PH201 - Optics and Lasers - Assignment

Name: M.Maheeth Reddy	**Roll No.:** 1801CS31	**Date:** 12-May-2020

Single pass gain of a laser can be determined by the formula:

$$\boxed{\frac{I}{I_0} = e^{\sigma_{ul} \cdot \Delta N_{ul} \cdot z}}$$

$\sigma_{ul} \longrightarrow$ stimulated emission cross section

$\Delta N_{ul} = N_u - N_l \longrightarrow$ inversion density

$N_l \longrightarrow$ pop. density at lower laser level

$N_u \longrightarrow$ pop. density at higher laser level

$z \longrightarrow$ length of laser rod

For an Nd: YAG laser. $\boxed{\sigma_{ul} = 2.8 \times 10^{-23} m^2}$

For ΔN_{ul}, we should know, N_u & N_l

$$\boxed{N_u = \frac{\Gamma_{oi}}{\gamma_{ul}} N_0} \qquad \boxed{N_l = \frac{\gamma_{ol} + \Gamma_{oi}}{\gamma_{lo}} N_0'}$$

$\Gamma_{oi} \longrightarrow$ plumbing rate to intermediate level i

$\gamma_{ol} \longrightarrow$ upward rate from thermal excitation from level 0 to l

$\gamma_{ul} \longrightarrow$ downward rate for thermal de-excitation from level u to l.

Given,

$$\Gamma_{oi} = 100 \times \gamma_{ul}\, e^{-\frac{\Delta E_{lo}}{kT}}$$

$k = 8.62 \times 10^{-5}\ eV/k$
$T = 300K$

and $\Delta E_{lo} = 0.27\,eV,\quad \gamma_{ul} = 4 \times 10^{3}\, s^{-1} (= A_{ul})$

$$\Rightarrow \Gamma_{oi} = 100 \times 4 \times 10^{3} \times e^{-\frac{0.27}{8.62 \times 10^{-5} \times 300}}$$

$$\Rightarrow \boxed{\Gamma_{oi} \approx 11.88}$$

$$N_u = \frac{\Gamma_{oi}}{\gamma_{ul}} N_0 = \frac{11.88}{4 \times 10^{3}} \times 10^{24} = 2.97 \times 10^{23} / m^3$$

$$N_l = \frac{\gamma_{ol} + \Gamma_{oi}}{\gamma_{lo}} N_0 = \frac{\gamma_{lo}\, e^{-\frac{0.27}{8.62 \times 10^{-5} \times 300}} + 11.88}{\gamma_{lo}} N_0$$

$$\approx 2.97 \times 10^{-5} N_0 \Rightarrow N_l = 2.97 \times 10^{21} / m^3$$

Hence, single pass gain $= e^{\sigma_{ul} \times \Delta N_{ul} \times L} = e^{2.8 \times 10^{-23} \times 2.97 (10^{23} - 10^{21}) \times 0.1}$

$$\Rightarrow \boxed{\text{Single Pass gain} = 2.278}$$