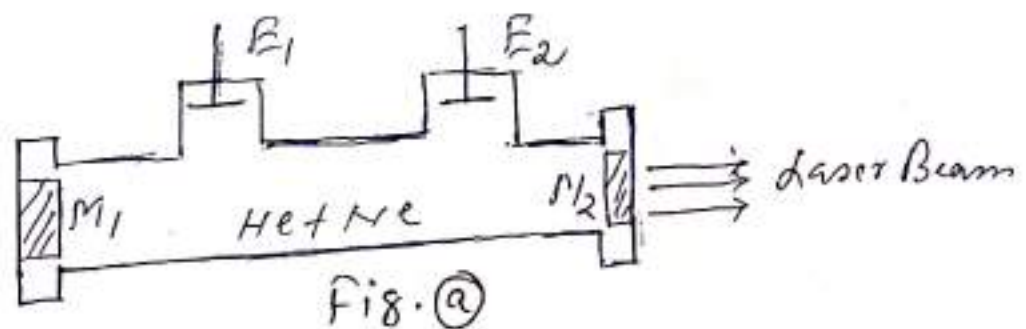


## Helium-Neon Laser :-

(9)

Construction :- It consists of a long and narrow discharge tube about 80 cm long and 1 cm in diameter, filled with a mixture of helium at a pressure of 1 mm and neon at a pressure of 0.1 mm of mercury column, which forms the laser medium. Two electrodes  $E_1$  and  $E_2$  are fitted to the discharge tube as shown in fig (a).  $M_1$  and  $M_2$  are the two mirrors which form a resonant cavity. The mirror  $M_1$  is fully reflecting and  $M_2$  is partially reflecting, so as to allow the laser beam to pass out of it.



Working :- As soon as the electric discharge passes through the mixture of He and Ne gases, electrons in the tube are accelerated. These collide with helium atoms and excite them to higher energy levels  $S_2$  and  $S_3$  as shown in figure (b). These levels of helium are metastable and the excited helium atoms remain in these levels for a long time before being de-excited. on the other hand

Some of the excited energy states, say  $E_4$  and  $E_6$  of neon corresponds very approximately to the energy state  $S_2$  and  $S_3$  respectively of helium.

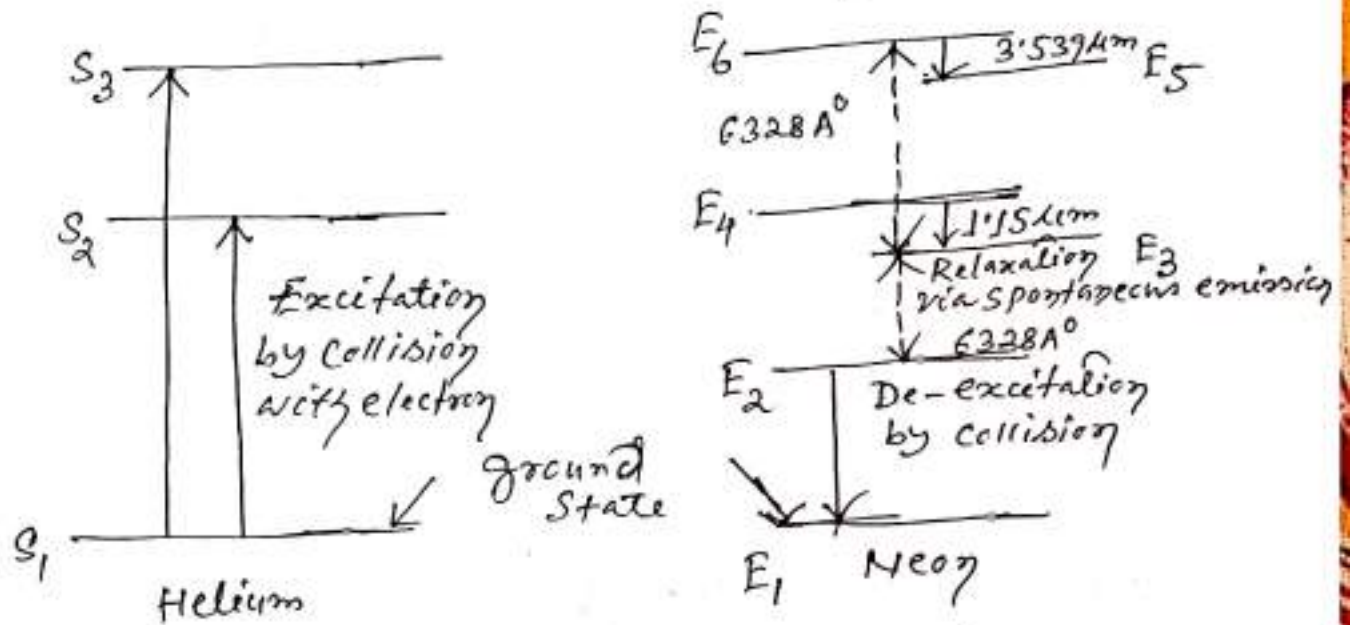


Fig.(b)

Because of this, when helium atoms in the energy states  $S_2$  and  $S_3$  collide with neon atoms in the ground state  $E_1$ , neon atom absorbs energy and are excited to the energy states  $E_4$  and  $E_6$ , where as helium atoms lose energy and are de-excited to the ground state  $S_1$ . This process continuously transfer more and more neon atoms from the ground state to the excited state  $E_4$  and  $E_6$ .

Slightly below the energy state  $E_4$  and  $E_6$ , there are two more energy state  $E_3$  and  $E_5$  and another energy state  $E_2$  in neon. Since  $E_4$  and  $E_6$  energy state is highly populated, there is a population inversion between the

State  $E_4$  and  $E_6$  and the lower energy state  $E_3$  and  $E_5$ . Transition between  $E_6$  and  $E_5$ ,  $E_4$  and  $E_3$  and  $E_6$  and  $E_2$  respectively lead to emission of wavelength  $3.539 \mu\text{m}$ ,  $1.15 \mu\text{m}$  and  $6328 \text{ \AA}$ . The first two lie in the infrared region and the last corresponds to the red light from the He-Ne laser in the visible region, which is generally used as a laser beam for experimental and other purposes. Selection of a suitable frequency is made by using mirrors which reflect only a small range of frequency band.

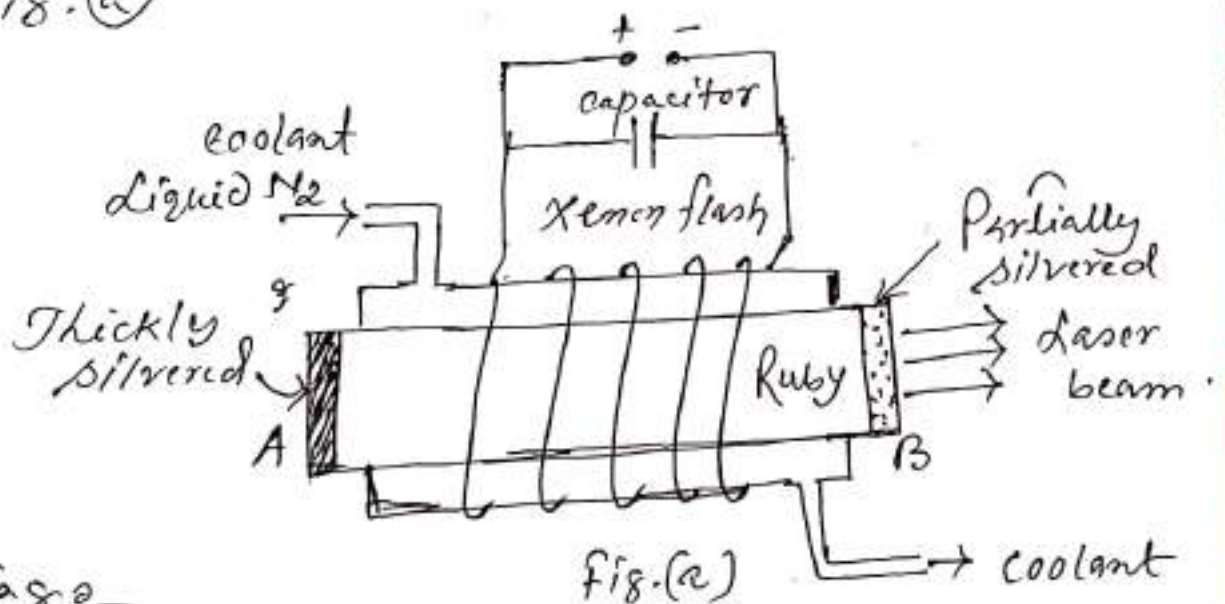
Operational wavelength:- The emission wavelength of He-Ne laser are  $1.15 \mu\text{m}$ ,  $3.539 \mu\text{m}$  and  $6328 \text{ \AA}$ . The first two lie in infrared region and the last one corresponds to <sup>the</sup> red light in the visible region. This wavelength  $6328 \text{ \AA}$  is therefore operational wavelength.

### Rubi laser:-

Rubi laser is a solid state laser. It makes use of the three level scheme of population inversion with a ruby as a solid state laser element.

Construction:- Rubi rod is taken in the form of a cylindrical rod of about

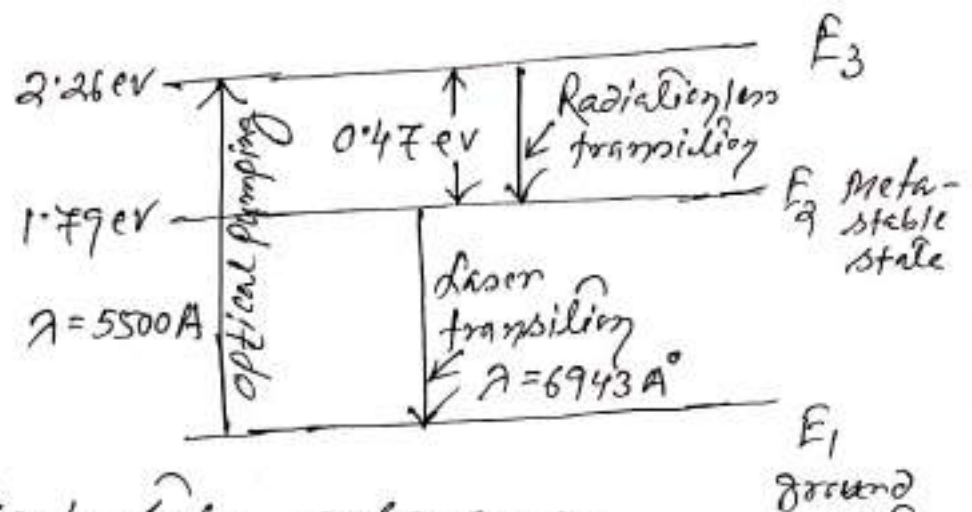
40 cm in length and 0.5 cm diameter. Both the end faces of the crystal are made optically flat and silvered. One face A is thickly coated to become fully reflecting, while the other face B is partially coated to make it reflecting. The rod is surrounded by a cylindrical glass tube, through which liquid nitrogen is circulated to keep the rod cool. A Xenon flash tube is wound round the glass cylinder, so that the ruby rod lies along its axis. It is connected to a suitable source of power supply and made to flash for a few milli-second. A schematic diagram of the Ruby-laser is shown in fig. (a)



### Working:-

Ruby laser uses a three level pumping scheme. Ruby consists of a crystal of  $Al_2O_3$  doped with 0.03 to 0.05% of  $Cr_2O_3$  (chromium oxide), so that  $Cr^{3+}$  ions replace some

of the Al atoms. The crystal field splits (ii) up the energy levels of  $\text{Cr}^{+3}$  ions in such a way that it has a short lived energy state  $E_3 = 2.26 \text{ eV}$  and an intermediate metastable energy state  $E_2 = 1.79 \text{ eV}$  above the ground state  $E_1$ , as shown in fig. (b)



The xenon flash tube acts as an optical pump and only a small fraction of the energy emitted by it in the form of blue green radiation of  $\lambda = 5500 \text{ \AA}$ , corresponding to energy level  $E_3 - E_1$ , is absorbed by the ruby and used to excite the  $\text{Cr}^{+3}$  ions. The rest of the energy is used in heating the apparatus, which therefore, has to be kept cold by circulating liquid  $\text{N}_2$  through the glass tube surrounding the Ruby rod.

The excited  $\text{Cr}^{+3}$  ions are excited to the energy level  $E_3$  and quickly jump to the metastable state  $E_2$  by a non-radiative process. As a result the level  $E_2$  becomes more populated than the level  $E_1$ .

Such a system with population inversion is very unstable. Once the stimulated emission is started photons of energy  $1.79 \text{ eV}$  corresponding to red light of  $\lambda = 6943 \text{ \AA}$  are continuously produced. These photons so produced undergo multiple reflections from the silvered ends of the crystal till the beam becomes sufficiently intense to emerge out of the partially silvered end. Thus, a highly intense, monochromatic, coherent and unidirectional beam is obtained.

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