① 11/04/25

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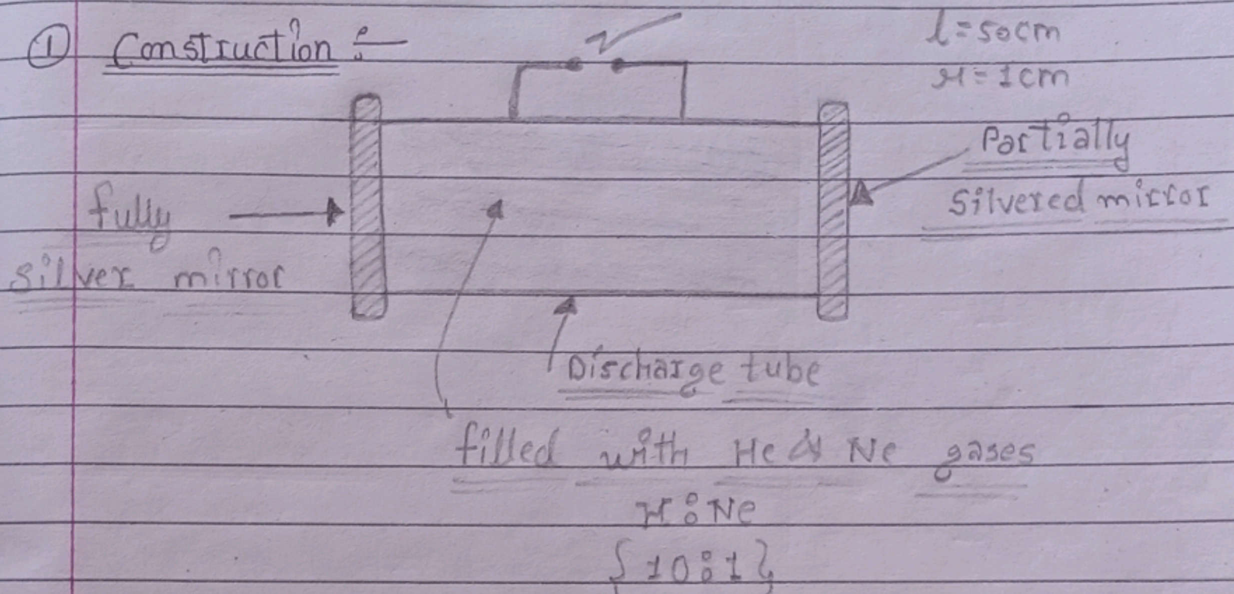
÷ Assignment ÷

Engineering Physics "BT-201"

Q.1 :- Explain Construction & working of He-Ne laser

① Construction :-



① It is a gaseous laser
② It Consist of a discharge tube of length 50cm & diameter 1cm.
③ This tube is filled with He & Ne gases in the ratios of 10:1
④ Their is a fully silvered mirror at one end and partially silver mirror on the other end of the discharge tube.
⑤ Two electrodes are connected with discharge tube to provide electrical discharge.

② Working of He-Ne laser :-

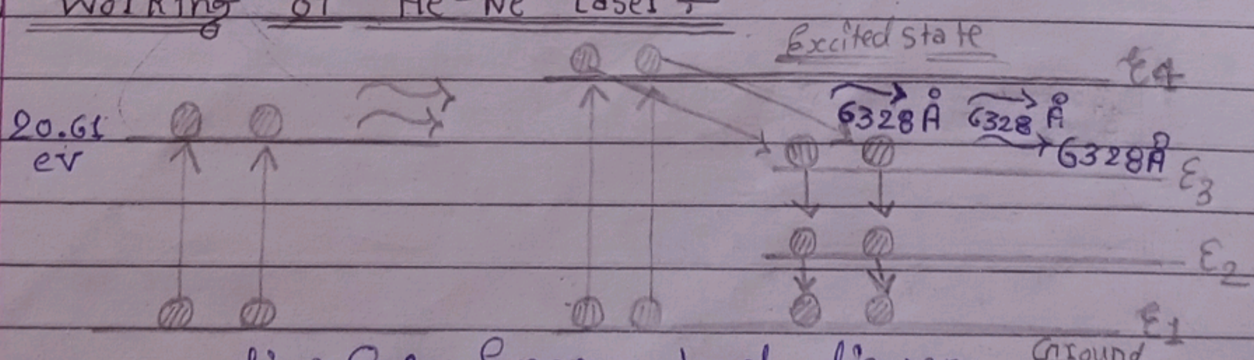


fig:- ~~Enrgy~~ Energy level diagram

⇒ Initially He & Ne atoms are at the ground state, then we flow current through the mixture of He & Ne gases.

⇒ By Absorbing the Energy the He & Ne atoms are raised to Excited State

⇒ Ne atoms are Excited by two ways, one due to flow of the current and second ~~due~~ to Collision by He atoms.

⇒ From Excited state E_4 (20.66eV). Ne atoms Come down to E_3 energy level by spontaneous emission of photon wavelength 6328Å / If this strikes on other E_4 Energy level Ne - atom then the other will Come down by stimulated emission of two photons (6328Å)

⇒ from E_3 Energy level Ne-atoms Comedown to E_2 level and then E_1 level by transferring their energy to other ground state atom.

APPLICATION (USES):-

1. This Laser is operating in Contineous mode.
2. This laser is mainly use for Barcode Reading
3. Efficiency of this laser is higher than Ruby Laser.
4. This laser is used for targeting an object.
5. This laser is used for industrial work and Research or Study work.

Q.8: Write short notes on – Properties of laser
– Stimulated Emission
– Application of laser

⇒ **Properties of laser light**

① **Coherent:** Laser light waves are coherent wave (having same phase & frequency) where as ordinary light waves are not coherent

② **Monochromatic:** Laser light waves are monochromatic, where as ordinary light wave are not Monochromatic

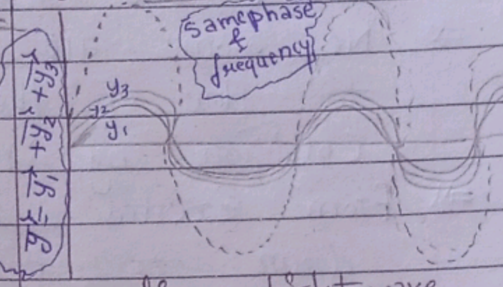
Means single wavelength closed

③ **Directionality:** Laser light does not diverge with distance, where as ordinary light diverges

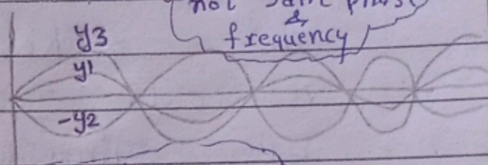
④ **Intensity:** Intensity of laser light is very high as compare to ordinary light.

⑤ **Distance:** Laser light travel longer distance as compare to ordinary light.

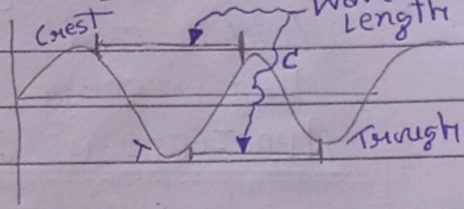
Diagram: Laser light wave



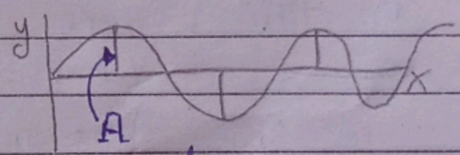
ordinary light wave
not same phase & frequency



$\vec{y} = \vec{y_1} - \vec{y_2} + \vec{y_3}$



$I \propto A^2$



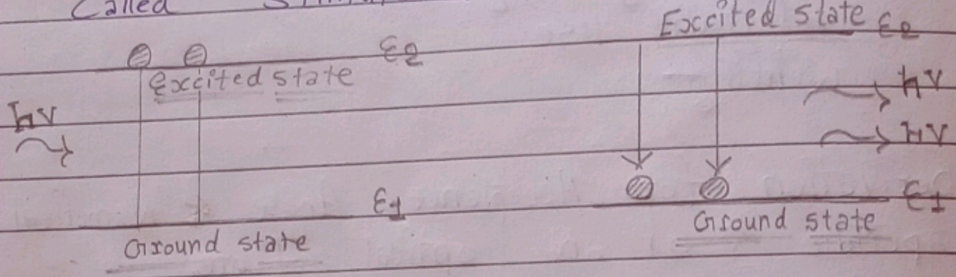
Amplitude

Displacement on y-axis

$y = A \sin \omega t$
or
$y = A \cos \omega t$

Stimulated Emission :-

When atom is at higher energy state and other photon are incident on it, then whenever this atoms comes down to ground state, it emits two photon of same frequency and phase, this phenomenon is called stimulated emission



Probability of Stimulated emission :-

⇒ It is directly proportional to energy density $u(\nu)$. It is given by $B_{21}\, u(\nu)$

where B_{21} is a constant known as Einstein Coefficient of stimulated emission.

⇒ Total Probability of an atom of higher energy state to come down to the ground state is given by

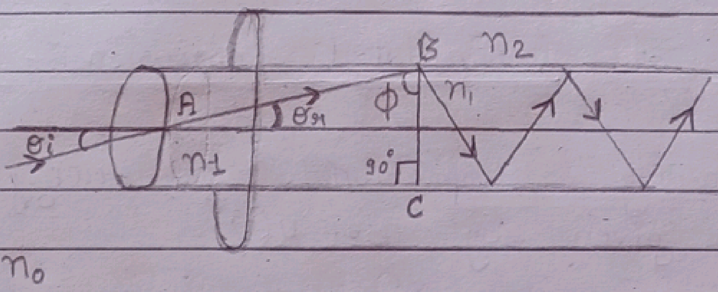
$$\boxed{P_{21} = A_{21} + B_{21}\, u(\nu)}$$

ical angle

Application of laser :-

1. Helium Neon laser
2. Distance Measure
3. Surgery
4. Medical field CO_2 AND Nd-YAG laser
5. Laser shows
6. Skin Tightening
7. Industrial use
8. Welding

Q.3:- Derivation for Acceptance Angle & Numerical aperture of an optical fibre.



let n_0, n_1 & n_2 be the refractive index of outside medium, core, cladding. respectively then by Applying Snel's law at point A

$$\frac{\sin\theta_i}{\sin\theta_r} = \frac{n_1}{n_0}$$

$$\sin\theta_i = \frac{n_1}{n_0} \cdot \sin\theta_r \quad \text{— (1)}$$

By ΔABC, $\theta_r + \phi + 90 = 180^\circ$

$$\theta_r = 90 - \phi$$

By placing this value in Eqn (1)

$$\sin\theta_i = \frac{n_1}{n_0}\sin(90-\phi)$$

$$\sin\theta_i = \frac{n_1}{n_0}\cos\phi \quad \text{— (2)}$$

when $\theta_i = \theta_{max}$ then, $\phi = \phi_c$ c is critical angle

$$\sin\theta_{max} = \frac{n_1}{n_0}\cos\phi_c \quad \text{— (3)}$$

At point B by applying Snel's law

$$\frac{\sin\phi_c}{\sin 90} = \frac{n_2}{n_1}$$

$$\sin\phi_c = \frac{n_2}{n_1} \Rightarrow \cos\phi_c = \sqrt{1-\frac{n_2^2}{n_1^2}}$$

$$\cos\phi_c = \frac{\sqrt{n_1^2-n_2^2}}{n_1}$$

By placing this value in Eqn (3)

$$\sin\theta_{max} = \frac{\cancel{n_1}}{n_0}\frac{\sqrt{n_1^2-n_2^2}}{\cancel{n_1}}$$

$$\sin\theta_{max} = \frac{\sqrt{n_1^2-n_2^2}}{n_0}$$

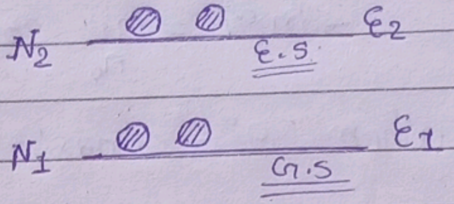
If first medium is air $n_0 = 1$

$$\cancel{\theta_{max} =} \quad \boxed{\sin\theta_{max} = \sqrt{n_1^2-n_2^2}} \rightarrow \text{Numerical aperture}$$

$$\theta_{max} = \sin^{-1}\sqrt{n_1^2-n_2^2} \rightarrow \text{acceptance angle}$$

Q.04: Prove that the ratio of A_{21} & B_{21} Coefficients is directly proportional to ν^3 $\left(\frac{A_{21}}{B_{21}} \propto \nu^3\right)$

Let N_1 atoms are at the ground state. &
N_2 atoms are at Excited state



Probability of N_1 atoms to move to Excited state is –

$$N_1 P_{12} = N_1 B_{12}\, u(\nu) \quad \text{—} (1)$$

Probability of N_2 atoms to comedown to ground state is –

$$N_2 P_{21} = N_2 \left(A_{21} + B_{21}\, u(\nu)\right) \quad \text{—} (2)$$

from Eqn (i) & (ii)

$$N_1 P_{12} = N_2 P_{21}$$

So

$$N_1 B_{12}\, u(\nu) = N_2 \left(A_{21} + B_{21}\, u(\nu)\right)$$

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

$$\left(N_1 B_{12} - N_2 B_{21}\right) u(\nu) = N_2 A_{21}$$

$$u(\nu) = \frac{N_2 A_{21}}{\left(N_2 B_{12} - N_2 B_{21}\right)}$$

$$u(\nu) = \frac{\cancel{N_2} A_{21}}{\cancel{N_2}\left(\frac{N_1}{N_2} B_{12} - B_{21}\right)}$$

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

$$\mu(\nu) = \frac{A_{21}}{B_{21}\left(\frac{N_1}{N_2}\frac{B_{12}}{B_{21}} - 1\right)}$$

In thermodynamic Equilibrium condition $\therefore B_{12} = B_{21}$

So, $$\mu(\nu) = \frac{A_{21}}{B_{21}\left(\frac{N_1}{N_2} - 1\right)} \quad \text{——} \; (3)$$

By Maxwell Boltzmann

$$N \propto e^{-E/KT}$$

{where E is Energy
K is Boltzmann Constant
or T is Temperature}

So, $N_1 \propto e^{-E_1/KT}$ or $N_2 \propto e^{-E_2/KT}$

Or $$= \frac{N_1}{N_2} = \frac{e^{-E_1/KT}}{e^{-E_2/KT}}$$

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

photo electric

$E = h\nu$

$E_2 - E_1 = h\nu$

we know that

$E_2 - E_1 = h\nu$

So, $$\boxed{\frac{N_1}{N_2} = e^{h\nu/KT}}$$

Put this value in Eqn (3)

$$\mu(\nu) = \frac{A_{21}}{B_{21}\left(e^{h\nu/KT} - 1\right)} \quad \text{——} \; (4)$$

According to Plank

$$\mu(\nu) = \frac{8\pi h\nu^3}{c^3(e^{h\nu/kT}-1)} \quad \text{— (5)}$$

where, 8π is constant
h is called Plank's Constant
value $h = 6.63 \times 10^{-34}$ Js,
ν is frequency, c is speed of light
value $c = 3\times10^8$ m/s

Compare (4) & (5)

$$\frac{A_{21}}{B_{21}(e^{h\nu/kT}-1)} = \frac{8\pi h\nu^3}{c^3(e^{h\nu/kT}-1)}$$

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

$$\frac{A_{21}}{B_{21}} \propto \nu^3$$ → for other term Constant

Hence proved.