Laser Gain

The output power of the laser at specific moment is determined by two conflicting factors:

1. **Active medium gain** - which depends on:

a) **Population Inversion** .

b) **Fluorescence line-shape** of the spontaneous emission that is related to the lasing transition .

2. **Losses in the laser**, which include:

a) **Reflections from end mirrors**.

b) **Radiation losses inside the active medium** - due to absorption and scattering.

c) **Diffraction losses** - Due to the finite size of the laser components.

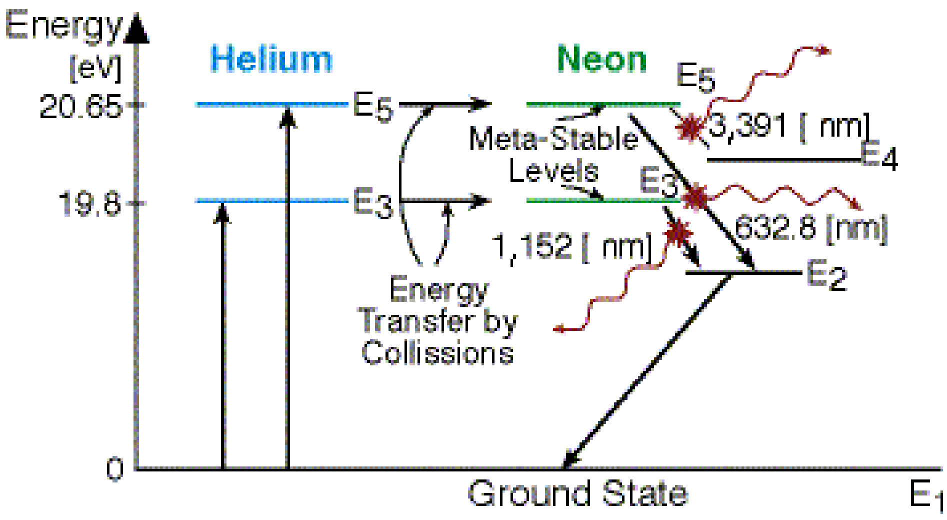
It is clear that a **required condition for lasing** is:

In a round trip path of the radiation between the laser mirrors, the gain must exceed (or at least be equal to) the losses.

Fluorescence line shape of the laser

Laser action inside matter is possible only for those wavelengths for which this material have fluorescent emission.

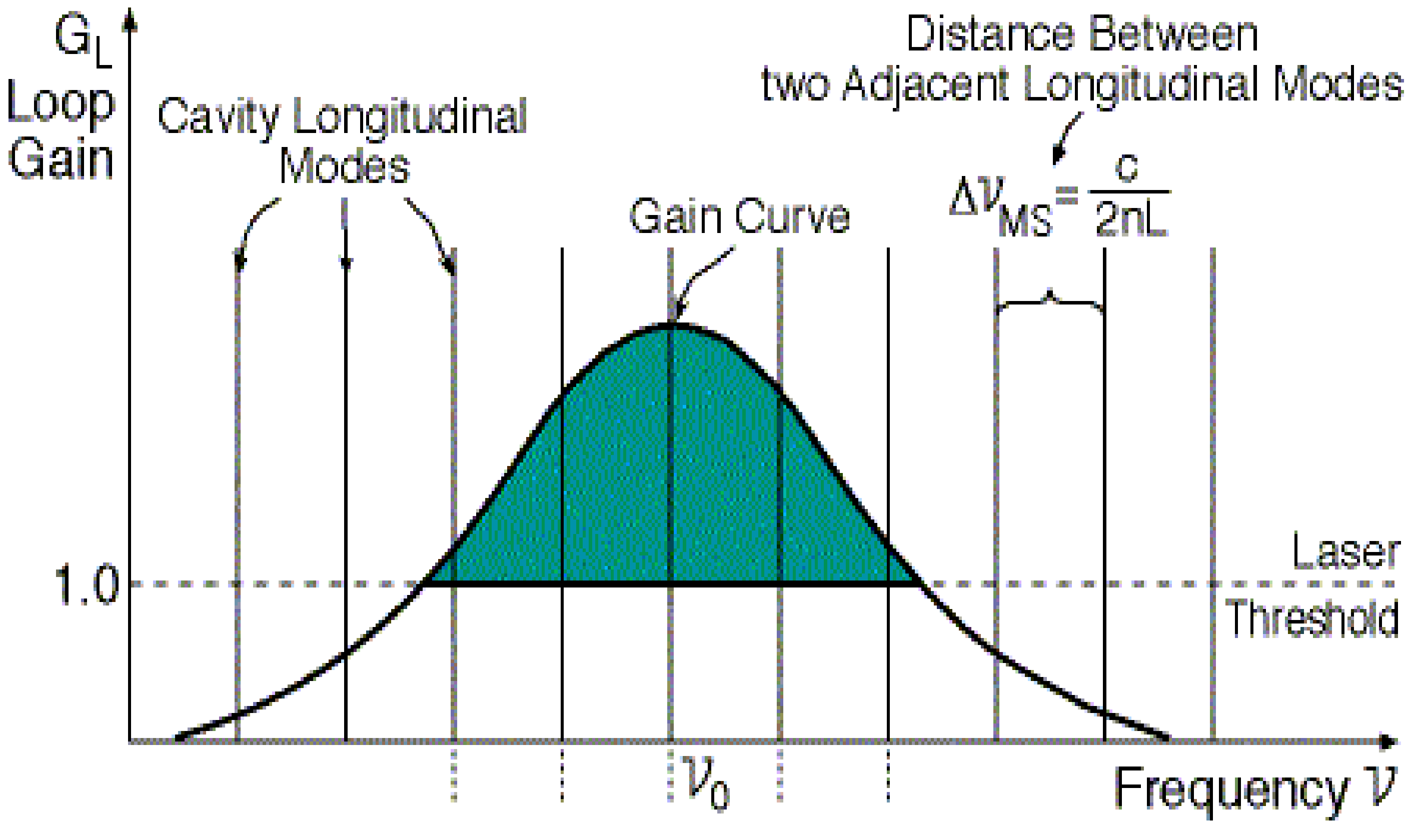
Fluorescence line is described by plotting spontaneous emission radiation intensity
as a function of frequency
(or wavelength),
for the specific lasing transition.



The main transition in the visible spectrum is from level E_5 to level E_2, and the emission is at **red wavelength of 632.8 [nm]**.

Gain Curve of the Active Medium

The gain curve of the active mediumis marked with the **lasing threshold** and **possible longitudinal modes of the laser.**



Longitudinal Modes in a Laser explains that **only specific frequencies are possible inside the optical cavity of a laser**, according to **standing wave condition**.

From all these possible frequencies, only those that have **amplification above certain minimum, to overcome**, will be emitted out of the laser.
This minimum amplification is defined as **lasing threshold**.
The condition of minimum amplification means that the amplification is equal to losses, so that in a round trip path inside the cavity $\mathbf{G_L = 1}$.

The height of each lasing line depends on the losses in a round trip inside the cavity, including the emitted radiation through the output coupler.

The marked region under the curve and above the lasing threshold include the range where lasing can occur.

The height of the gain curve depend on the length of the active medium and its excitation.

The **possible longitudinal modes** of the laser are marked as perpendicular lines at equal distances from each other.
Only frequencies from those allowed inside the cavity, are above the lasing threshold.

The Number of Longitudinal Optical Modes

In this laser 5 frequencies are allowed at the output, and they are spaced at equal distances, which are equal to the mode spacing:

$$\Delta\nu_{MS} = \frac{c}{2\,nL}$$

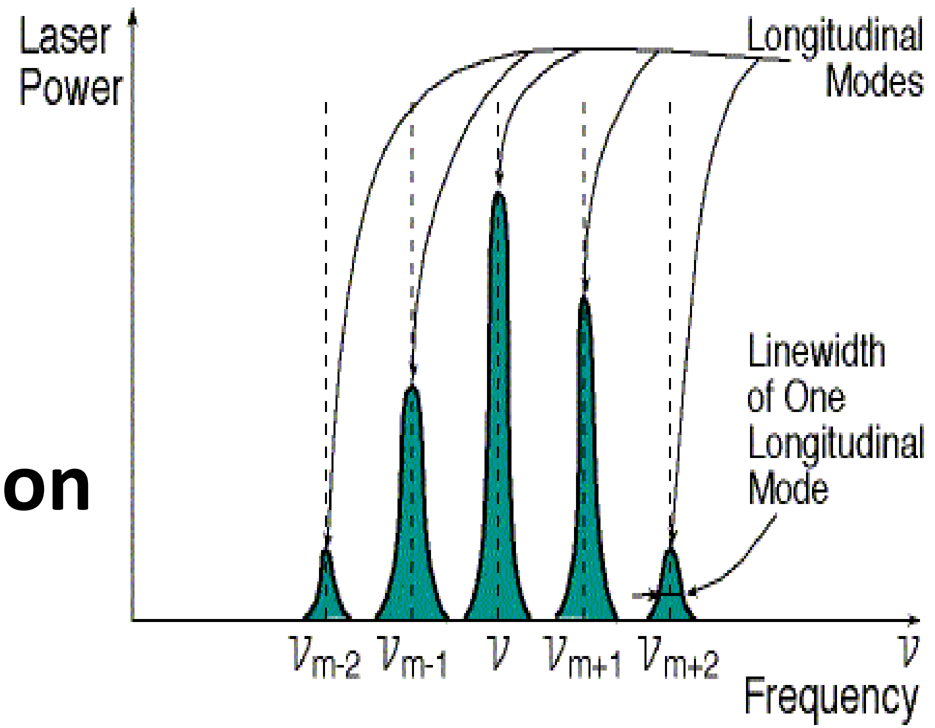


Figure: Spectral distribution of laser lines.