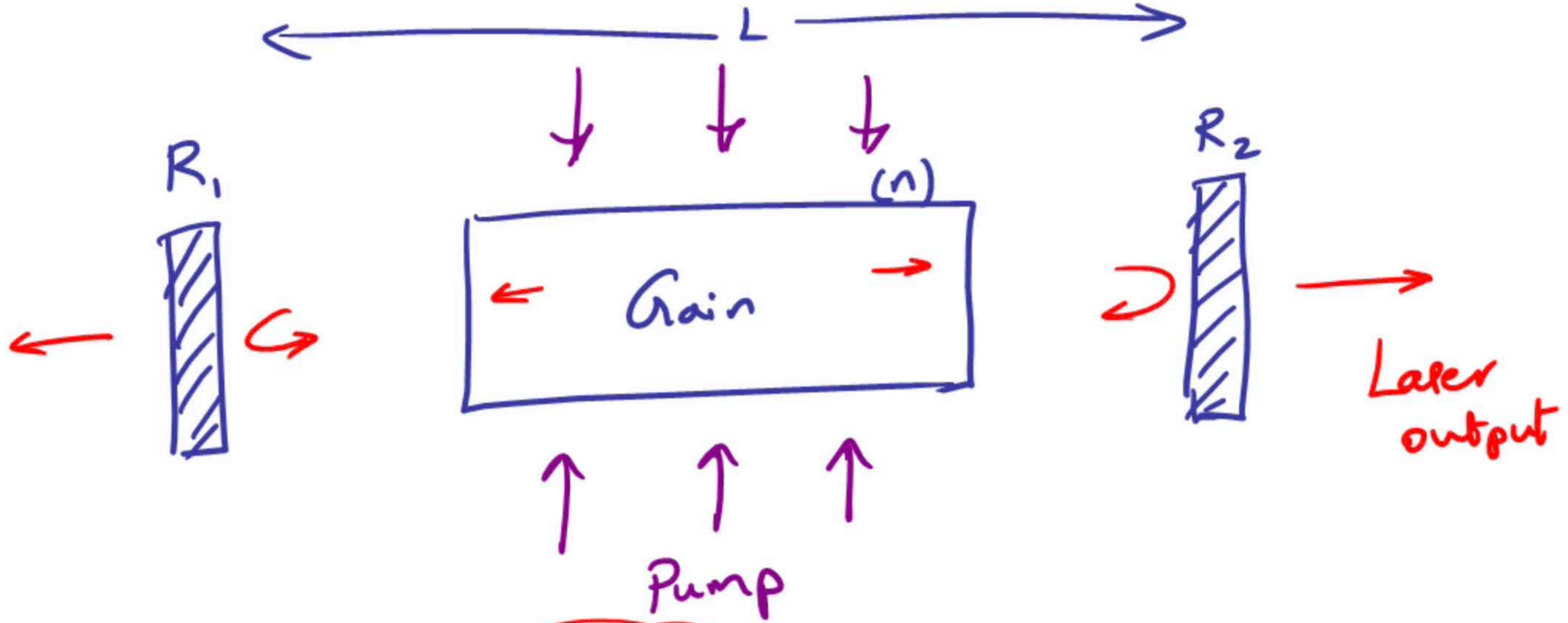
LO : Identify the fundamental principles of laser & quantify their characteristics



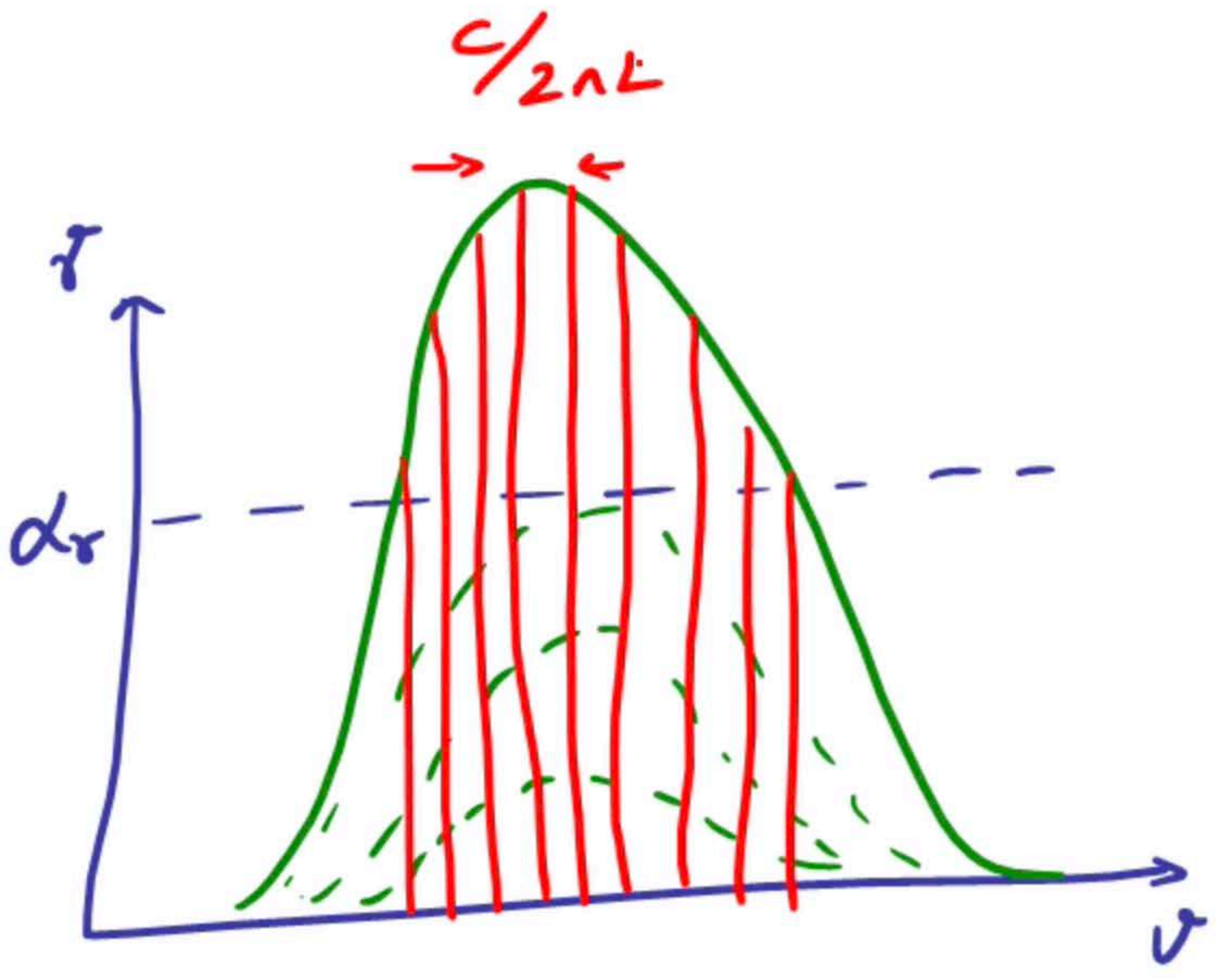
Laser oscillation condition

$$E_0 \, e^{+\gamma/2 \cdot 2L} \, e^{-\alpha_{int}/2 \cdot 2L} \sqrt{R_1 R_2} \cdot e^{-j k_0 n \cdot 2L} = E_0$$

$$e^{\gamma L} \, e^{-\alpha_{int} L} \sqrt{R_1 R_2} = 1$$

$$k_0 \cdot n \cdot 2L = 2\pi m$$

① $\Rightarrow$ $\boxed{\gamma = \alpha_{int} + \frac{1}{2L} \ln\left(\frac{1}{R_1 R_2}\right)} = \alpha_r$



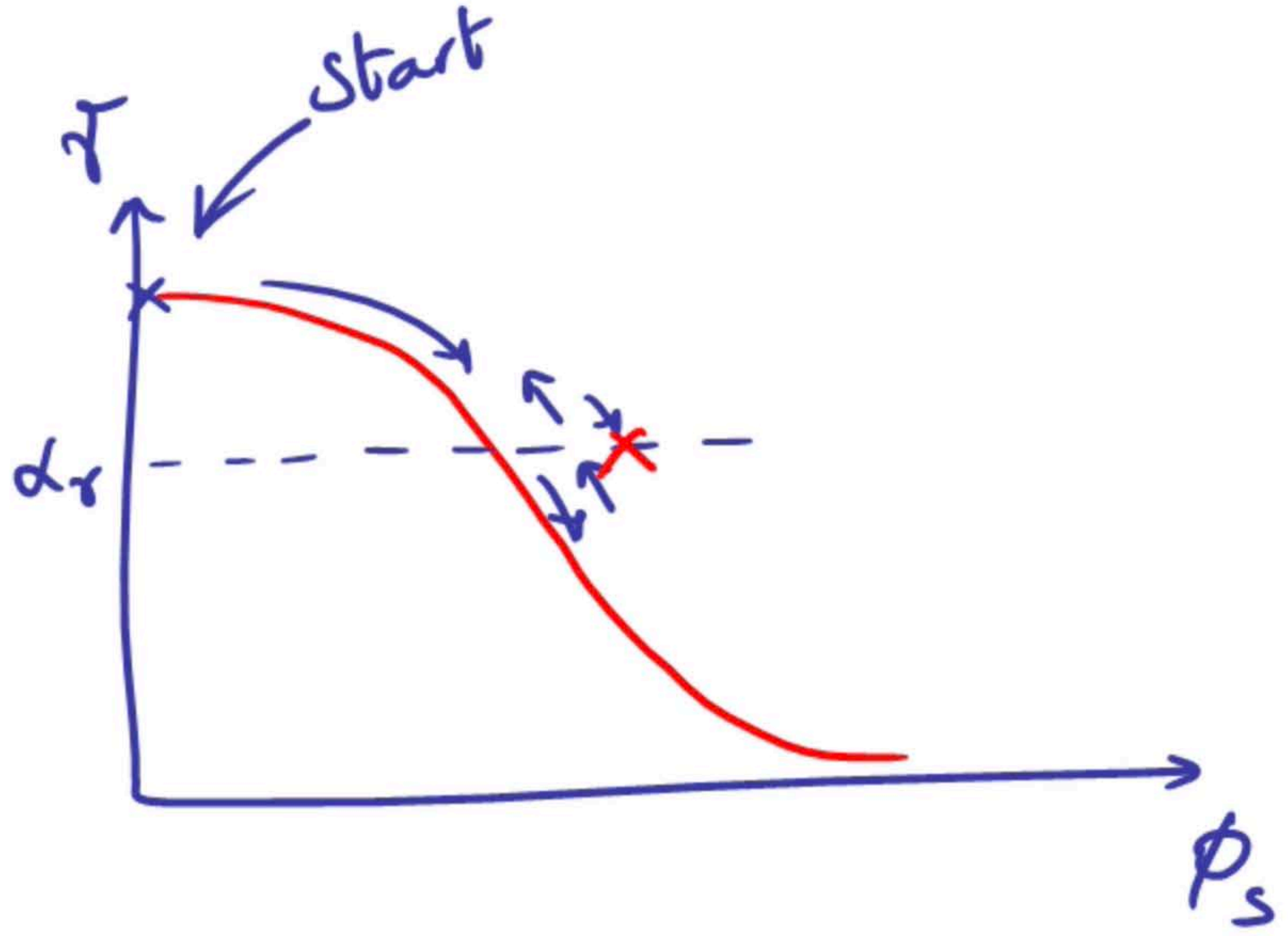
② $\Rightarrow$ $\frac{2\pi}{\lambda} \cdot n \cdot 2L = 2\pi m$

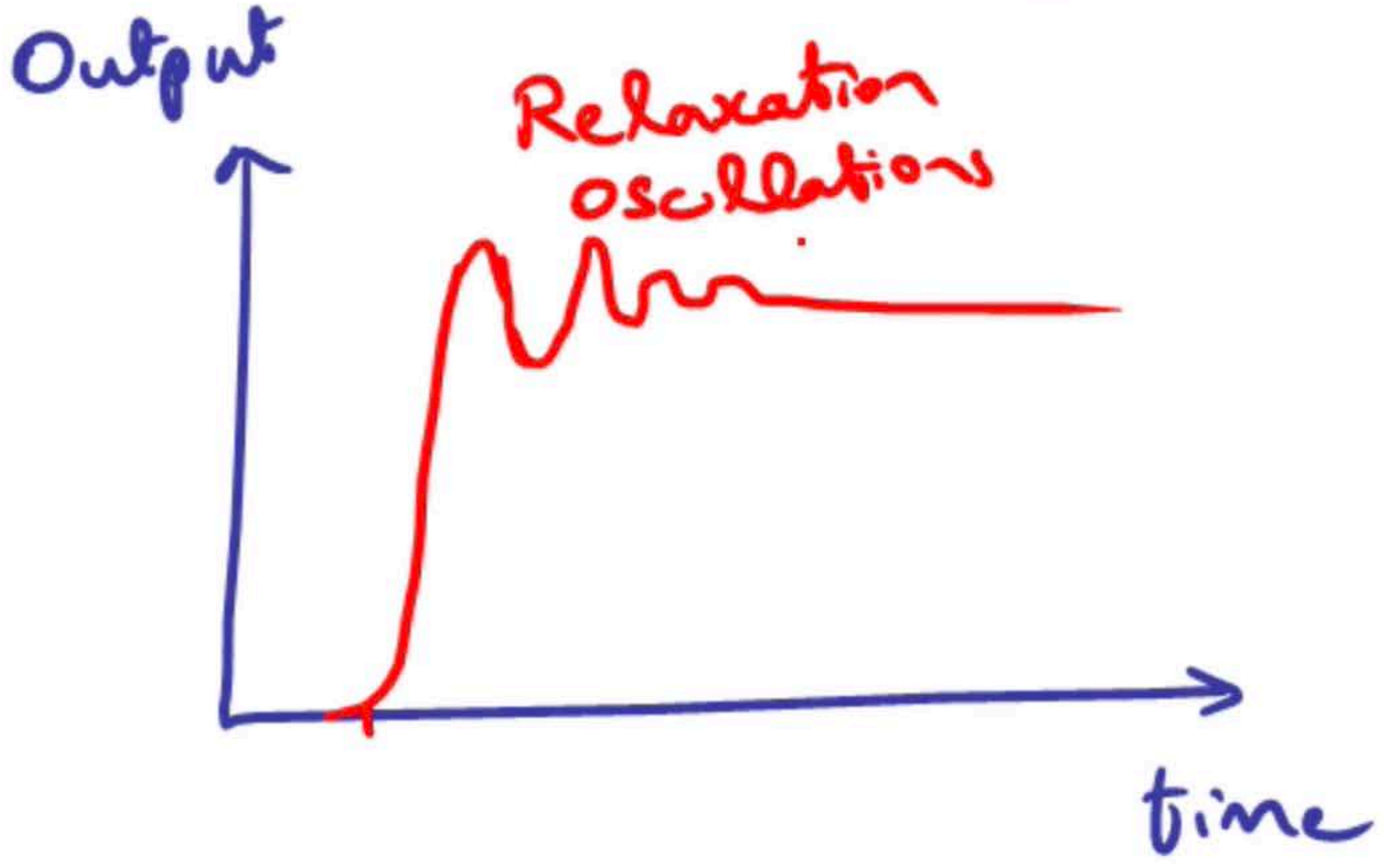
$$\boxed{\nu = m \cdot \frac{c}{2nL}}$$

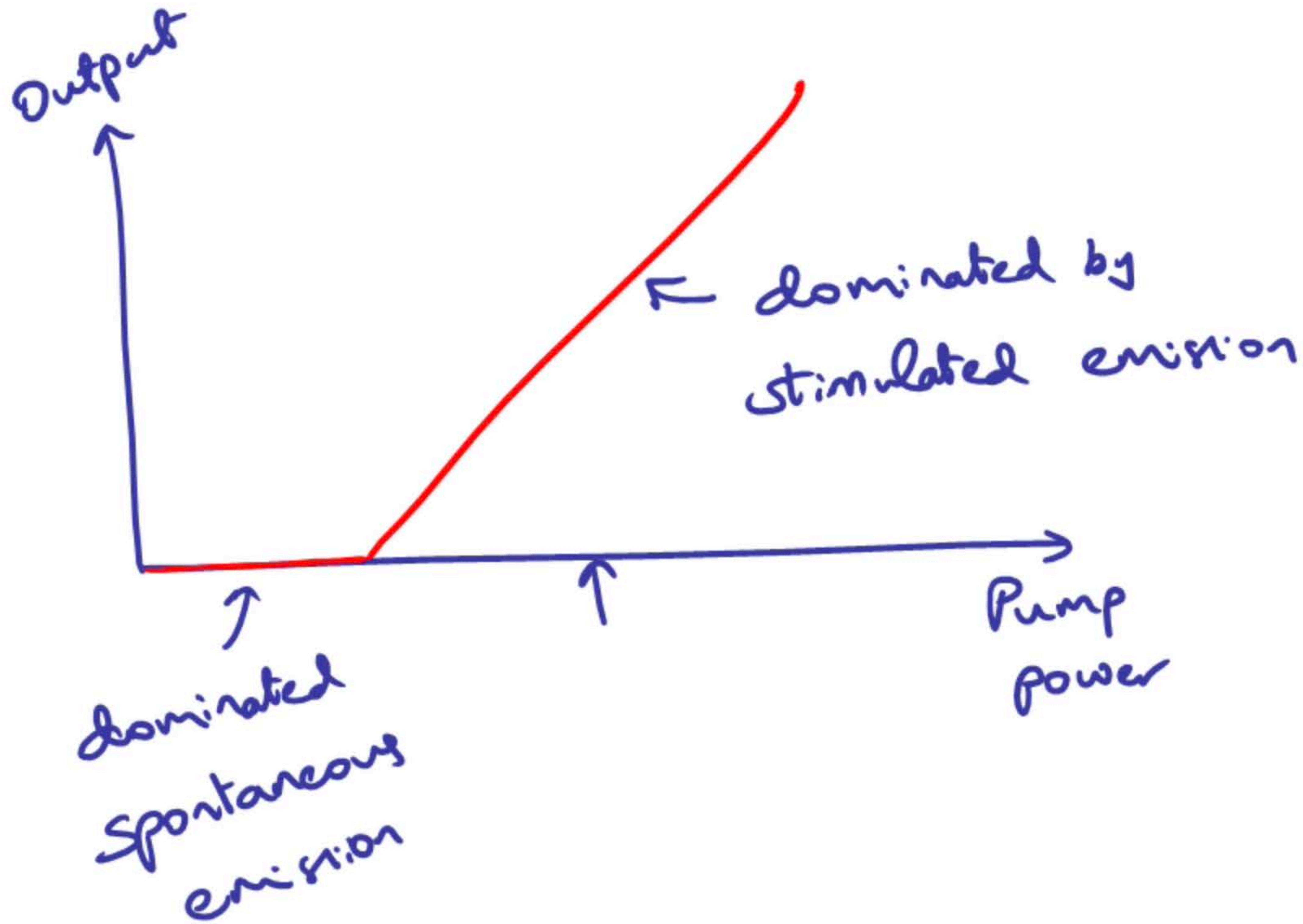
Avg. Photon lifetime, $\tau_{ph} \propto \frac{1}{\alpha_r}$

$$\tau_{ph} = \frac{1}{c.\alpha_r} \Rightarrow \alpha_r = \frac{1}{c.\tau_{ph}}$$

$$\Rightarrow \boxed{N_{th} = \frac{1}{c.\tau_{ph}.\sigma}}$$



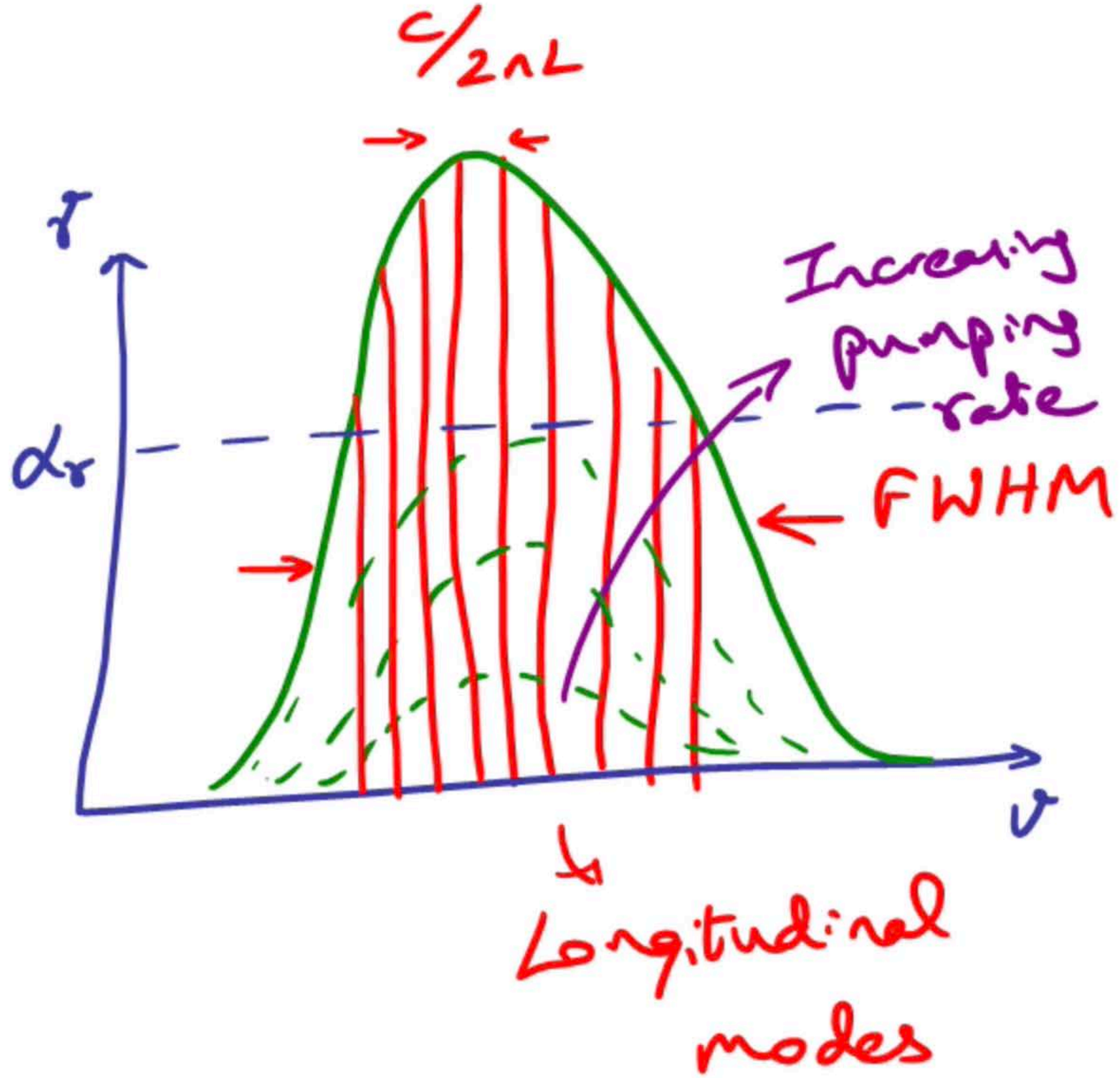



Output
dominated by
stimulated emission
Pump
power
dominated
spontaneous
emission

① $\Rightarrow$ $$\boxed{\gamma = \alpha_{int} + \frac{1}{2L}\ln\left(\frac{1}{R_1R_2}\right)} = \alpha_r$$

② $\Rightarrow$ $$\frac{2\pi}{\lambda}\cdot n\cdot 2L = 2\pi m$$

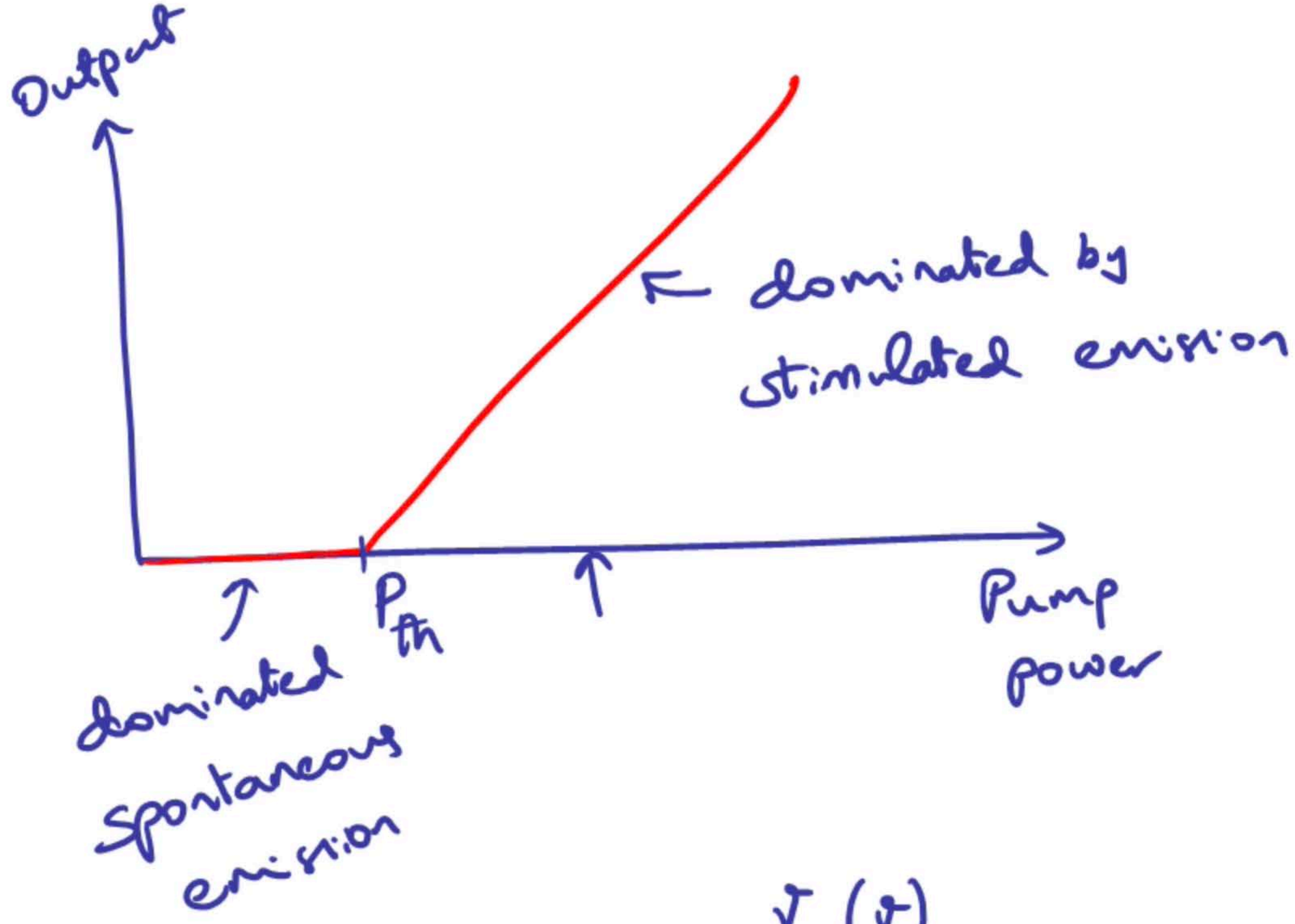
$$\boxed{\nu = m\cdot\frac{c}{2nL}}$$



For laser oscillation, $\gamma > \alpha_r$

Assume $\sigma_e = \sigma_a = \sigma$, $\sigma N > \alpha_r$

Threshold inversion $N_{th} = \dfrac{\alpha_r}{\sigma}$



$$\frac{\gamma_0(\nu)}{1+\phi_s(\nu)/\phi_{sat}} = \alpha_r \quad \text{at threshold}$$