

**Useful Formulae:**

Wein's Law:  $\lambda_{\max} T = 2.897 \cdot 10^{-3} \text{ mK}$

Gain:  $g = \Delta N \sigma_0$

Power:  $P(\text{mW}) = 10^{\frac{-P(\text{dbm})}{10}}$

Saturation Intensity:  $I_{\text{sat}} = \frac{h\nu}{\sigma_0 \tau}$

Planck's Relationship:  $E = h\nu = \frac{hc}{\lambda}$

Boltzmann's Law:  $N = N_0 e^{\frac{-E}{kT}}$

Threshold Gain:  
(simple configuration)  $g_{\text{threshold}} = \gamma + \frac{1}{2x} \ln\left(\frac{1}{R_1 R_2}\right)$

Saturated Gain:  $g_{\text{sat}} = \frac{g_0}{1 + \frac{\rho}{\rho_{\text{sat}}}}$

Fresnel equation:  $R = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2$

Mode Spacing:  $\Delta\nu = \frac{c}{2nL}$

ULL Rate Equation:  $\frac{dN_{\text{ULL}}}{dt} = \frac{\Delta N}{\tau}$

Recombination Rate:  $\frac{dN_{\text{ULL}}}{dt} = \frac{J}{q \times t}$

Minimum Pump Power:  $P_{\text{Minimum}} = \frac{dN_{\text{ULL}}}{dt} V h \nu_{\text{MP}}$

Level Lifetime:  $\tau = \frac{1}{\sum A_i}$

Re-absorption loss:  
(Quasi-3 manifold)  $\gamma_{\text{THERMAL}} = \sigma_0 N_{\text{LLL}} = \sigma_0 f_L N_0$

Partition Function:  $f_L = \frac{g_x e^{\frac{-E_x}{kT}}}{\sum_i g_i e^{\frac{-E_i}{kT}}}$

Rigrod Solution:  $I_2 = \frac{I_{\text{SAT}} (g_0 x_g + \ln(\sqrt{R_1 R_2}))}{1 + \sqrt{\frac{R_2}{R_1}} - R_2 - \sqrt{R_1 R_2}}$

Cavity lifetime:  $\tau_{\text{CAVITY}} = \frac{1}{\frac{c}{n} \times g_{\text{th}}}$

Pulse Power:  $P_{\text{PEAK}} = (1 - R_{\text{OC}}) h \nu V \frac{1}{\tau_{\text{CAVITY}}} \left[ \frac{1}{2} \Delta N_{\text{th}} \ln\left(\frac{\Delta N_{\text{th}}}{\Delta N_i}\right) - \frac{1}{2} \Delta N_{\text{th}} + \frac{1}{2} \Delta N_i \right]$

Pulse Energy:  
(approximation)  $E = \frac{1}{2} (1 - R_{\text{OC}}) h \nu \Delta N_i$

Decay:  $N = N_0 \exp\left(\frac{-t}{\tau}\right)$

Small-signal absorption:  $T_0 = e^{-\alpha_0 t} = e^{-n_0 \sigma_g t}$

Saturated absorption:  $T_{\text{MAX}} = e^{-n_0 \sigma_e t}$

Saturation fluence:  $E_{\text{SAT}} = \frac{hc}{\sigma_g}$

**Constants and Conversions:**

1eV = 1.602E-19J

0 C = 273.15 K

k = Boltzmann's constant (1.381 \* 10<sup>-23</sup> J/K)

h = Planck's constant (6.626 \* 10<sup>-34</sup> Js)

c = Speed of Light (3\*10<sup>8</sup> m/s)

1 mole (Avogadro's number) = 6.02\*10<sup>23</sup> atoms/molecules

Indices of Refraction: Quartz = 1.46, Glass = 1.51