PHGN 480: Laser Physics due 8 Sept 2011
Homework 2

1) Suppose an atom is placed inside a blackbody cavity at a temperature T and the level populations come to thermal equilibrium with the radiation.
   a. Show that the condition for the rate of stimulated emission from the upper level being equal to the rate of spontaneous emission is
   $$k_B T = \frac{\hbar\omega_{21}}{\ln 2}$$
   where $\hbar\omega_{21}$ is the energy spacing of the levels.
   b. Find the temperature in eV units and Kelvin when this condition is met for the transitions in the following regions of the electromagnetic spectrum:
      i. Radio frequencies at 50MHz
      ii. Microwaves at 1 GHz
      iii. Visible light at 500nm
      iv. X-rays of energy 1keV
   c. Under this condition of thermal equilibrium with the field, what is the ratio of the populations per state in the upper and lower level? Explain your answer in terms of the spontaneous, stimulated, and absorption transition rates between the two levels.

2) Find a relation between spontaneous emission lifetime and cross section for a simple atomic transition that is independent of the dipole moment (take the expressions for each, and eliminate the dipole moment).

3) Svelto problem 2.5.

4) Calculate the natural lineshape function assuming the electric field of a decaying state follows the function $E(t) = E_0 \exp\left[-t/2\tau_{sp}\right]\cos\left[\omega_0 t\right]$ for $t \geq 0$. Do this using the Fourier transform as we did in class. Make use of the shift theorem.

5) Calculate the Doppler broadened linewidth for
   a. the 488nm transition of an argon ion laser, given that the temperature of the discharge is around 400K
   b. the 632.8nm transition of the HeNe laser, with a discharge temperature of 400K

6) Svelto problem 2.12