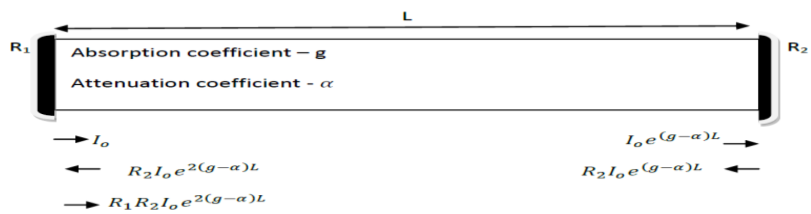
CL40_Q1. Discuss round trip gain in a laser medium and hence obtain the expression for threshold gain.

Ans:



The stimulated emission provides gain with a optical feedback mechanism of reflecting mirrors on both ends of the cavity. This arrangement results in multiple travel of the trapped optical beam in the medium. The gain of photons as the beam progresses is given by the intensity increasing as $\boldsymbol{I = I_o e^{gx}}$ where g is the gain coefficient.

However, there are also losses in the medium due to absorption, scattering and the partial transmission from one of the mirrors. The reduction in the intensity due to scattering and absorption is described by $\boldsymbol{I = I_o e^{-\alpha x}}$ where $\boldsymbol{\alpha}$ is the loss coefficient.

If I_0 is the starting intensity of photons from the mirror on one end, then the intensity after one round trip gain is given by $\boldsymbol{I = I_0 R_1 R_2 e^{2(g_o - \alpha)L}}$

The amplification factor is then the ratio of the output intensity to the input intensity and should be equal to $\boldsymbol{R_1 R_2 e^{2(g_o - \alpha)L}}$.

If $\boldsymbol{R_1 R_2 e^{2(g_o - \alpha)L}} > 1$,

Oscillations can build up and the laser is said to be above the threshold. The threshold of laser oscillations is then defined by $\boldsymbol{R_1 R_2 e^{2(g_o - \alpha)L} = 1}$

$$\boldsymbol{g_{th} = \frac{1}{2L}(2\alpha L - ln(R_1 R_2))}$$

CL40_Q2. Explain the necessary conditions for designing a laser cavity?

Ans:

An optical cavity, resonating cavity or optical resonator is an arrangement of mirrors that forms a standing wave cavity resonator for light waves. Optical cavities are a major component of lasers, surrounding the gain medium and providing feedback of the laser light.

Once the lasing action is initiated, the stimulated emission of the desired wavelength is amplified to get a sustainable laser action of sufficient intensity. The optical cavity has to be a narrow region whose length in the direction of propagation is a multiple of the desired wavelength. This also helps in eliminating undesired wavelengths and increases the monochromaticity. Also, because of its relatively longer length as compared to the wavelength of light, the resonator may support simultaneously several standing waves.

CL40_Q3. Find the number of modes of the standing waves and their frequency separation in the resonant cavity of length 1m of He-Ne laser operating at wavelength of 632.8 nm.

Ans:

Solution: Given L=1m, λ=632.8 nm

For a laser cavity of length L and wavelength λ, $L = \frac{n\lambda}{2}$

$$n = \frac{2L}{\lambda} = \frac{2 \times 1}{632.8 \times 10^{-9}} = 3160556$$

Frequency separation in cavity is, $\Delta v = \frac{v}{2L}$

For gas laser like He-Ne, $v \approx c$

$$\therefore \ \Delta v = \frac{c}{2L} = \frac{3 \times 10^8}{2 \times 1} = 1.5 \times 10^8 \ Hz$$