Laser Physics: PHYS 5734

Spring 2009, Homework Set - 5

Due: Friday, April 3

21 **Homogeneous and inhomogeneous absorption (chemical lasers):** By burning D_2 and F_2 to get chemicaly excited DF molecules, and then letting them expand through a supersonic nozzle we can make very powerful lasers that can generate hundreds of kW cw power. Such lasers have been proposed as military weapons (if the laser doesn't get them the toxic chemicals will!).

The peak absorption coefficient versus pressure of the $\lambda = 3.67\,\mu$m transition of the DF molecule at room temperature is linear at low pressures and essentially flat at high pressures (see Fig. 3.21 in Siegman). Explain this behavior. [Hint: At low pressures the line is Doppler broadened Gaussian and at high pressure it is pressure broadened, Lorentzian. Natural broadening is negligible in both cases.]

22(a) **Absorption cross-section of Ne:** The neon line at $\lambda = 1.15\,\mu$m is predominantly Doppler broadened to $\Delta\nu_D = 9 \times 10^8$ Hz. The upper state life time which is approximately the laser transition lifetime is ≈ 100 ns. Calculate the peak cross-section for this laser transition.

(b) If the operating temperature of the laser at this wavelength is 400 K and the cavity is 40 cm long, how many longitudinal modes lie under the Doppler broadened line?

23(a) **Absorption in Na-vapor:** Show that the number of atoms per cm^3 of an ideal gas at pressure P (in torr) and temperature T (in degrees K) is given by

$$\mathcal{N} = 9.65 \times 10^{18} \frac{P(\text{torr})}{T(^o\text{K})}.$$

(b) Estimate the absorption coefficient for 589 nm transition in sodium vapor containing 2.70×10^{12}atoms/cm^3 at 200^o C. For decay rates, lifetimes etc. see Table 3.1 on pp 122 in Siegman and note the error in the first entry where the time should be 16 ns.

24 **Doppler and collision broadening in CO_2:** Calculate the Doppler linewidth of a CO_2 laser transition at $\lambda = 10.6\ \mu$ m at 400 K. Collision broadening of this transition is about 5 MHz/torr. Calculate the pressure at which the two broadening mechanisms give equal contribution to the linewidth.