have a monochromatic laser, with wavelength λ_L and angular frequency $\omega_L = 2\pi c/\lambda_L$, which interacts with a gas of ^{87}Rb atoms. At the far range of the visible spectrum, close to near-infrared wavelengths, exist the lowest energy optical excitations from the $5S_{1/2}$ ground state to the $5P_{1/2}$ and $5P_{3/2}$ excited states, referred to as the D1 and D2 lines, respectively. The D1 and D2 lines have resonance wavelengths (in vacuum, although we're just looking for rough numbers here) of roughly 780 nm and 795 nm. Both of these excited states have the same natural linewidth ($\sim 2\pi \times 6$ MHz), although the dipole matrix element relating to the D2 transition is larger than that for the D1 transition by a factor of $\sqrt{2}$ [this follows from that fact that $\langle J = 1/2||er||J' = 3/2\rangle = \sqrt{2}\langle J = 1/2||er||J' = 1/2\rangle$, and correspondingly $|\langle J = 1/2||er||J' = 3/2\rangle|^2 = 2|\langle J = 1/2||er||J' = 1/2\rangle|^2$].

(a) Restricting your laser wavelength to lie between the D1 and D2 resonance values, and assuming light with π polarization and fixed intensity, at what wavelength will the AC Stark shift vanish?

(b) With the same restrictions as in (a), at what wavelength will the rate of off-resonant scattering be minimized?

Q2) [4 pts] **Foot Exercise 10.4 – *"Evaporative cooling"***

Q3) [2 pts] **Foot Exercise 10.5 – *"The properties at the phase transition"***

Q4) [5 pts] **Foot Exercise 10.10 – "*Derivation of the speed of sound"***