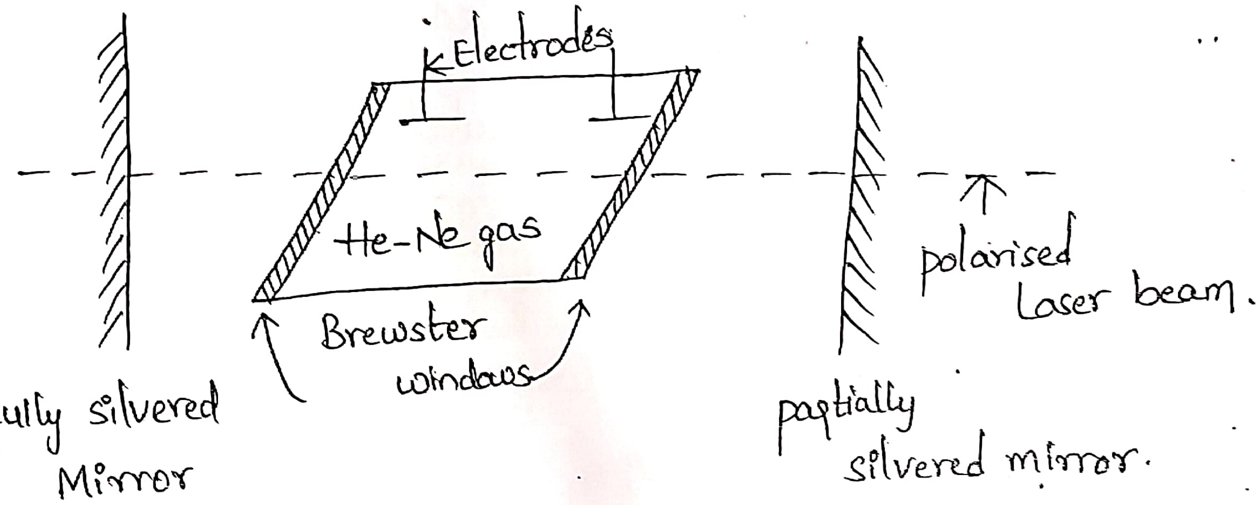
He-Ne Laser :—

The main drawback of Ruby laser is th the output beam is not continuous through very in. For the Continuous laser beam, gas lasers are used. For increased efficiency and Continuous emission of laser, we prefer the Helium -Neon laser. This is a gaseous state Laser, fabricated by Ail Javan. The experimental set-up as shown in fig:



Construction:—

It Consists of a large and narrow discharge tube which is filled with a mixture of Helium and Neon gases in the ratio of 10:1 with partial pressures of 1 torr and 0.1 torr.

The actual lasing atoms are neon atoms and Helium is used for selective pumping of the laser levels of neon. The gas mixture will serve as active medium.

The discharge that takes place between the two electrodes exciting the Helium atoms and in turn neon atoms will acts as a source of energy.

is The discharge tube is enclosed between fully
very & partially reflective mirrors which serve as optical
ed. (or) Resonator. The two end windows are set at
aser Brewster's angle, so that the reflected radiations from
is the mirror entering into tube become polarised. Thus,
only the Component having vibrations parallel to the
plane of incidence become dominent and sustains
Laser emission. The emerging Laser is linearly polarised.

Working :- when a voltage of about 1000V is applied
between the electrodes, then electric discharge
takes place through the gas in the tube. The free
electrons accelerate towards the positive electrode.
In their journey, some of these electrons collide
with majority Hellium atoms in the tube.

when a fast moving electron collides with
ground state 'He' atoms then the Helium atoms
are pumped to F_2 and F_3 of 'He' as shown in fig.
These excited atoms make collisions with the neon
atoms present in the ground state and excite them
into E_4 and E_6. The populations in these levels more
than those in the lower energy levels E_3 and E_5.
Thus, a state of population inversion is achieved.
During the collision, Resonance transfer of energy
from 'He' to 'Ne' atoms takes place because the
F_2, F_3 energy levels of the atoms are very close

$\nu + \Delta\nu$ ... the ... in ... frequency ...

with E_4 and E_6 energy levels of Neon

The excited neon atoms transit to ground in three different ways leading to three different wavelengths. They are.

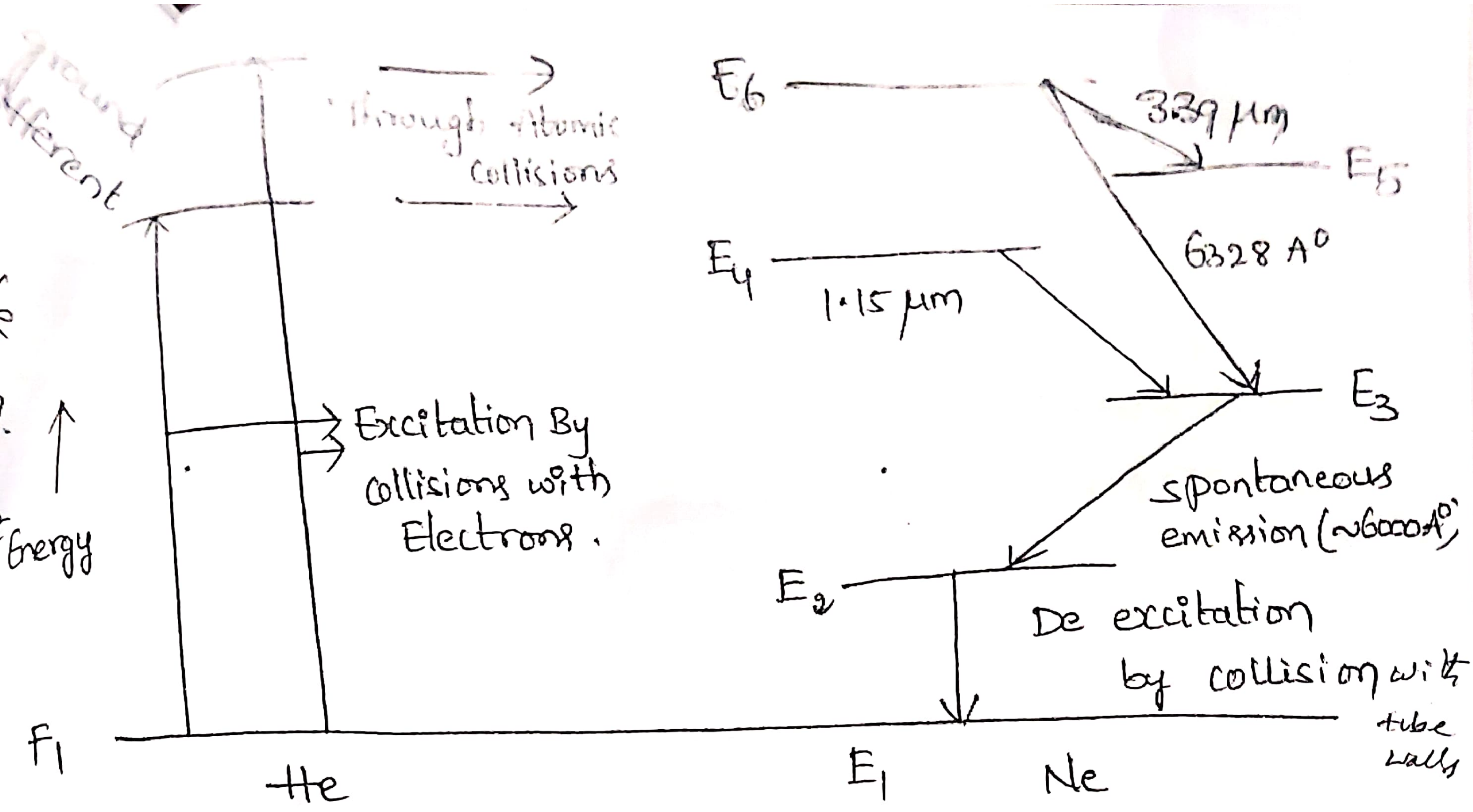
(1) The transistions from E_6 to E_5, result in the emission of radiation having wavelengths 3.39 μm.

(2) The transitions from E_4 to E_3, result in the emission of radiation having wavelengths 1.15 μm. These two wavelengths are in infrared region are invisible.

(3) The transition from E_6 to E_3, result in the emission of radiation of wavelength 6328 A° is in red colour.

The transition from E_3 to E_2 is spontaneous from E_2, the neon atoms get de-excited by collision with the walls of the discharge tube.

The optical cavity enchances the stimulated emissions. Red laser light comes out of the partially silvered mirror.



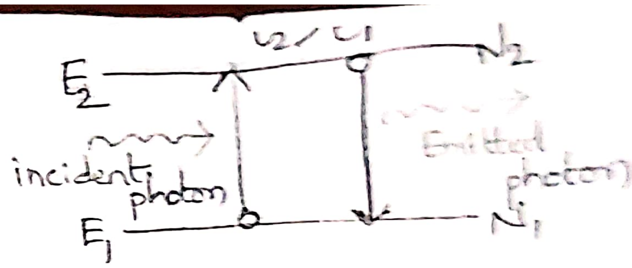
Advantages :-

1. Gas laser emit more monochromatic and directional laser radiations when compared to solid state lasers.

2. He-Ne laser emits continuous laser radiations.

3. Due to setting of end windows at Brewster's angles the output laser is linearly polarised.

s coefficients :-



...der two energy levels of ...ergies E_1 and E_2 such that $E_2 > E_1$. Let N_1 and N_2 be the number of atoms per unit volume of E_1 and E_2. In the presence of incident radiation (photon), the atoms in E_1 get Excited and we have stimulated absorption of radiation.

The number of stimulated absorption of radiation $= N_1 B_{12} \rho(\nu)$

The excited of atom while transiting to lower energy level E_1 emits a radiation.

The number of spontaneous emission of radiation $= N_2 A_{21}$

The number of stimulated emission of radiation $= N_2 B_{21} \rho(\nu)$

At thermal Equilibrium state.

$$N_1 B_{12} \rho(\nu) = N_2 A_{21} + N_2 B_{21} \rho(\nu)$$

$$\rho(\nu) [N_1 B_{12} - N_2 B_{21}] = N_2 A_{21}$$

$$\rho(\nu) = \frac{N_2 A_{21}}{[N_1 B_{12} - N_2 B_{21}]}$$

Dividing the ~~number~~ numerator and denominator with N_2

$$\rho(\nu) = \frac{A_{21}}{\left[\frac{N_1}{N_2} B_{12} - B_{21}\right]}$$

$$\rho(\nu) = \frac{A_{21}}{B_{12}\left[\frac{N_1}{N_2} - \frac{B_{21}}{B_{12}}\right]} \longrightarrow (1)$$

From Boltzmann's Equation

$$N_2 = N_1 e^{-(E_2-E_1)/K_BT}$$

$$\frac{N_1}{N_2} = e^{(E_2-E_1)/K_BT}$$

But $E_2-E_1 = h\nu$

$$\frac{N_1}{N_2} = e^{h\nu/K_BT} \longrightarrow (2)$$

Substituting the above value in Equ (1), we get

$$\rho(\nu) = \frac{A_{21}}{B_{12}\left[e^{h\nu/K_BT} - \frac{B_{21}}{B_{12}}\right]} \longrightarrow (3)$$

From plank's radiation law, we get

$$\rho(\nu) = \frac{8\pi h\nu^3}{c^3}\left[\frac{1}{e^{(h\nu/K_BT)}-1}\right] \longrightarrow (4)$$

h is planck's Constant ν is frequency
c velocity of light
Comparing the above two equations, we get

$$\frac{B_{21}}{B_{12}} = 1 \Rightarrow B_{21} = B_{12}.$$

$$\frac{A_{21}}{B_{12}} = \frac{8\pi h\nu^3}{c^3}$$

$$A_{21} = B_{12}\left[\frac{8\pi h\nu^3}{c^3}\right]$$

$$A_{21} = B_{21}\left[\frac{8\pi h\nu^3}{c^3}\right]$$

The above equations represent relation between Einstein's coefficients.

No. of stimulated emissions $\propto$

$$\propto \rho(\nu)$$
$$\propto N_2 \rho(\nu)$$
$$= N_2 B_{21} \rho(\nu)$$

B_{21} is Known as Einstein's Coefficient of stimulated emission of radiation.

Distinction between spontaneous and stimulated Emission of Radiation.

Spontaneous emission	stimulated emission.
1. spontaneous emission takes place when an atom in higher energy state transits.	1. stimulated emission takes place when the atom in higher energy state gets stimulated by the incident photons and transists to lower energy state.
2. spontaneous emission is independent of incident radiation density.	2. stimulated emission depends upon the incident radiation density.
3. It takes place after 10^{-8} seconds	3. It takes place with in a time of 10^{-8} seconds.
4. It is a slow process Compared to stimulated emission.	4. It is fast process.

Incident radiation ...

Applications of LASER :—

Industry :—

1. Lasers can be used as a welding tool
2. Lasers are used to cut glass and quartz
3. Lasers are used to drill holes in Ceramics, to drill aerosol nozzles.
4. Lasers are used for heat treatment in the tooling and automotive industry.
5. Lasers are used in electronic industry in trimming the Components of ICs.
6. In plastic industry, polymers are obtained by irradiating monomers by Lasers.

Medicine :—

1. opthalmologists use Laser for attaching the retina in retinal - deatachment cases.
2. Lasers are used for cataract removal.
3. Lasers are used for eye lens curvature corrections.
4. Lasers are used for bloodless surgery.

Nd : YAG Laser :— (10M)

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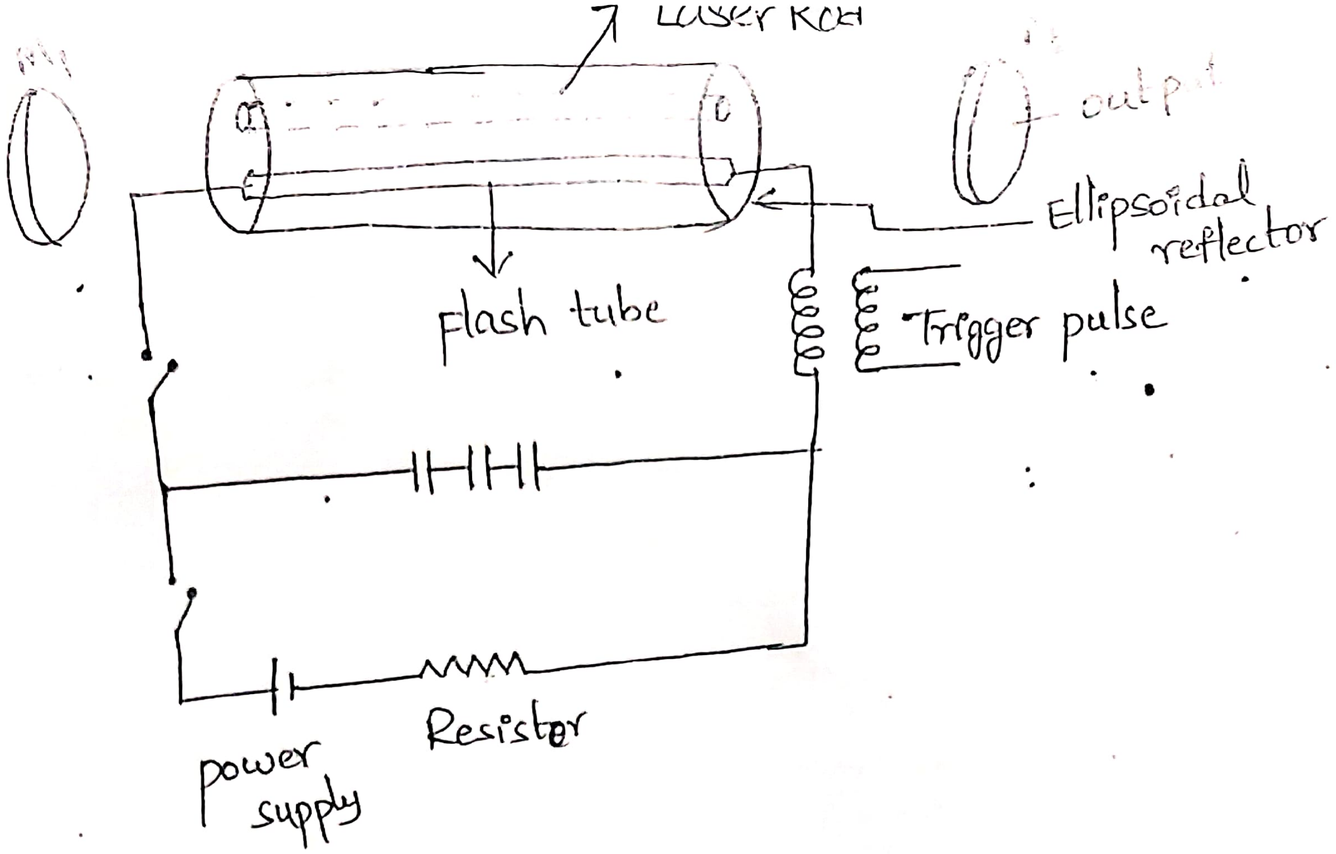


Construction :-

It Consists of three main parts.

1. Active medium : Nd^{+3} ions in Nd : YAG Laser Rod.
2. A resonant cavity : Made of fully reflecting mirror of left laser rod (Nd : YAG) and a partially reflecting mirror at the right of the Laser rod. Both mirrors are exactly parallel to eachother.
3. Exciting system : Krypton flash lamp with power supply

Nd : YAG (neodymium doped yttrium Aluminium Garnet) is a Crystal that is used as a lasing medium for solid state Lasers. The dopant triply ionised (Nd^{3+}) neodymium replaces the small fraction (1%) of yttrium ions in the host crystal structure of the crystal (YAG). Nd^{3+} acts as active medium.

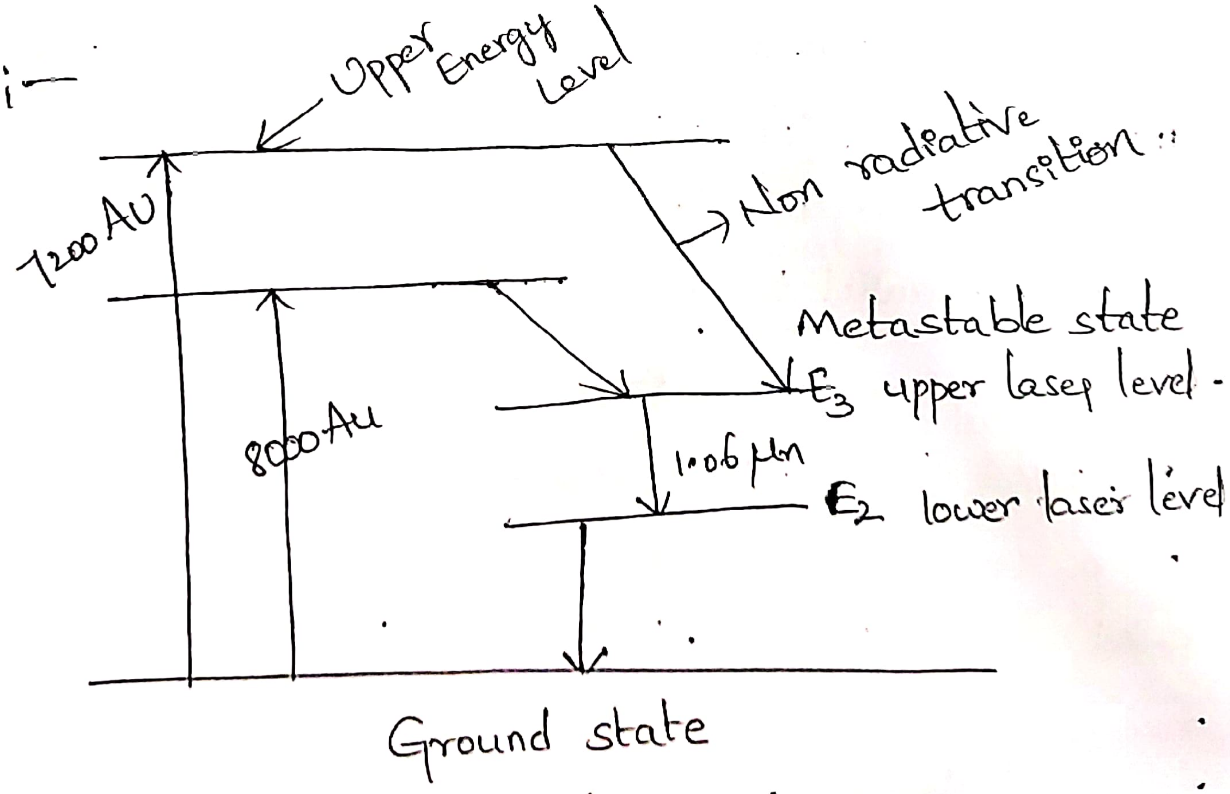
The length of laser rod varies [illegible]
depending on the power of laser and diameter [illegible]
6 to 9 mm.

The laser rod and a linear flash lamp placed in [illegible] elliptical reflector cavity at foci of the ellipse. so the light emitted by lamp is effectively coupled to the ~~Rod~~ laser rod.

the ends of the rod are polished and made optically flat and papallel. The optical cavity by using two external reflecting mirrors as shown in fig one mirror is made fully reflecting while the other mirror is left slightly transmitting to draw the output.

The system is cooled by either air (or) water circulation.

Working :-



Nd:YAG is a four level system. The pumping of Neodymium (Nd^{3+}) ions to upper level (E_4) is done using Kripton flash lamp. Thus optical pumping is used in this Laser.

2. The wave length of light 7200 AU to 8000 AU excites the ground state (E_1) Nd^{3+} ion to E_4 states. From E_4 states. They make a non radiative transition and come to E_3 state. E_3 is the metastable state, so population inversion is achieved between E_3 & E_2.

3. After this process of stimulated emission will occurs. Thus, the laser emission will occur in between the levels E_3 and E_2 with the process of stimulated emission. Here E_3 - upper laser level and E_2 - lower laser level.

4. Then Nd^{3+} ions come back to ground state E_1 occur in infrared region of spectrum.