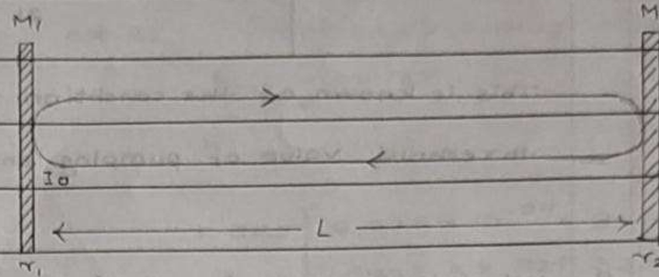
7. Threshold condition for lasing.

→ Let us assume that the laser medium fills the space between the mirrors M_1 and M_2 which have reflectivity r_1 and r_2 respectively. Let the mirrors be separated by a distance L. Further, let the intensity of the light beam be I_0 at M_1. Then, in travelling from mirror M_1 to M_2, the beam intensity increases from I_0 to $I(L)$, which is given by,



$$I(L) = I_0 e^{(\gamma - \alpha_s)L}$$

where, γ is the gain coefficient and α is the loss coefficient of the active medium.

After reflection at M_2, the beam intensity will be $r_2 I_0 e^{(\gamma - \alpha_s)L}$ and after a complete round trip, the final intensity will be

$$\boxed{I(2L) = r_1 r_2 I_0 e^{(\gamma - \alpha_s)2L}}$$

The amplification obtained during the round trip is

$$\boxed{G = \frac{I(2L)}{I_0} = r_1 r_2 e^{(\gamma - \alpha_s)2L}}$$

0,450

The product $r_1 r_2$ represents the losses at the mirrors whereas α_s includes all the distributed losses such as scattering, diffraction and absorption occuring in that medium. The losses are balanced by gain, when $G \geq 1$ or $I(2L) = I_0$. It requires that,

$$r_1 r_2 e^{(\gamma - \alpha_s)2L} \geq 1$$

$$e^{(\gamma - \alpha_s)2L} \geq 1/r_1 r_2$$

taking logarithm on both sides, we get,

$$2L(\gamma - \alpha_s) \geq -\ln(r_1 r_2)$$

$$\gamma - \alpha_s \geq \frac{-\ln(r_1 r_2)}{2L}$$

$$\gamma \geq \alpha_s - \frac{\ln(r_1 r_2)}{2L}$$

or $$\boxed{\gamma \geq \alpha_s + \frac{1}{2L}\ln\left(\frac{1}{r_1 r_2}\right)}$$

This is known as the condition for lasing. It is used to determine the threshold value of pumping energy for lasing action.