

Assignment 7

1. Consider the atomic system shown below.

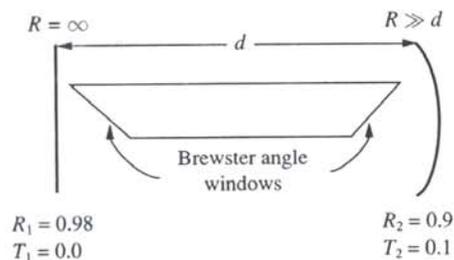
$$\begin{aligned} A_{21} &= 5 \times 10^7 \text{ s}^{-1} \\ A_{20} &= 2 \times 10^7 \text{ s}^{-1} \\ A_{10} &= 10^8 \text{ s}^{-1} \end{aligned}$$

$$1 \text{ ————— } 1.1$$

$$2 \text{ ————— } 3.4 \text{ eV}$$

$$0 \text{ ————— } 0$$

- a) What are the wavelengths of the various transitions in nm?
 - b) What is the lifetime of state 2?
 - c) What is the branching ratio of the 2-1 transition?
 - d) Suppose that 10^{14} atoms/cm³ are excited from state 0 to state 2 at time $t = 0$ by some external mechanism. Write down the equations governing the time evolution of the populations in states 0, 1 and 2.
 - e) Suppose that this external agent is strong enough to keep a steady state population of 10^{14} atoms/cm³ in state 2.
 - i. How much power per unit volume is absorbed by the atoms?
 - ii. What is the steady state population density of state 1?
 - iii. What power per unit volume radiated spontaneously in the 2→1 transition?
2. An argon ion laser at 514.5 nm generates a TEM₀₀ Hermite-Gaussian beam with the laser cavity shown below.
- a) Specify the polarization of the optical electric field.
 - b) If the minimum spot size is 1 mm and the output power is 8 W, what is the peak electric field inside the laser cavity incident on the spherical mirror?



3. Suppose that the amplitudes of the modes of a laser had a Lorentzian like distribution of power such that

$$P(\omega) = P_0 \sum_{n=-\infty}^{\infty} \left[\frac{(\Delta\omega/2)^2}{(n\omega_c)^2 + (\Delta\omega/2)^2} \right]^2 \delta(\omega - (\omega_0 + n\omega_c))$$

where P_0 is the average power of the mode at the line center and $\Delta\omega$ is the FWHM of the oscillating spectrum. Compute the following quantities as a function of $\Delta\omega$ and P_0 .

- The total average power produced by this laser.
 - The peak power of the mode locked pulse.
 - The pulse width (FWHM) of the mode locked pulse.
4. The argon ion laser is inhomogeneously broadened with a width of 5 GHz and is contained in a cavity 100 cm long. How many TEM_{00q} modes are above threshold? Assume that the central mode is at line center).