17-04-2023

3. POLARIZATION

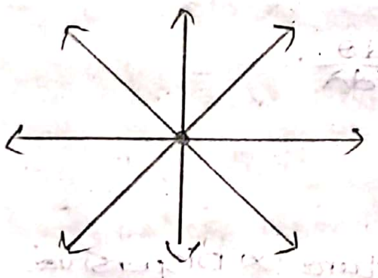
Introduction.

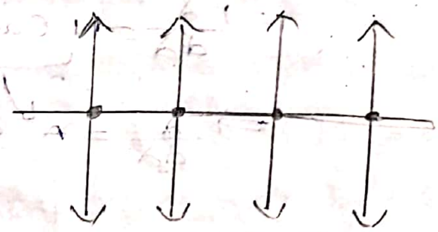
* **Polarization:-** Onesideness of Light.

→ The phenomenon of restricting the vibrations of electric vector E of light in a particular plane is called the 'polarization of light'.

* **Unpolarized Light:-**

→ The light wave that has vibrations in all directions perpendicular to the direction of propagation of light is known as 'unpolarized light'.

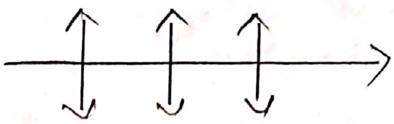




* **Plane polarized light:-**

→ The light wave that has vibrations in one plane is said to be plane polarized light.

→ The vibrations along one straight line perpendicular to the direction of propagation of light is called 'plane polarized light'.



* **Plane of vibration:-**

→ A plane in which the vibrations of polarized light are confined is called plane of vibration of plane polarized light.

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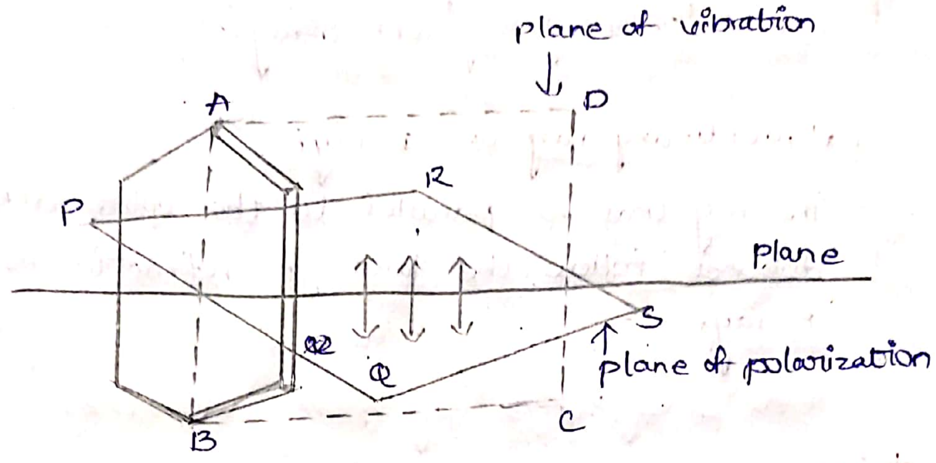
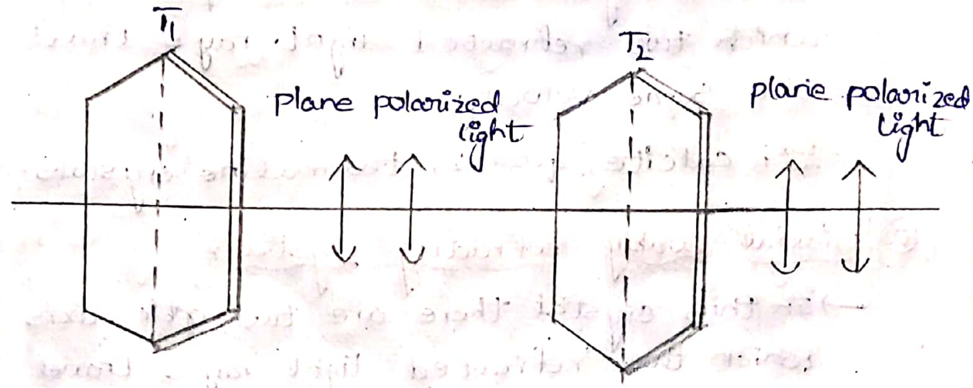
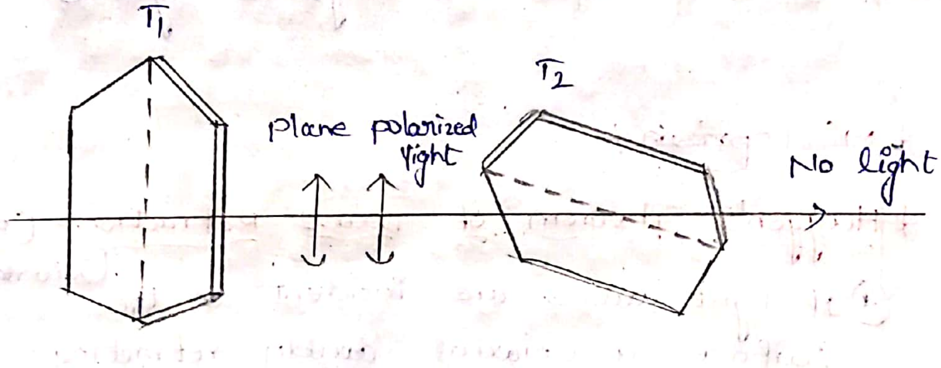
* Plane of polarization:-

→ The plane perpendicular to plane of vibration is called the plane of polarization of plane polarized light.



* Transverse Nature of Light:-





* Double Refraction and Doubly Refracting crystals:-

→ The phenomenon in which incident light ray splits into ordinary (or) O-ray and extraordinary (or) E-ray by quartz, calcite or tourmaline crystals is called as 'Double Refraction' & the crystals which show double refraction are called as 'Doubly refracting crystals'

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Ordinary ray (o-ray):

→ The ray that is perpendicular to the optic axis and ~~doesnot~~ follow the laws of refraction is called 'ordinary ray' (or) o-ray.

Extraordinary ray (or) E-ray:

→ The ray that is parallel to the optic axis and doesnot follow the laws of refraction is called 'E-ray'.

* Types of doubly refracting crystals:-

① Uniaxial doubly refracting crystal:-

→ In this crystal, there is one optic axis along which two refracted light rays travel with the same velocity.

Ex:- calcite, quartz, tourmaline crystals.

② Biaxial doubly refracting crystal:-

→ In this crystal there are two optic axis along which two refracted light rays travel with same velocity.

Ex:- Mica, topaz and aragonite crystals.

* ~~Nicol prism~~ :-

* Huygen's Theorem of Double Refraction:- [Based on Secondary wavelets]

① If light waves are incident on the surface of uniaxial doubly refracting crystals, each point on the surface of crystal becomes the origin of two secondary wavelets, o-ray & E-ray.

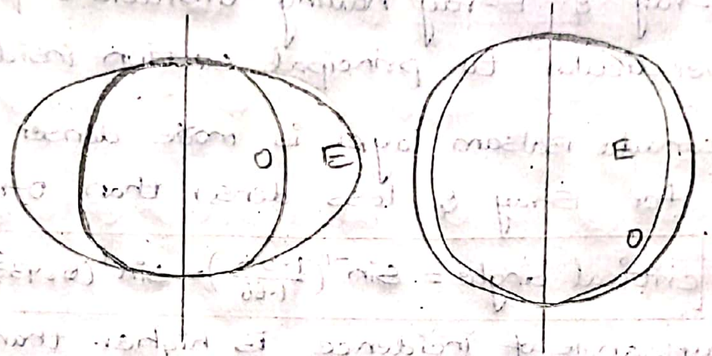
② The wavefront of o-ray is spherical because it travels with same velocity in all directions.

③ The wavefront of E-ray is ellipsoid because it travels with different velocity in different directions.

④ Along optic axis, the velocities of o-ray and E-ray are constant.

⑤ In negative crystals (calcite) $\mu_o > \mu_E$, hence $V_o < V_E$. This means that velocity of E-ray is greater than o-ray inside the crystal. so, spherical wavefront lies inside the ellipsoid as shown in Fig ⓐ.

⑥ In positive crystals $\mu_o < \mu_E$, hence $V_o > V_E$. This means velocity of o-ray is greater than E-ray inside crystal. so, spherical wavefront lies outside ellipsoid in fig ⓑ.



*Nicol prism:-

→ In 1828, William Nicol invented an optical device used for producing & analyzing plane polarized light.

Principle:-

→ Nicol prism is based on phenomenon of Double refraction

→ In Nicol, O-ray is eliminated by total internal reflection & E-ray is transmitted through crystal which is plane polarized light.

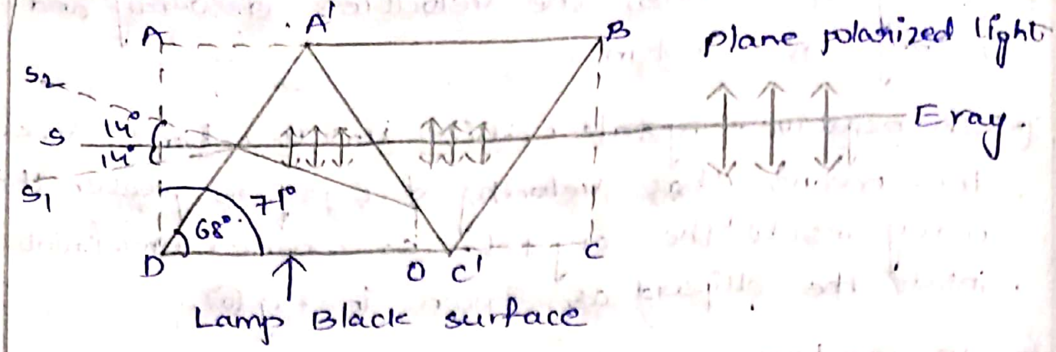
construction:-

→ consider a calcite crystal whose length is 3 times its width.

→ cut it so that it makes 90° with two end faces.

→ The two surfaces are grounded, polished optically flat and then cemented together with a transparent material called Canada Balsam.

→ For sodium light, refractive indices are 1.66, 1.55 & 1.49 for o-ray, canada balsam and E-ray respectively.



Working:-

→ If an ordinary light falls on face A'D, it splits into 'o-ray' & 'E-ray' having vibrations parallel & perpendicular to principal section inside crystal.

→ Here, canada Balsam layer is more denser than calcite for E-ray & less denser than o-ray.

i.e, $\boxed{\text{critical angle} = \sin^{-1}\left(\frac{1.55}{1.66}\right) = \sin^{-1}(0.933) \approx 69^\circ.}$

→ For o-ray, angle of incidence is higher than critical angle of calcite & canada Balsam.

→ By 'Total Internal reflection', o-ray is reflected from layer of canada Balsam & absorbed by lamp black surface.

→ 'E-ray' transmitted from Canada balsam layer is 'plane polarized light'.

→ In this way 'Nicol prism' acts as a polarizer.

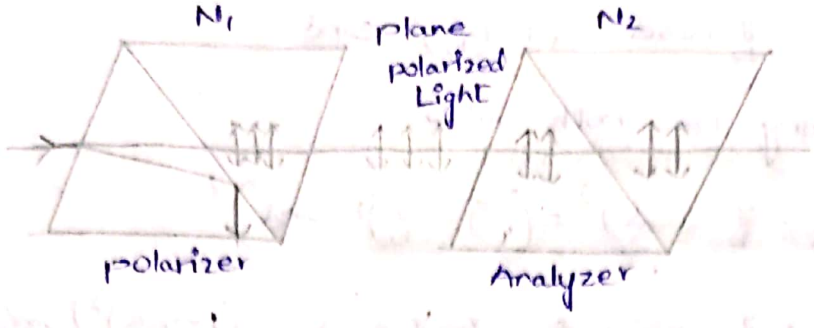
* Nicol prism as an Analyzer:-

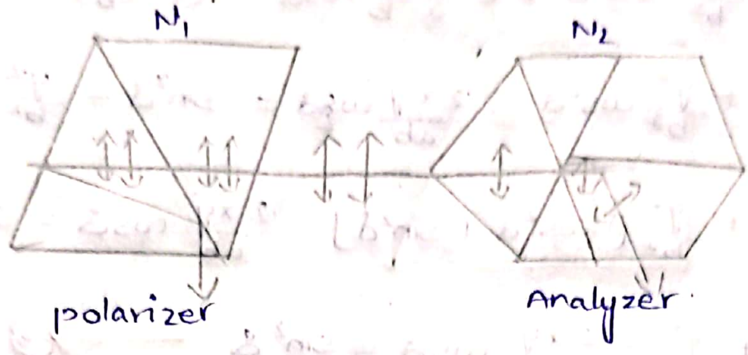
→ If two Nicol prisms 'N_1' & 'N_2' are parallel then only E-ray passes through them. Here First Nicol acts as polarizer and other acts as 'analyzer'.

→ When second Nicol is gradually rotated then intensity of E-ray decreases.

→ If 'N_1' & 'N_2' are perpendicular then no light comes out. Here, if N_2 is rotated, then intensity of emergent light increases.

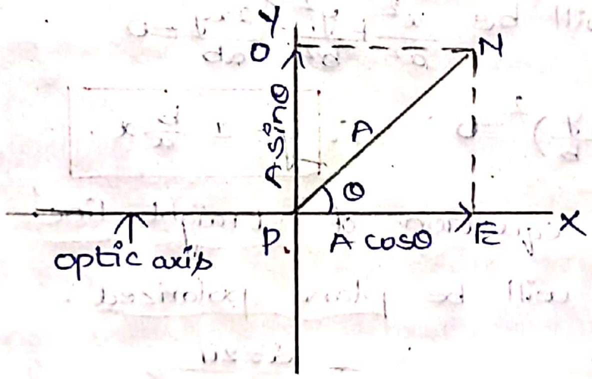
→ In this way, Nicol prism acts as an Analyzer.





* Mathematical Treatment for Production and Analysis of plane, circularly and Elliptical polarized Light.

→ Let a beam of plane polarized light fall normally on a calcite crystal cut with faces parallel to optic axis.



For E-ray, $x = A\cos\theta \sin(\omega t + \delta)$ [δ is phase difference]

For O-ray, $y = A\sin\theta \sin\omega t$.

Let $a = A\cos\theta$, $b = A\sin\theta$.

$\Rightarrow x = a\sin(\omega t + \delta)$ $\Rightarrow \frac{x}{a} = \sin\omega t \cos\delta + \cos\omega t \sin\delta$. → ①

$\Rightarrow y = b\sin\omega t$. $\Rightarrow \frac{y}{b} = \sin\omega t$ → ②

From ① & ② [substitute ② in ①].

$\Rightarrow \frac{x}{a} = \frac{y}{b}\cos\delta + \cos\omega t \sin\delta$

$\Rightarrow \frac{x}{a} = \frac{y}{b}\cos\delta + \sqrt{1-\left(\frac{y}{b}\right)^2}\sin\delta$ [$\because \cos\omega t = \sqrt{1-\sin^2\omega t} = \sqrt{1-\left(\frac{y}{b}\right)^2}$]

$$\Rightarrow \frac{x}{a} - \frac{y}{b}\cos\delta = \sqrt{1-\left(\frac{y}{b}\right)^2}\sin\delta$$

squaring on both sides

$$\Rightarrow \left(\frac{x}{a} - \frac{y}{b}\cos\delta\right)^2 = \left(\sqrt{1-\left(\frac{y}{b}\right)^2}\sin\delta\right)^2$$

$$\Rightarrow \frac{x^2}{a^2} + \frac{y^2}{b^2}\cos^2\delta - 2\cdot\frac{x}{a}\cdot\frac{y}{b}\cos\delta = \left(1-\left(\frac{y}{b}\right)^2\right)\sin^2\delta.$$

$$\Rightarrow \frac{x^2}{a^2} + \frac{y^2}{b^2}\cos^2\delta - \frac{2xy}{ab}\cos\delta = \sin^2\delta - \frac{y^2}{b^2}\sin^2\delta$$

$$\Rightarrow \frac{x^2}{a^2} + \frac{y^2}{b^2}\left[\cos^2\delta + \sin^2\delta\right] - \frac{2xy}{ab}\cos\delta = \sin^2\delta$$

$$\Rightarrow \frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab}\cos\delta = \sin^2\delta. \longrightarrow (3)$$

$\therefore$ Equation (3) is 'General equation of ellipse'.

Case-1:-

If $\delta = 0, 2\pi, 4\pi, \ldots\ldots 2n\pi$

$\Rightarrow \cos\delta = 1$ and $\sin\delta = 0$.

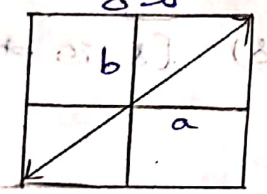
$\therefore$ Eq^n (3) will be $\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab} = 0$

$$\Rightarrow \left(\frac{x}{a} - \frac{y}{b}\right)^2 = 0 \qquad \therefore \boxed{y = \pm\frac{b}{a}x.}$$

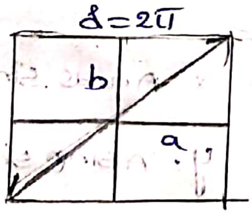
This is the equation of 'straight line'.

$\therefore$ The Light will be plane polarized.

$\delta = 0$



$\delta = 2\pi$

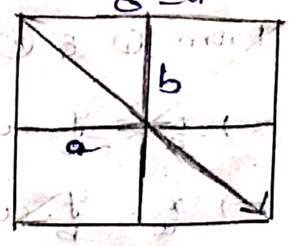


Case-2:-

If $\delta = \pi, 3\pi, 5\pi, \ldots\ldots (2n+1)\pi$ then $\cos\delta = -1$, $\sin\delta = 0$.

$$\therefore \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{2xy}{ab} = 0 \quad \Rightarrow \left(\frac{x}{a} + \frac{y}{b}\right)^2 = 0$$

$\delta = \pi$



$\therefore \boxed{y = -\frac{b}{a}x}$

This is again equation of 'Straight Line'

$\therefore$ Light will be plane polarized.

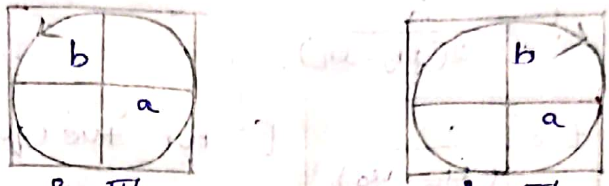
case-3 :-

If $\delta = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \ldots (2n+1)\frac{\pi}{2}$ and $a \neq b$, then

$\cos\delta = 0$ & $\sin\delta = 1$.

$$\therefore \boxed{\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1} \longrightarrow \text{Ellipse equation.}$$

∴ Light will be elliptically polarized.



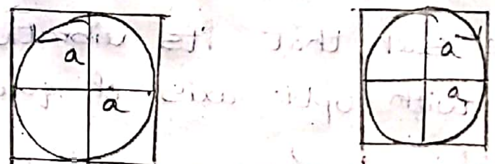
$\delta = \pi/2$ $\qquad$ $\delta = 3\pi/2$

case-4 :-

If $\delta = (2n+1)\frac{\pi}{2}$ and $a = b$, then $\cos\delta = 0$ & $\sin\delta = 1$

$$\therefore \boxed{x^2 + y^2 = a^2} \longrightarrow \text{circle equation}$$

∴ Light will be circularly polarized. $[\theta = 45°]$.



* Retardation Plates :-

→ It is used to produce a phase difference b/w ordinary & extraordinary rays [O-ray & E-ray] during transmission through doubly refracting crystals.

→ These are two types.

1. Quarter-wave plate
2. Half-wave plate

① Quarter-wave plate :-

Here phase difference $= \frac{\pi}{2}$

path difference $= \frac{\lambda}{4}$

We have, $\boxed{\Delta = (\mu_o - \mu_E)t}$ $\quad$ [∵ μ_o, μ_E = refractive Index of O-ray & E-ray]

$\Rightarrow \frac{\lambda}{4} = (\mu_o - \mu_E)t$

$\Rightarrow t = \frac{\lambda}{4(\mu_o - \mu_E)}$ $\quad$ $\therefore \boxed{t = \frac{\lambda}{4(\mu_E - \mu_o)}}$ For +ve (quartz) crystal.

(2) Half-wave plate :-

Here, phase difference $= \pi$

path difference $= \frac{\lambda}{2}$

We have, $\Delta = (\mu_0 - \mu_E)t$

$$\Rightarrow \frac{\lambda}{2} = (\mu_0 - \mu_E)t$$

$$\therefore t = \frac{\lambda}{2(\mu_0 - \mu_E)}$$

$$\therefore \boxed{t = \frac{\lambda}{2(\mu_E - \mu_0)}}$$ [$\because$ For +ve (quartz) crystal]

* Production of plane polarized, circularly and Elliptically polarized Light.

→ When the plane polarized light emergent from a Nicol prism is allowed to fall on a quarter-wave plate such that its vibrations make an angle of θ with optic axis of quarter-wave plate.

→ (1) For '$\theta = 0°$' and '$90°$', the emergent light remains plane polarized.

(2) For '$\theta = 45°$', - circulary polarized.

(3) For 'θ' value other than '$0°$', '$45°$', '$90°$' - Elliptically polarized

* Detection of Unpolarized, polarized, circularly polarized & Elliptically polarized Light :-

Given beam of Light

↓

Rotating Nicol prism.

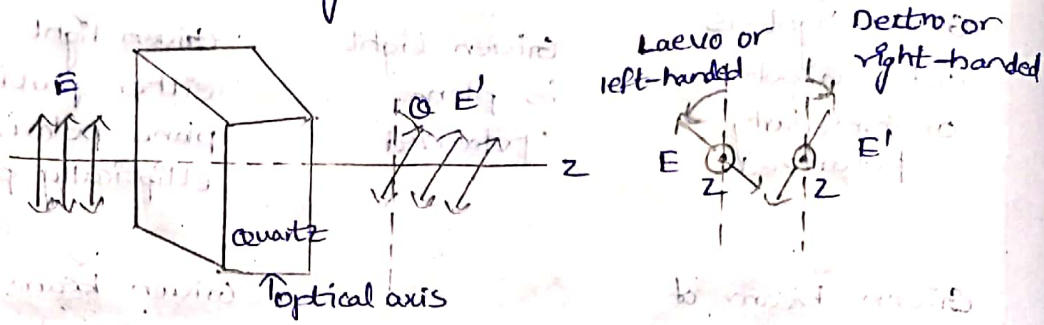
- No Intensity variation
  - ↓ Given light is either unpolarized or circularly polarized
  - ↓ Given beam of Light
  - ↓ $\frac{\lambda}{4}$ plate
  - ↓ Rotating Nicol prism
    - No Intensity variation → Given Light is unpolarized
    - Intensity variation with minimum Intensity zero → Given Light is circularly polarized.
- Intensity variation with minimum intensity zero
  - ↓ Given light is plane polarized.
- Intensity variation with minimum Intensity not zero
  - ↓ Given light is either partially plane polarized or elliptically polarized
  - ↓ Given beam of Light
  - ↓ $\frac{\lambda}{4}$ plate
  - ↓ Rotating Nicol prism.
    - Intensity variation with minimum Intensity not zero. → Given light is Unpolarized
    - Intensity variation with minimum Intensity zero → Given Light is elliptically polarized.

* Optical Activity

→ The property of rotating the plane of polarization of plane polarized light by certain crystals is called "optical activity."

→ This phenomenon is known as 'optical rotation' and such substances are called "optically active substances".

Ex:- Quartz, sugar crystals, sodium chlorate, cinabar sugar solution etc.



→ There are two types of optically active substances.

① Dextro rotatory or Right-handed :-

→ If an optically active substance rotates the plane of polarization in a clockwise direction, it is known as Dextrorotatory or right-handed.

② Laevorotatory or Left-handed :-

→ If the plane of polarization of plane polarized light is rotated in the anticlockwise direction by an optically active substance, it is known as Laevorotatory or left-handed.

* Laws of optical Rotation / optical Activity :-

① $\theta \propto l$ [θ = Angle of Rotation, l is Length]

② $\theta \propto c$ [c = concentration of solution].

③ $\theta \propto \frac{1}{\lambda^2}$ [λ = wavelength].

④ $\theta = \theta_1 \pm \theta_2 \pm \theta_3 \pm$ ______.

* Specific Rotation:-

→ It is defined as the optical rotation 'θ' produced by one decimeter of solution containing one gram of optically active substance per cc of solution.

$$\boxed{S = \frac{\theta}{lc}}, \quad \text{degree } (dm)^{-1} \left(\frac{gm}{cc}\right)^{-1}$$

If length of liquid is in centimeter,

$$\boxed{S = \frac{100\,\theta}{lc}}$$

* Laurent's Half-shade Polarimeter

→ It is an optical device used for measuring the optical rotation of optically active substances.

Construction:-

O → a monochromatic light source.

S → a slit to obtain monochromatic light emitted from 'O' in a particular direction.

L → a convex lens to convert monochromatic light emmitted from 'O' in the form of a parallel beam

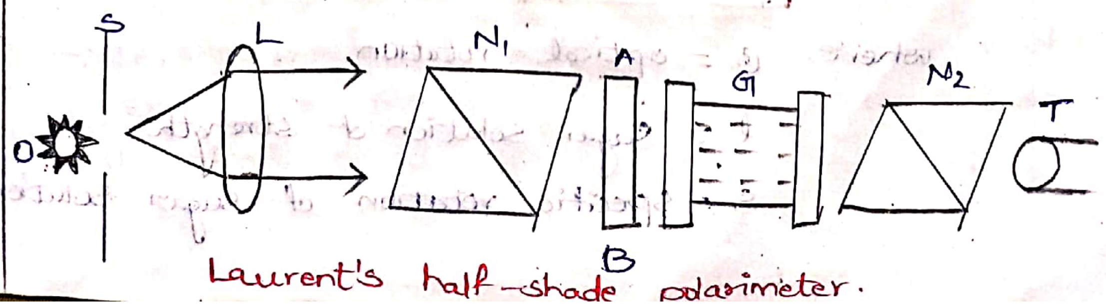
N_1 → a Nicol prism, acts as polarizer.

AB → a circular plate [Half-shade device / Laurent's plate]
Its left-half part is made of glass & right-half part is of quartz.

G → a hollow tube for filling optically active substance

N_2 → a Nicol prism, acts as Analyzer.

T → a telescope to observe optical rotation.

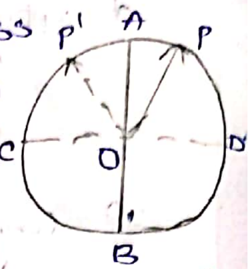


Laurent's half-shade polarimeter.

Working :-

→ The light passing through 'N₁' is incident on 'AB' with its vibration along OP.

→ on passing through its semicircle glass-half part 'ACB', its vibration remain along OP & on passing through 'ADB', Lightray splits into 'o-ray' & 'E-ray'.



→ vibrations of 'o-ray' & 'E-ray' are along 'OD' & 'OA'.

→ Semicircle quartz-half part acts as '$\frac{\lambda}{2}$ plate' & gives a phase difference of 'π'.

→ on emergence from plate 'AB', vibrations of o-ray occur along 'OC' instead of 'OD'.

$$\angle POA = \angle P'OA.$$

→ observations when we analyze the light coming out of analyzer N_2 are

① If principal plate of N_2 ∥ to OP, glass-half ~~plate~~ part appears brighter.

② If principal plate of N_2 ∥ to OP', quartz-half part appears brighter.

③ If principal plane of N_2 ∥ to AOB, Both quartz and glass-half-parts appear equally bright.

④ If principal plane of N_2 ~~∥~~ is normal to AOB, Both appear equally less brighter than case ③.

Determination of strength of sugar solution

$$\boxed{S = \frac{\theta}{l \times c}}$$

where, θ = optical rotation

l = Sugar solution of strength

S = specific rotation of sugar solution

LASERS

LASER :- [Einstein, 1917]

→ LASER – "Light Amplification by Stimulated Emission of Radiation."

→ Laser is a 'monochromatic', 'collimated', 'unidirectional', 'intense' & 'highly coherent' beam of light with small divergence.

characteristics :-

1. The Laser beam is completely 'coherent'.
2. The Laser beam is perfectly 'Monochromatic'.
3. It emits radiation only in 'one direction' [Unidirectional]
4. Laser beam is 'highly intense' due to concentrated energy in a very small region.

$$\boxed{I = \frac{P}{4\pi r^2}}$$

P — Power
r — distance

5. Light from laser is 'brighter' than ordinary source.

$$\boxed{\text{Brightness} = \frac{\text{Power of source}}{\text{Area} \times \text{solid angle}}}$$

Concept of coherence :-

→ If the 'phase difference' b/w two light beams is constant with time, then beams are said to be 'coherent'.

→ There are two types of coherency.

1) Temporal coherence :-

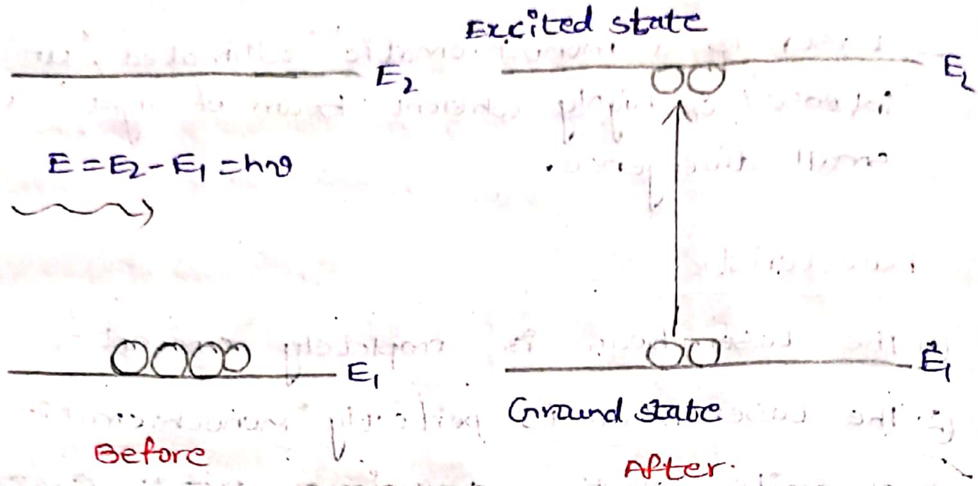
→ Here phase difference b/w two points along the direction of wave propagation remains constant.

2) spatial or Lateral coherence :-

→ If the phase difference b/w two points on a plane perpendicular to direction of propagation is constant, then it is called 'spatial / Lateral coherence'.

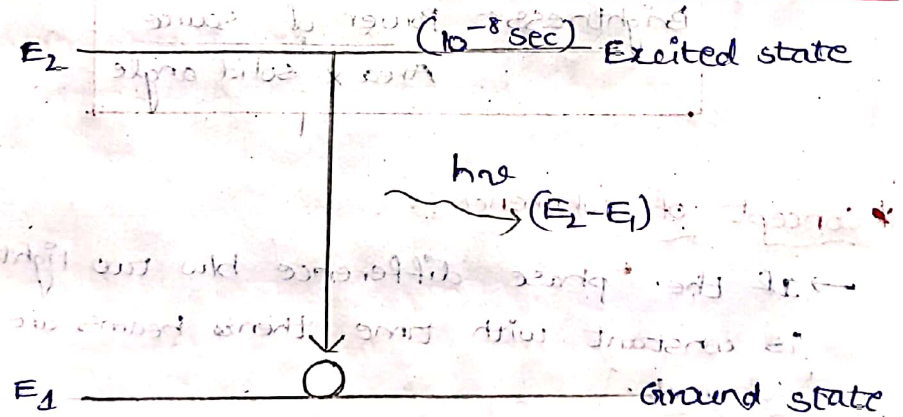
* Absorption of Radiation :-

→ It is the process in which a photon is absorbed by the atom E_1 increasing the no. of atoms to its excited state.



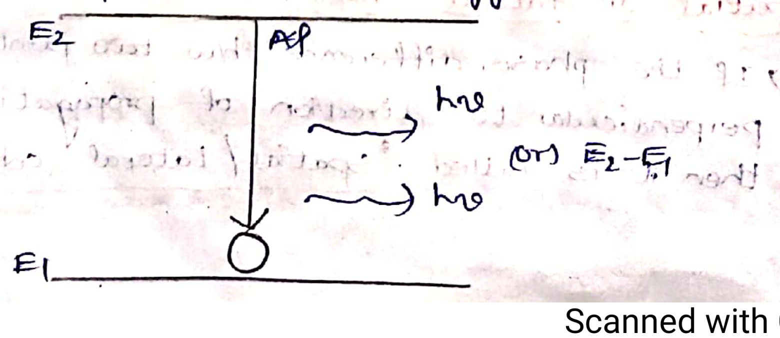
* Spontaneous Emission of Radiation :-

→ When an atom in its excited state E_2 makes a transition to its ground state by emitting a photon of energy $(E_2 - E_1)$ without any outside influence, then it is called spontaneous Emission.



* Stimulated Emission of Radiation :-

→ It is the process by which an atom is induced with photon, to make transition from higher energy level to lower energy level by emitting an additional photon of same energy.



Note :- [Einstein coefficient].

→ The probability of absorption transition is proportional to energy density of radiation of frequency.

$$\boxed{P \propto u(\nu)} \implies \boxed{P_{12} = B_{12}\, u(\nu)}$$

Einstein coefficient

① For spontaneous emission,

$$P_{21} = A_{21}$$

② Total probability for transition 2 → 1 is

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

* Differences between spontaneous & stimulated emission

Spontaneous emission	stimulated emission.
① Transition from higher to lower energy. without outside Influence.	① Transition from higher to lower energy by emitting photon's energy due to induced atom.
② It is Incoherent	② It is coherent
③ It is Less intense	③ It is Highly Intense
④ It has a broad spectrum.	④ It has single wavelength.

* Population Inversion :-

→ It is necessary phenomenon for working of Laser.

→ It is to increase the probability of stimulated emission, the no. of atoms in higher energy state (N_2) must be greater than no. of atoms in lower state (N_1)

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

where K = 'Boltzmann constant'

T = 'Temperature'

→ The system where population inversion is achieved is 'active system.'

* Pumping:-

→ The process by which we can raise atoms from 'lower to higher energy' state is called Pumping.

(1) Optical pumping:-

→ It is the process in which population Inversion can be achieved by providing optical energy to ground state atoms.

(2) Electrical pumping:-

→ It is used for population inversion in gas lasers such as He-Ne laser.

(3) Direct electric pumping:-

→ Here electric current directly creats enough mobile charges at interphase of two different types of semiconductors.

Ex:- GaAs laser.

(4) chemical pumping:-

→ The exothermic chemical reactions generate enough heat energy to utilize for pumping the atoms to higher energy levels.

Ex:- CO_2 Laser.

* Optical cavity or optical Resonator:-

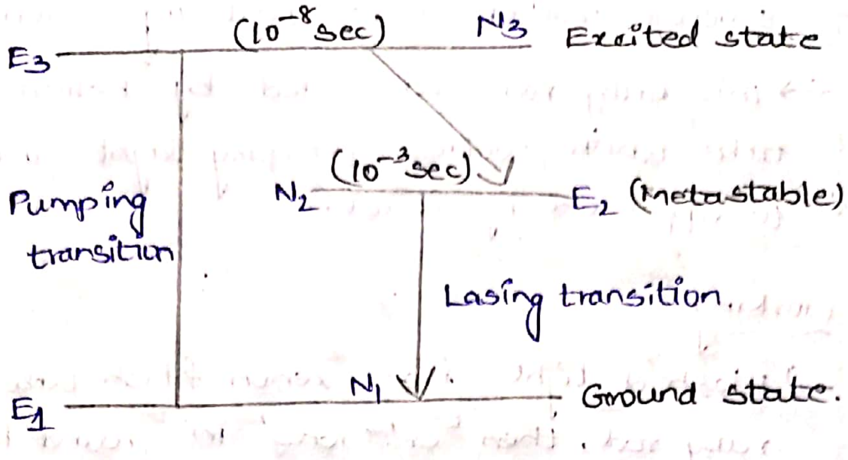
→ An arrangement of pair of mirrors in which the active material is placed in between is known as "optical Resonator."

→ Advantages:-

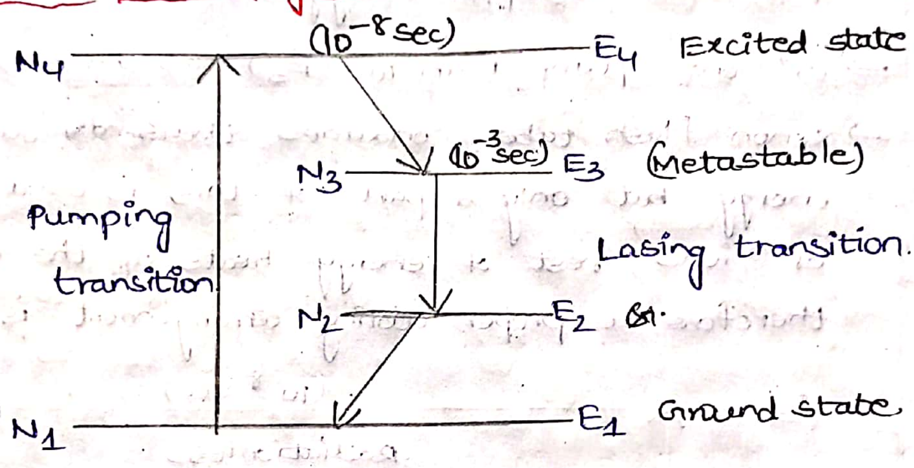
1. It increases monochromaticity.
2. It improves coherence.
3. It reduces pumping power requirements.
4. It controls reflection rate & beam quality.
5. It improves gain of laser medium.

$$\text{Laser gain} = \frac{P_{out}\ [\text{Power of outing beam}]}{P_{in}\ [\text{Power of Incoming beam}]}$$

* Three Level Laser system :-



* Four Level Laser system :-



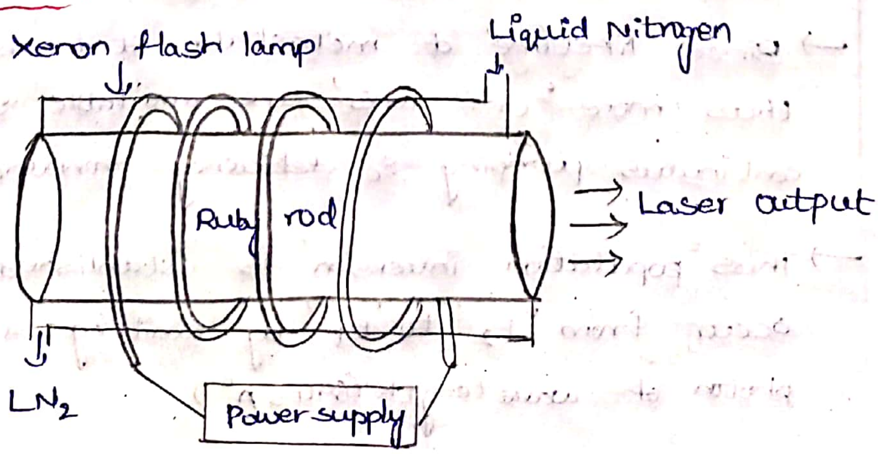
* Ruby Laser :- [solid state Laser].

→ It was first laser developed by 'Maiman', in '1960' based on '3-energy level system.'

→ Ruby is a crystal of 'Al_2O_3' doped with 'Cr_2O_3'.

→ Ruby laser operates in a 'pulse mode laser beam' of wavelength '6943 A°'.

Construction :-



→ Ruby rod – cylindrical – one end is optically completely silvered another end is partially silvered.

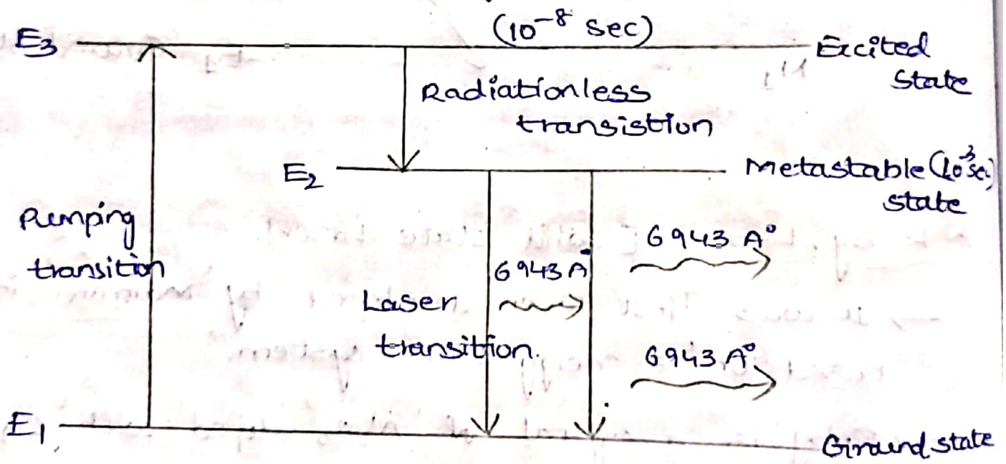
→ This Ruby rod surrounded by helical xenon flash tube which provides pumping light to raise Cr^{+3} ions to upper energy level.

Working :-

→ Flash of light from xenon flash tube falls on ruby rod, then 'Cr^{+3} ions' in ground level/state absorb light of wavelength [5000–6000Å] 5500Å & excited to upper energy state.

→ 'Cr^{+3} ions' pumped in to (E_3). as shown below

→ xenon flash tube consumes thousands joules of energy but only a part of this is used in pumping Cr^{+3} ions, rest of energy heats up the experiment therefore a proper cooling arrangement is required.



→ Due to small mean lifetime of atoms (10^{-8} sec) some atoms jump back to 'ground state' & some jump to 'metastable state' (E_2).

→ Since lifetime of metastable state is (10^{-3} sec) thus more 'Cr^{+3} ions' are available & due to continuous pumping & deficiency pronounced in ground state.

→ Thus population inversion' is established & transitions occur from 'E_2' to 'E_1' by emitting a stimulated photon of wavelength (6943 Å)

Draw Backs :-

① Due to '3-level system', 'high power pumping system' is required for population inversion.

② The output beam occurs in the form of micro-second's duration of 'pulses'.

③ 'Effeciency' is very Low because it uses only green part of pumping light.

* Helium-Neon (He-Ne) Laser :- [gas laser]

→ It is based on '4-level laser system'.

→ It used a mixture of 'He' & 'Ne' in ratio '10:1' or '7:1' at low pressure.

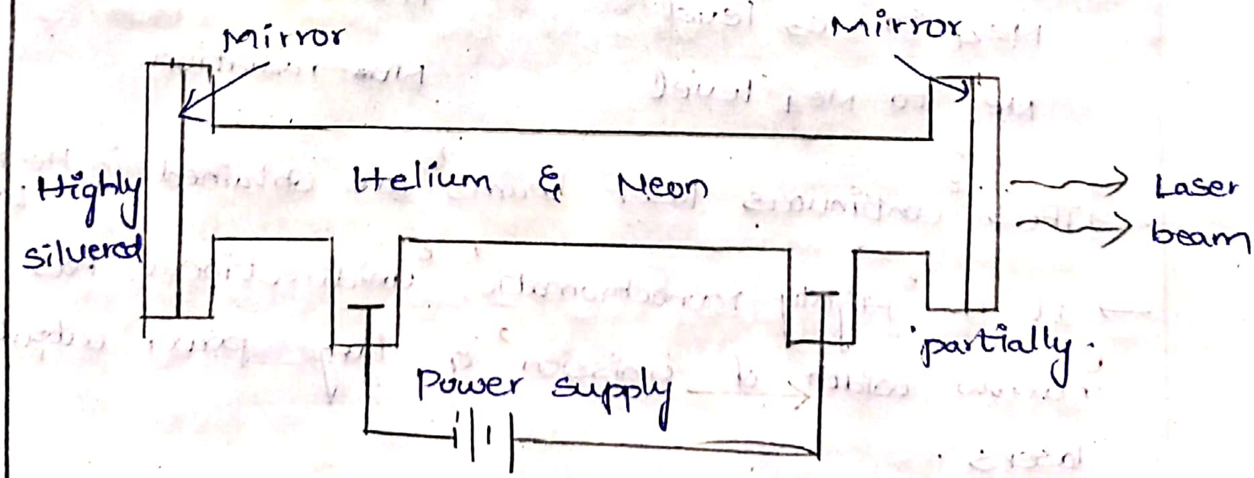
→ It is superior to Ruby Laser because it gives continuous laser beams of wavelength '6328A°', '33913 A°' and '11523 A°'.

Construction :-

→ It consists of 'glass' tube of length 10-100 cm & Narrow diameter of 2-10 mm.

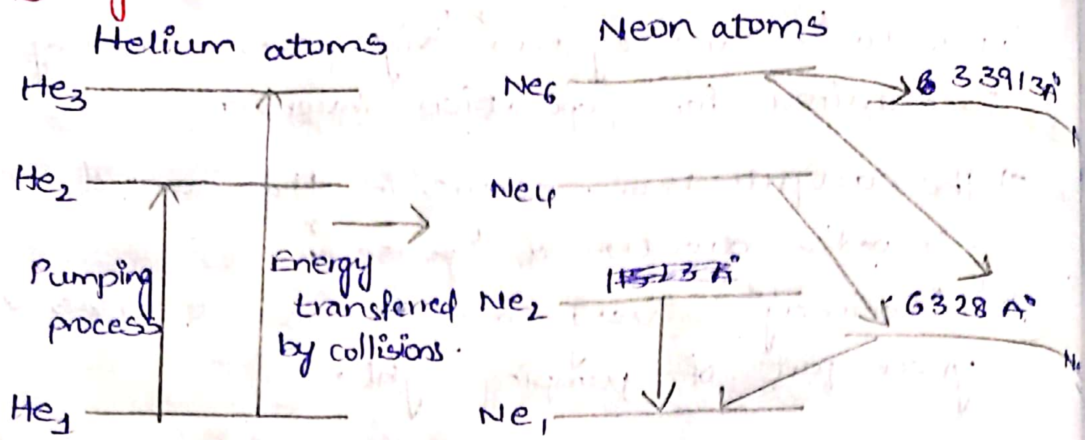
→ one end is 'highly silvered' & other is 'partially silvered'

→ Two electrodes are inserted in tube to get high power to achieve 'population inversion' by 'electric discharge method'.



Scanned with CamScanner

Working :-



Energy level diagram of He-Ne Laser.

→ A High voltage is applied across electrodes to ionize the gas.

→ The probability of collision of electrons & ions with He atoms is higher than Ne atoms.

→ He atoms reach the higher energy states.

→ some of He atoms collide with Ne atoms and transfer energy to them which excite to Ne_4 & Ne_6 levels to achieve population inversion.

→ Ne_2, Ne_4, Ne_6 are metastable states for Ne atoms

Transitions	Radiation [wavelengths]
Ne_6 to Ne_5 level	33913 A°
Ne_6 to Ne_3 level	6328 A°
Ne_4 to Ne_3 level	11523 A°
Ne_2 to Ne_1 level	Non-radiation.

→ Thus continuous laser beams are obtained in He-Ne Laser.

→ It is Highly monochromatic, unidirectional, has narrow width of emission & large power output lasers.

→ In it, atomic inelastic collisions are used as pumping for population inversion.

* Nd:YAG [Neodymium-doped Yttrium Aluminium Garnet : $Nd:Y_3Al_5O_{12}$] Laser :-

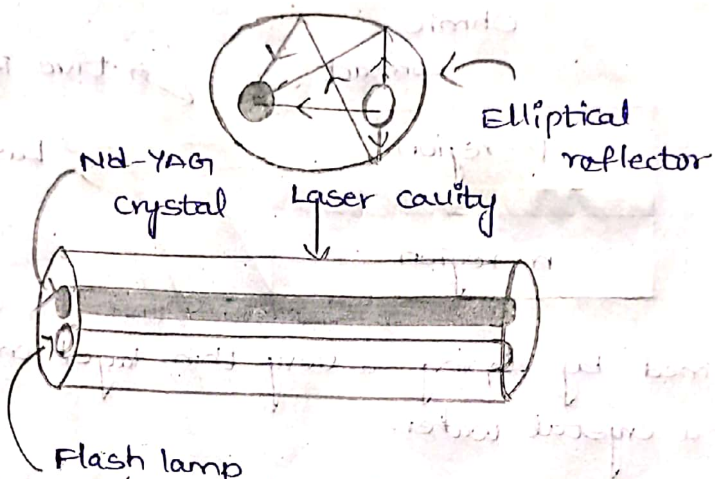
→ It is optically pumped solid-state laser & 4-level system

→ It is given by Geusic et al. in 1964 at Bell laboratories

construction :-

→ It consists of a cylindrical crystal, which forms 'laser cavity' & has reflective ends.

→ one end is 100% reflective, other is partial.



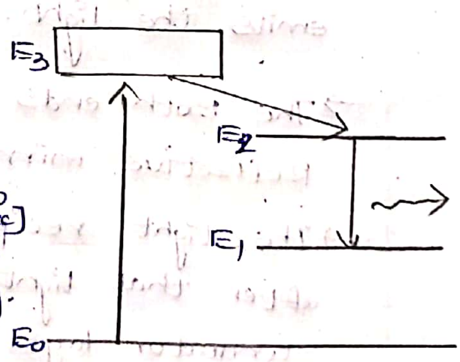
Working :-

→ Population inversion results from shining light on this crystal.

→ Light transition from ground state into absorption bands by ~~with~~ a flash lamp.

→ Atoms transition efficiently from the E_3 level to upper energy levels.

→ The radiative decays to ground state E_0 from these bands have long lifetimes, [Micro-sec] as compared to fast transitions to upper energy levels [Nano-sec].



→ Approximately 99% of ions are excited to absorption band transfer to the upper energy levels

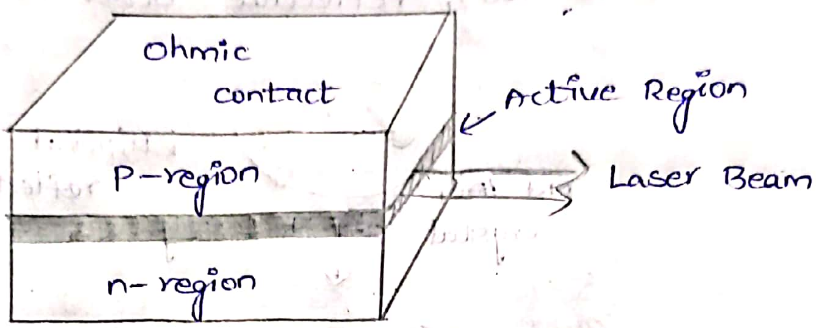
→ Due to long lifetime [Milli seconds], these levels de-excite solely due to spontaneous emission.

* Semiconductor Laser :-

→ It is a laser ~~diode~~ in which the active medium is a semiconductor similar to that found in a light-emitting diode.

→ It is formed from a p-n junction & powered by injected electrical current.

Construction :-



→ Formed by doping a very thin layer on the surface of a crystal wafer.

→ crystal is doped to produce n-type & p-type regions and results a p-n junction diode.

→ The junction surface of diode laser is polished at two sides.

Working:-

→ When forward voltage is applied, electrons combines with holes at the p-n junction & emits the light.

→ The Both ends of Active layer acts as a Reflective mirror.

→ The light reciprocates in the active layer. after that light is amplified and the semi-conductor layer oscillation is generated.

Advantages :-

→ small in size and low cost

→ Having High efficiency

→ construction is very simple.

Disadvantages :-

→ It depends on temperature.

→ Due to lower power consumption it is not suitable for many laser applications.

Applications :-

→ used in telecommunications.

→ used for Barcode Readers.

→ used in measuring instruments like Range-finders.

→ Infrared & red laser diodes are common in CD players, CD-ROMs and DVD technology.

* Applications of Lasers :-

① In communications.

② In welding & cutting.

③ In surgery. [Medical].

④ In computer Industry.

⑤ In Holography.

⑥ In spectroscopy

⑦ In scientific and Industrial Research.