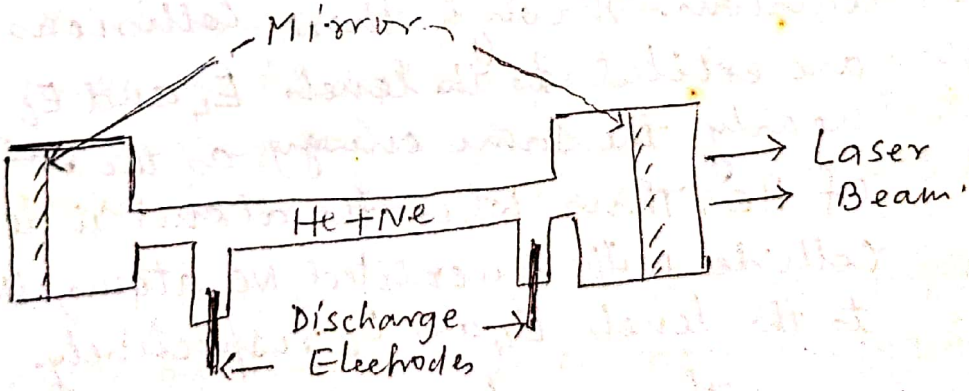
He - Ne Laser

Laser is a device which amplifies or generates radiation by means of the stimulated emission process. Its name is derived from the initials of Light Amplification by Stimulated Emission of Radiation. All lasers require an active medium for amplification in a narrow frequency region by population inversion achieved between a pair of energy levels. Under the condition of population inversion, the amplification of a wave occur as it passes through the active medium. This amplification is coherent.

The He-Ne laser is the most widely used laser with continuous power output in the range of a fraction of mW to tens of mW. It is easy to construct and is reliable in operation. It was the first gas laser to be operated successfully. It was fabricated by Ali Javan in 1961. It is four-level laser in which population inversion is achieved by electric discharge.

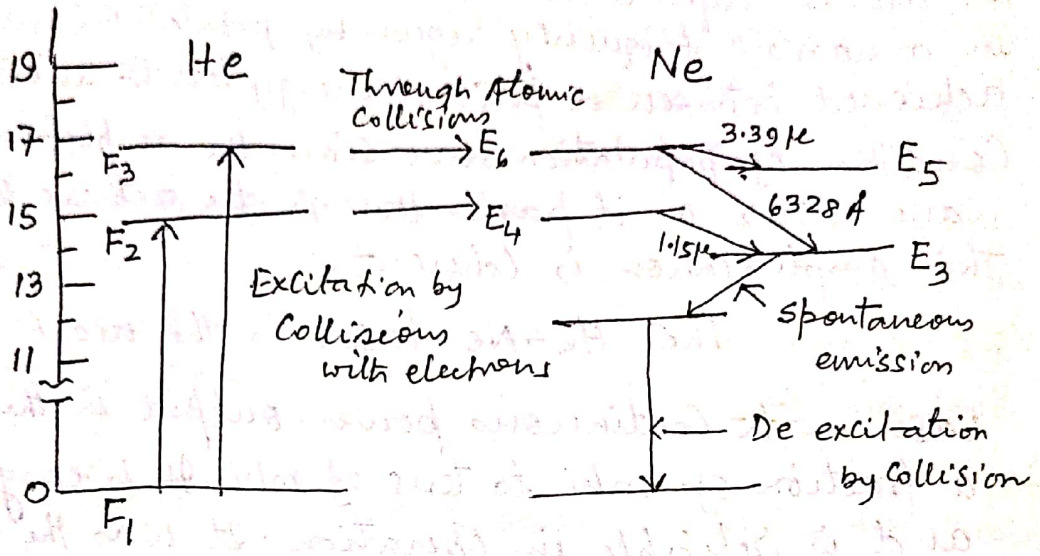
The He-Ne laser consists of a mixture of He and Ne in the ratio of about 10:1 placed



inside a long narrow tube (see fig). The pressure inside the tube is 1 Torr (= 1 mm of Hg). The gas system is enclosed between a pair of plane mirrors so that a resonator system is formed.

one of the mirror is of very high reflectivity while the other is partially transparent so that the energy may be coupled out of the system.

The Lasing action of He-Ne laser has been shown by the energy level diagram. The few first energy levels have been taken for convenience of fig.



When an electric discharge is passed through the gas, the electrons travelling down the tube collide with He atoms and excite them (ground state F_1) to the levels marked F_2 and F_3. These levels are metastable i.e. He atoms excited to these states where stay these levels for a sufficiently long time before losing energy through collisions. Through these collisions, the Ne atoms are excited to the levels E_4 and E_6 which have nearly the same energy as the ~~the~~ levels F_2 and F_3 of He. Thus when the atoms in levels F_2 and F_3 collide with unexcited Ne atoms, they raise them to the levels E_4 and E_6 respectively.

Thus, we have following two step process—

1. He atom in ground state F_1 + Collision with electron
   ⟶ He atom is excited to F_2 or F_3 state
   + electron with lesser kinetic energy

2. He atom in excited state F_3 + Ne atom in the ground state → He atom in ground state + Ne atom in excited state E_6

Similarly

He atom in excited state F_2 + Ne atom in the ground state

→ He atom in ground state + Ne atom is excited to E_4 state.

This results in the sizeable population of the levels E_4 and E_6. The population in these levels happen to be much more than those in the lower levels E_3 and E_5. Thus a state of population inversion is achieved and any spontaneously emitted photon can trigger laser action in any of the three transitions as shown in fig. The Ne atoms then drop down from the lower laser level E_2 through spontaneous emission. From the level E_2 the Ne atoms are brought back to the ground state through collisions with the walls. The transition from E_6 to E_5, E_4 to E_3 and E_6 to E_3 result in the emission of radiation having wavelength 3.39 μm, 1.15 μm and 6328 Å° respectively. The 6328 Å° transition correspond to the well known red light of He-Ne laser. Rest two are not in visible region.

A proper selection of different frequencies may be made by chosing end mirrors having high reflectivity over only the required wavelength range. The pressures of two gases must be so chosen that the condition of population inversion is not quenched. Thus, the condition must be such that there is an

efficient transfer of energy from He to Ne atoms. Referring to the fig, it may be mentioned that actually there are a large no. of levels grouped around E_2, E_3, E_4, E_5 & E_6. only those levels are shown in the fig which corresponds to the important laser action.

Gas lasers are, in general, found to emit light, which is more directional and more monochromatic. This is because of the absence of such effects as crystalline imperfection, thermal distortion and scattering, which are present in solid state laser. Gas lasers are capable of operating continuously without need for cooling.

Applications: Lasers have tremendous uses. Modulated laser beams have been used for communication. Lasers have been used by the medical professionals in surgery, where retinal tissues is cauterised to weld detached retina. They have been used by surveyors and engineers for critical alignment as well as for ranging in metrology and determining the distance of the moon. Attenuation and scattering of lasers beams have been used in atmospheric research. High power lasers have been used to cut through diamond and steel plates and to initiate thermo nuclear reactions. It has been used in the production and research with holograms. Also used to study Biological samples. During war-time lasers are used to detect and destroy enemy missiles. Now laser rifles, laser bombs are used. There are further many more applications.