22.5 Helium-Neon Laser

We will now briefly discuss the He-Ne laser which was first fabricated by Ali Javan and his coworkers at Bell Telephone Laboratories in USA. This was also the first gas laser to be operated successfully.

The He-Ne laser consists of a mixture of He and Ne of about 10: 1 placed inside a long narrow discharge tube (see Fig. 22.11). The pressure

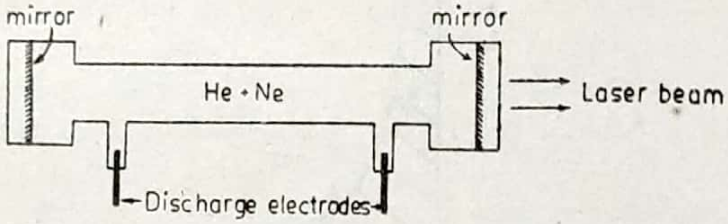

Fig. 22.11 The He-Ne Laser.

inside the tube is about 1 mm of mercury. The gas system is enclosed between a set of plane mirrors or a set of concave mirrors so that a resonator system is formed. One of the mirrors is of very high reflectivity while the other is partially transparent so that energy may be coupled out of the system.

The first few energy levels of He and Ne atoms are shown in Fig 22.12. When a discharge is passed through the gas, the electrons which travel

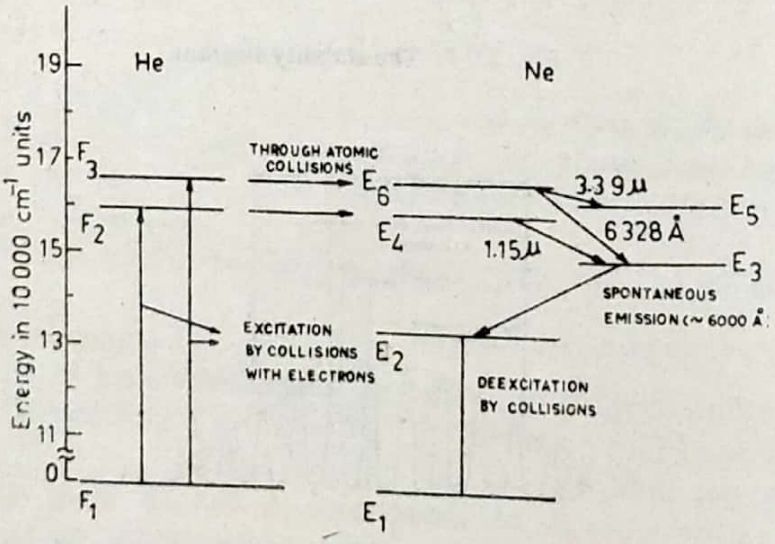

Fig. 22.12 Relevant energy levels of helium and neon.

down the tube collide with the He atoms and excite them to the levels marked F_2 and F_3. These levels are metastable, i.e. He atoms excited to these states stay in these levels for a sufficiently long time before losing energy through collisions. Through these collisions, the Ne atoms are excited to the levels marked as E_4 and E_6 which have nearly the same energy as the levels F_2 and F_3 of He. Thus when He 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. This results in a sizeable population of the levels

E_4 and E_6. The population in these levels happens to be much more than those in the lower levels E_3 and E_5. Thus a state of population inversion has been achieved and any spontenecously emitted photon can trigger laser action in any of the three transitions shown in Fig. 22.12. The Ne atoms then drop down from the lower laser levels to the 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 wavelengths 3.39μ, 1.15μ and 6328 Å respectively.* Proper selection of different frequencies may be made by choosing end mirrors having high reflectivity over only the required wavelength range. The pressures of the two gases must be so chosen that the condition of population inversion is not quenched. Thus the conditions must be such that there is an efficient transfer of energy from He to Ne atoms. Also since the level marked E_2 is metastable, electrons colliding with atoms in level E_2 may excite them to level E_3, thus decreasing the population inversion. The tube containing the gaseous mixture is also made narrow so that Ne atoms in level E_2 can get de-excited by collision with the walls of the tube.

Referring to Fig. 22.11, it may be mentioned that actually there are a large number of levels grouped around E_2, E_3, E_4, E_5 and E_6. Only those levels are shown in the figure which correspond to the important laser transitions.

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