Types of Laser

Lasers can be classified based on

number of levels involved

(i) Two-level Lasers
(ii) Three-level Lasers
(iii) Four-level Lasers

and types of active medium

(i) Solid state Lasers
(ii) Gas Lasers
(iii) Liquid Lasers

Main Components

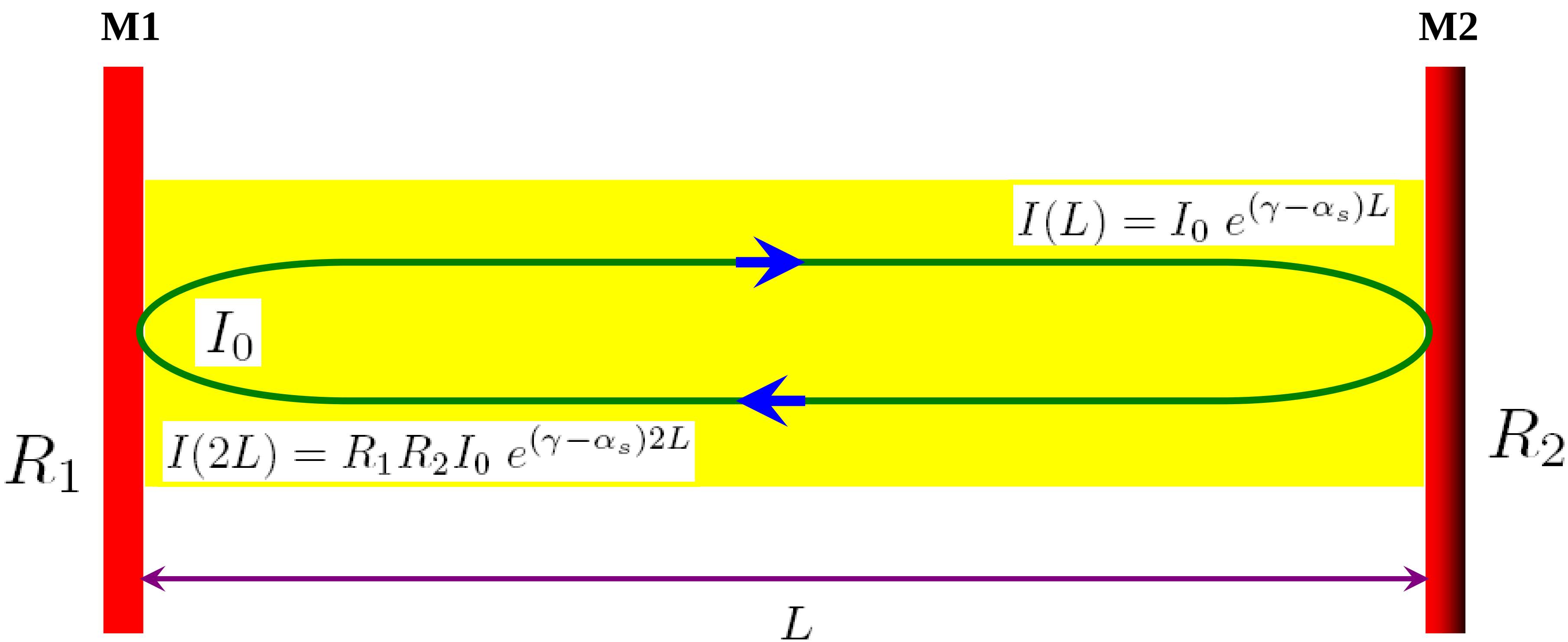
Three main components of **ANY** lasers are

(i) The active medium
(ii) The pumping source
(iii) The optical resonator

- The active medium acts as an **amplifier** for light waves
- For amplification, **medium** should be in a state of **Population inversion**
- Population inversion – **metastable levels** – lifetime is bit longer as compared to excited state
- The active medium placed inside an optical resonator – acts as an **oscillator**
- A pair of mirrors + active medium - optical resonators

Threshold condition for LASING action

- Output of the active medium bouncing back and forth in the optical resonator.
- During amplification it suffers various losses



The losses occur mainly due to

1. Transmission at the output mirror

2. Scattering, diffraction and absorption of light with in the active medium

- **Proper build up of laser oscillation:** The amplification between two constructive reflections of light from rear end mirror must balance the losses.

- Assume that the active medium of the laser fills the space between the mirrors **M1** and **M2.**

- The reflectivity of both mirrors are $\mathbf{R_1}$ and $\mathbf{R_2}$

- Mirrors be separated by a distance **L**

- Let the intensity of light beam at **M1** be $\mathbf{I_0}$

- Traveling from **M1** to **M2**, the beam intensity increases from

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

Where γ is the gain of the laser medium

α_s losses due to scattering, diffraction and absorption in the medium

After reflection at mirror M2, the beam intensity will be

$$I(L) = R_2 I_0 \, e^{(\gamma - \alpha_s)L}$$

After complete the round trip the final intensity will be

$$I(2L) = R_1 R_2 I_0 \, e^{(\gamma - \alpha_s)2L}$$

The amplification obtained during the round trip

$$G = \frac{I(2L)}{I_0} = R_1 R_2 \, e^{(\gamma - \alpha_s)2L}$$

The product R_1R_2 represents the losses at the mirror

The losses are balanced by gain, when the amplification factor

$$G \geq 1$$

It requires that

$$R_1 R_2 \, e^{(\gamma - \alpha_s)2L} \geq 1$$

$$e^{(\gamma - \alpha_s)2L} \geq \frac{1}{R_1 R_2}$$

$$(\gamma - \alpha_s)2L \geq ln\left(\frac{1}{R_1 R_2}\right)$$

$$\gamma - \alpha_s \geq \frac{1}{2L} ln \left(\frac{1}{R_1 R_2} \right)$$

$$\gamma \geq \alpha_s + \frac{1}{2L} ln \left(\frac{1}{R_1 R_2} \right)$$

The above equation is the condition for the lasing action

This equation is determined the threshold value of pumping energy for lasing action

As the pump power is slowly increased, a value of γ^{th} called threshold value is reached and the laser starts oscillations

The threshold value γ^{th} is given by

$$\gamma_{th} = \alpha_s + \frac{1}{2L} ln \left(\frac{1}{R_1 R_2} \right)$$