Nalanda Open University

B.SC Part-3

Course : Physics (Hons)

Paper : 7

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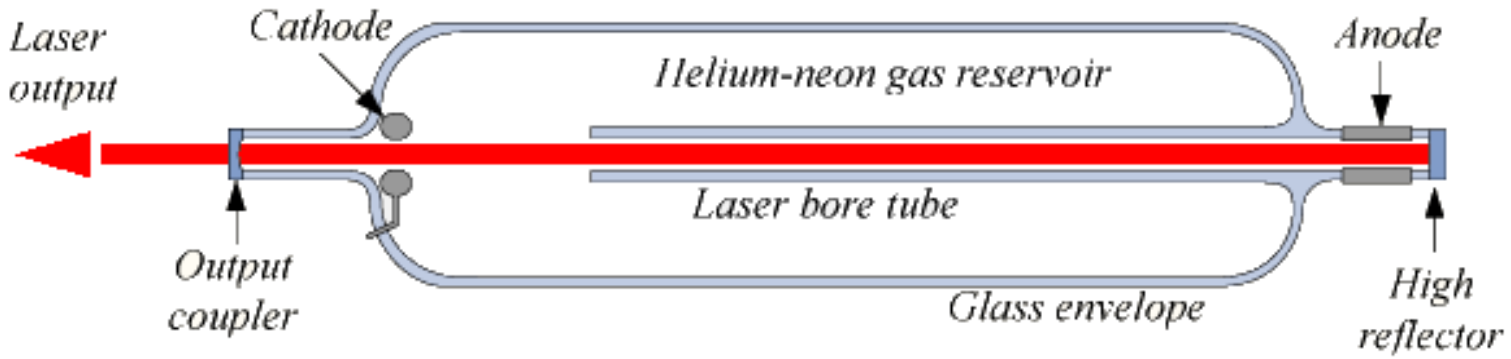
Topic- Laser (He-Ne Laser)

He-Ne Laser

He-Ne stands for Helium Neon. The He-Ne laser active medium consists of two gases which do not interact to form a molecule. Therefore He-Ne laser is one type of atomic gas lasers.

The construction of typical He-Ne laser plasma tube can be shown as:



The tube where the lasing action takes place consists of a glass envelop with a narrow capillary tube through the center. The capillary tube is designed to direct the electrical discharge through its small bore to produce very high current densities in the gas.

The output coupler and the HR (high reflective) mirror are located at the opposite ends of the plasma tube. To make laser tubes more economical and durable manufacturers often attach the mirror s directly to the ends of the capillary tube as shown above. This is very common with small low power lasers. With high power tubes or when optically polarized output is desired, the capillary tubes ends are cut at an angle and sealed with glass planes called Brewster windows. When this is done then the mirrors mush be mounted in mechanically stable but adjustable mounts. This allows the operator to align the mirror surfaces parallel to each other but perpendicular to the axis of the capillary tube.

The plasma tube has a large cylindrical metallic cathode and a smaller metallic anode. The current is directed from cathode to anode.

In figure shown, the gas reservoir provides a supply of extra gas. This reservoir helps to maintain a uniform pressure over long period of time and provides extra gas to replace any gas that may escape through the tube or through the seals where the loads pass through the glass envelop. Usually all He-Ne plasma tubes have a gas reservoir.

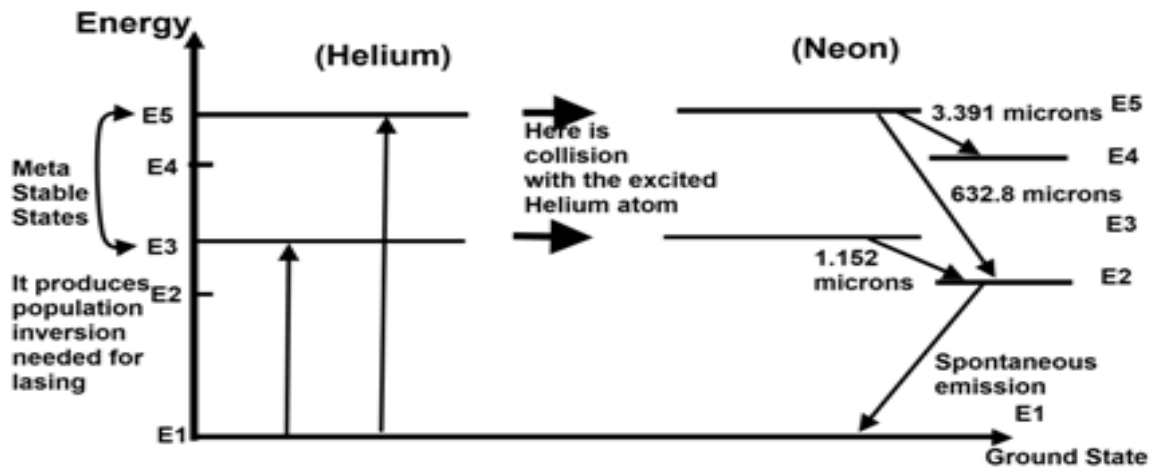
Note that! In He-Ne lasers active medium is low pressure gas mixture of Helium & Neon gas, which is contained in the plasma tube. The ratio of **He** to **Ne** within the tube vary from 5:1 to 20:1. Usually this ration average 8:1 can be considered.

Function of He-Ne

In the He-Ne laser the light is produced by atomic transitions within the Neon atom. The Helium does not directly produce laser light but it acts as a buffer gas, the purpose of which is to assist/help the atoms of the other gas to produce lasing in as manner.

When energy from the pumping source is applied He-Ne gas mixture then some of the energy is observed by the Helium atoms. In other words we can say that helium atoms achieve an excited state. Now when the Helium atoms move within the laser tube, they collide with the Neon atoms. At each collision some of the energy within the helium atom is transferred to the Neon atom and so raising it to an excited meta-stable state. When a sufficient number of Neon atoms reach to this state then population inversion occurs and hence the lasing can take place.

This can be shown by simplified energy level diagram as:



Helium Neon Laser Energy Level Diagram

Here upward transition shows the absorption of energy from the pumping source by Helium atom. While down ward transition shows the emission of energy / light or lasing present in the Neon atom only.

In diagram above there are 3 down word energy transitions for Neon that produce lasing. If transition occurs at the relatively small energy step from E5 to E4 then low energy infrared photon is released with a wavelength of 3.391 microns. If transition occurs at E5 to E2 which is much larger energy step then it produces short wavelength more energetic photon at 632.8nm. This gives the red light which is most desirable for He-Ne laser applications.

E3 to E2 then it produces a laser output at 1.152microns in infrared portion of the spectrum.

Note that! In all He-Ne lasers the feedback mechanism consists of pair of coated mirrors. The coating is usually reflecting mirror and 95%-99% of the light at output coupler. The reflection at the output mirror must be higher if the active medium is short in length because the gain of the active medium is low. If the active medium is longer more gain is produced an a larger percentage of the beam can be provided as an output. Therefore in He-Ne laser with a longer active medium, the reflectivity of the output coupler can be less.

Characteristics of He-Ne laser

The He-Ne laser is a relatively low power device with an output in the visible red portion of the spectrum. The most common wavelength produced by He-Ne lasers is 632.8nm, although two lower power (1.152μm and 3.391μm) infrared wavelengths can be produced if desired. Majority of He-Ne lasers generate less than 10m watt of power, but some can be obtained commercially with up to 50m watts of power. For He-Ne lasers the typical laser tube is from 10 to 100 cm in length and the life time of such a tube can be as high as 20,000 hours.

Advantages of He-Ne laser

- He-Ne laser has very good coherence property
- He-Ne laser can produce three wavelengths that are 1.152μm, 3.391 μm and 632.8nm, in which the 632.8nm is most common because it is visible usually in red color.
- He-Ne laser tube has very small length approximately from 10 to 100cm and best life time of 20.000 hours.
- Cost of He-Ne laser is less from most of other lasers.
- Construction of He-Ne laser is also not very complex.
- He-Ne laser provide inherent safety due to low power output.

Disadvantages of He-Ne laser

The weak points of He-Ne laser are

- It is relatively low power device means its output power is low.
- He-Ne laser is low gain system/ device.
- To obtain single wavelength laser light, the other two wavelengths of laser need suppression, which is done by many techniques and devices. So it requires extra technical skill and increases the cast also.
- High voltage requirement can be considered its disadvantage.
- Escaping of gas from laser plasma tube is also its disadvantage.

Suppressing unwanted wavelenghts in He-Ne laser

The He-Ne laser produces three different wavelengths that are 1.152μm, 3.391 μm and 632.8nm. At the 1st two the infrared photons are released while at the 3rd one i.e. 632.8nm more energetic photon of red color are released because in spectrum at 632.8 approximately red color occurs.

Since for He-Ne laser most applications, the red output is most desirable therefore it is necessary to suppress the infrared wave lengths and prevent them from lasing so that the energy directs into the desired output. In small He-Ne laser, it is normally done with proper coatings on the feedback mirrors. If they are coated for high reflectance at 632.8nm then they will not reflect a high percentage of eh infrared wavelengths. This causes the desired wavelength to have a low loss and the undesired wavelength to have a high loss, which reduces the possibility in the infrared wavelengths lasing and enhancer lasing at 632.8nm.

For high power He-Ne lasers the mirror coating cannot totally suppress the infrared wave length. Therefore in these lasers the magnet is placed near the plasma tube which provides an additional suppression effect on the infrared wavelength.

If these two suppression techniques are not enough to prevent infrared lasing than an infrared filter can be used between the laser mirrors to absorb the unwanted wavelengths.