(1)

POLARIZATION

BVR

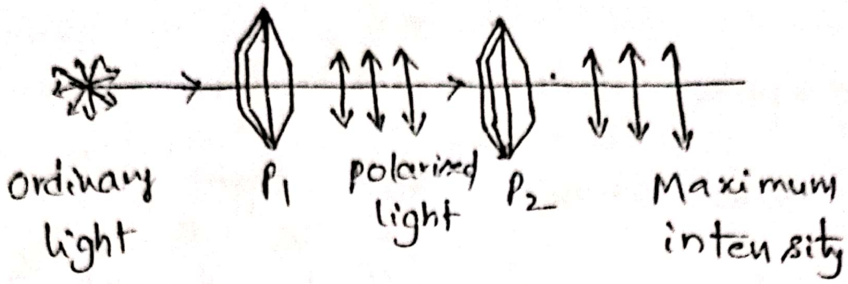
The experiments on inter-ference and diffra-ction have shown that light is a form of wave motion. These effects do not tell us about the type of wave motion. ie whether the light waves are longitudinal (or) transverse (or) whether the vibrations are linear, circular (or) torsional. The phenomenon of polarisation has helped to establish beyond doubt that light waves are transverse waves.

polarisation of light waves:-

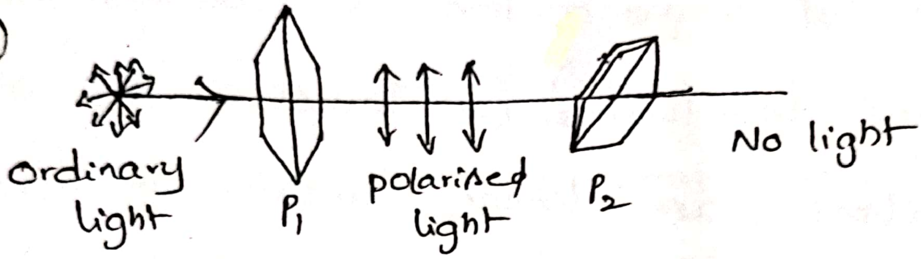
When ordinary light is passed through a pair of tourmaline crystals P_1 and P_2 with their planes at right angles to the direction of propagation of light, the intensity is maxi-mum in this position. But when the crystal P_2 is rotated through 90° the intensity is minimum in this case.

(PTO)

(a)



(b)

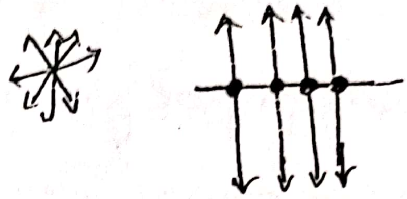


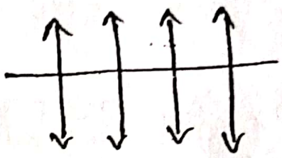
This shows that light is a transverse wave motion. It is clear that after passing through the crystal P_1, the light vibrates in only one direction, ie it is polarised because it has acquired the property of one-sideness.

* The light which has acquired the property of one sideness is called polarised light.

* If the vibrations are confined along a (straight line) single direction at right angles to the direction of propagation, the light is said as plane polarised.

Representation of Various type of light:

(a) unpolarised light 

(b) plane polarised light (vibrations parallel to the plane of the paper) 

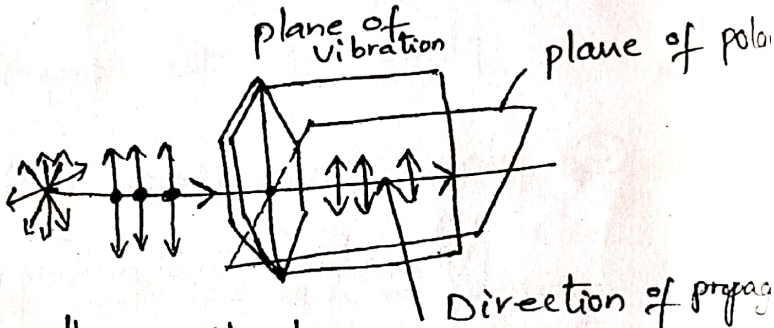
(c) plane polarised light 
(Vibrations perpendicular to the plane of paper)

plane polarised light:- We know that in plane-polarised light the vibrations are along a straight line. If the direction of vibration is parallel to the plane of the paper, it is represented by a straight line arrow.
If the direction of vibration is perpendicular to the plane of the paper, it is represent-ed by a dot as shown.

(5)

plane of polarisation :-

When ordinary light is passed through a tourm-line crystal, the light is polarised and the vibrations are confined only in one direction which is perpendicular to the direction of propo-ation of light.



The plane in which the vibrations of polarised light are confined is known as plane of vibration.

The plane which has no vibrations is known as plane of polarisation. i.e a plane passing thro the direction of propagation and perpendicular to the plane of vibration is known as plane of polarisation.

Polarisation by Reflection (Brewster's law) :-

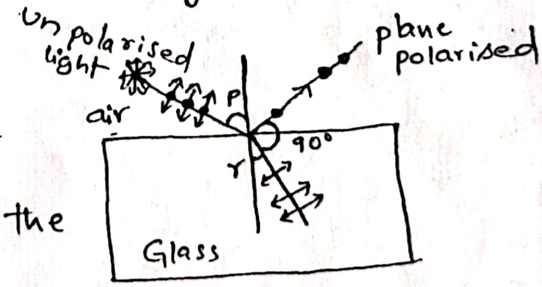
In 1811, Brewster observed that, when ordin light is reflected from the surface of a transparent medium like glass (or) water the reflected light is completely polarised at an angle of incidence called "angle of polarisation" p. Brewster proved that the refractive index of the medium (μ) is numerically equal to tangent of the angle of polarisation ($\tan p$).

$$\boxed{\therefore \quad \mu = \tan p}$$

This is known as Brewster's law.

Angle between reflected and refracted rays:

Suppose a beam of unpolarised light is incident on glass surface at polarising angle 'p' as shown.



A part of the incident light is reflected while a part is refracted. Let 'r' be the angle of refraction.

From Brewster's law, $\mu = \tan p$

i.e $\mu = \frac{\sin p}{\cos p}$ —①

but from Snell's law we have $\mu = \frac{\sin p}{\sin r}$ —②

from ① & ② $\frac{\sin p}{\cos p} = \frac{\sin p}{\sin r}$

$$\therefore \quad \sin r = \cos P$$

$$\sin r = \sin(90 - P)$$

$$\Rightarrow \quad r = 90 - P$$

$$\Rightarrow \quad \boxed{r + P = 90^\circ}$$

The angle between the reflected and refracted rays from the surface of the medium is 90°.

Malus law : According to Malus law the intensity of light passing through the analyser is directly proportional to the square of the cosine of the angle between the plane of analyser and plane of polariser. If θ is the angle between the plane of polariser and plane of analyser the intensity of light passing through analyser 'I' is proportional to $\cos^2\theta$

$$\therefore \quad I \propto \cos^2\theta$$

If the two planes are parallel, then $\theta = 0$ then $\cos\theta = 1$, the intensity of light is maximum.
If the two planes are perpendicular to each other then $\theta = 90^\circ$, then $\cos 90^\circ = 0$ and the intensity of light is minimum.

optic axis, Principle Section :-

A line passing through one of the blunt corners and making equal angles with the three faces which meet at this corner.

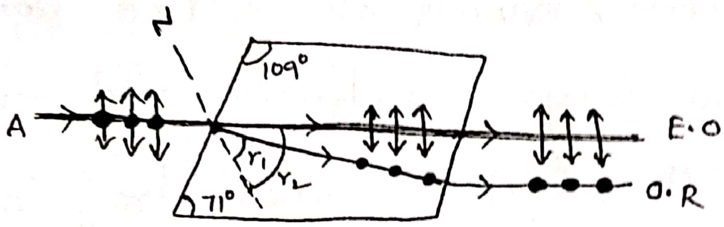
If the crystal has only one optic axis it is uni-axial crystal (quartz and calcite) and those having two optic axes are called bi-axial crystals (mica)

Principle Section is a plane which contains the optic axis and is perpendicular to the two faces (opposite faces) is known as the Principle Section.

Double Refraction :-

When a light ray passes through certain crystals like calcite, Quartz etc. The light ray is split into two rays ordinary and extra ordinary rays. The extra ordinary ray does not travel in a crystal with same velocity in all directions. This ray does not obey the laws of refraction. The ordinary ray moves with same velocity in all directions and obeys the laws of refraction. Both the rays are plane polarised.

The phenomenon of double refraction can be illustrated with the following simple experiment. An ink dot is made on a white paper, and a calcite crystal is placed over it. Now, looking through the top face, two images are observed. Now if the crystal is rotated slowly in a direction, it is observed that one image remains stationary while the other rotates in the direction of rotation of crystal. The stationary image is known as ordinary image. The rotating image is known as extra-ordinary image.



The refractive index of the ordinary ray 'μ_o' is constant in all directions of the crystal, where μ_e does not remain constant for extra ordinary rays, in all directions.

In double refracting crystals there are two types.
① positive double refracting crystal
② Negative double refracting crystal.

① In positive crystal like Quartz the speed of ordinary ray is more than that of extra-ordinary ray. For these crystals $\mu_e > \mu_o$

② In Negative crystals like Calcite, the speed of extra-ordinary ray is more than the speed of ordinary ray. i.e $\mu_o > \mu_e$.

Quarter wave Plate:-

Consider a calcite crystal plate having a thickness 't'. The optic axis is parallel to the upper surface of the plate. when a plane polarised is incident normally on the surface, then the light will split into ordinary and extra-ordinary rays. They travel with different velocities in same direction in the crystal.

As a result a path difference is created between these two rays. This path difference depends on the thickness of the plate. The thickness of the crystal is so designed in such a way that it introduces a phase change of $\pi/2$ (or) a path difference of '$\lambda/4$' between o-ray and e-ray. Such a plate is known as quarter wave plate.

In a calcite crystal the e-ray travel faster than o-ray, hence the refractive index of o-ray (μ_o) is higher than e-ray refractive index (μ_e).

The optical path covered by o-ray as it passes through the thickness of the crystal 't' is '$\mu_o t$'.

Similarly the optical path covered by e-ray as it is passing through the thickness of the crystal 't' is '$\mu_e t$'

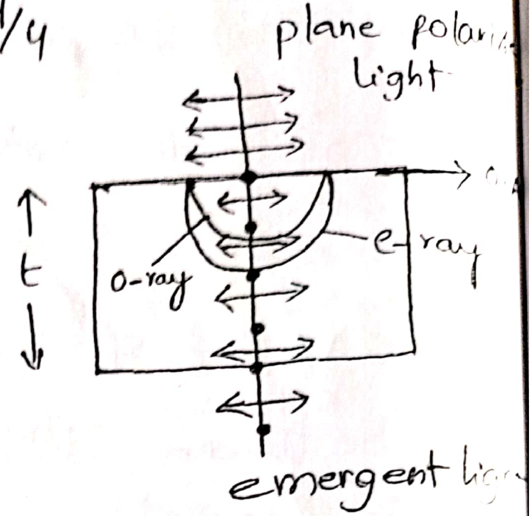
Hence the path difference between o-ray and e-ray is $\mu_o t - \mu_e t$.

Scanned with OKEN Scanner

As the crystal is a Quarter wave plate,

we have $(\mu_o - \mu_e)t = \lambda/4$

i.e $\boxed{t = \frac{\lambda}{4(\mu_o - \mu_e)}}$

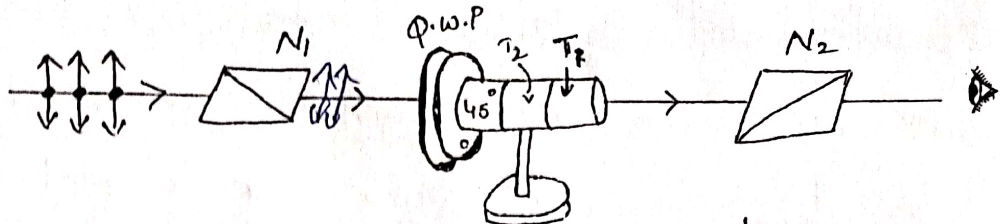


Production and detection of plane, circular and elliptical polarised lights:-

production:-

(a) plane polarised light: when an unpolarised light is incident on Nicol prism the emergent light is plane polarised light.

(b) circularly Polarised light:- A beam of mono chromatic light is incident on Nicol prism N_1, another Nicol prism N_2 is placed in a crossed position so that no light emerges out of analyser N_2. A quarter wave plate is mounted on a tube T_1. The tube T_1 can be rotated about the outer fixed tube T_2.



When observed through analyser some light is found to be emerging through it. The quarter wave plate is rotated until the field of view is completely dark. In this position the plane polarised light is incident normally on Quarter wave plate. Now quarter wave plate is rotated through an angle of 45°. In this position ~~the plane polarised light~~ the amplitude of o-ray and e-rays are equal and the emergent light is circularly polarised.

© Elliptically Polarised light:-

For the production of elliptically polarised light the same experimental set up is used. A beam of monochromatic light is incident on the Nicol prism N_1. The emergent ray is plane polarised. A Nicol prism N_2 is kept in crossed position and the field of view is completly dark.

A quarter wave plate is introduced between N_1 and N_2 and some light is observed through the analyser. The quarter wave plate is rotated until the field of view is completely dark. From this position the quarter wave plate is rotated through any angle other than 45°, the emergent light is elliptically polarised

Detection (or) analysis

The given light is passed through a rotating Nicol and the light emitted from the Nicol is observed. If the intensity of light becomes maximum and zero alternately, the light is plane polarised.

When the Nicol is rotated, if the intensity of light changes from maximum to minimum (not zero), the light is either partially polarised (or) elliptically polarised.

When the Nicol is rotated if there is no change in the intensity of the transmitted light, the light is either unpolarised (or) circularly polarised.

To differentiate between the partially polarised and elliptically polarised lights, the light is first passed through a quarter wave plate and then observed with the analysing Nicol. When the analyser is rotated if the intensity changes from maximum to zero, the light is elliptically polarised. If the intensity changes to maximum to minimum (not zero) then the light is partially polarised.

To distinguish between circularly and unpolarised light, the incident light is passed through the quarter wave plate and then observed through the rotating Nicol. If there is no change in intensity of the transmitted light when the Nicol is rotated, the light is unpolarised. If the intensity varies from maximum to zero the light is circularly polarised.

Optical Activity, Specific Rotation:

When a plane polarised passes through a substance (crystal) the plane of vibration is rotated. This phenomenon is known as optical activity.

If this plane is rotated in anti-clock wise direction this is leavo rotatory and if it is rotated in clock wise direction it is dextro. rotatory. Substances like Sugar solution, quartz etc. which exhibits this property are known as optical active substances. The angle through which the plane of vibration is rotated is the angle of rotation. The angle of rotation is proportional to the thickness of the crystal. It is also proportional to concentration in case of solutions. The angle of rotation is inversely proportional to the square of the wave-length of light used.

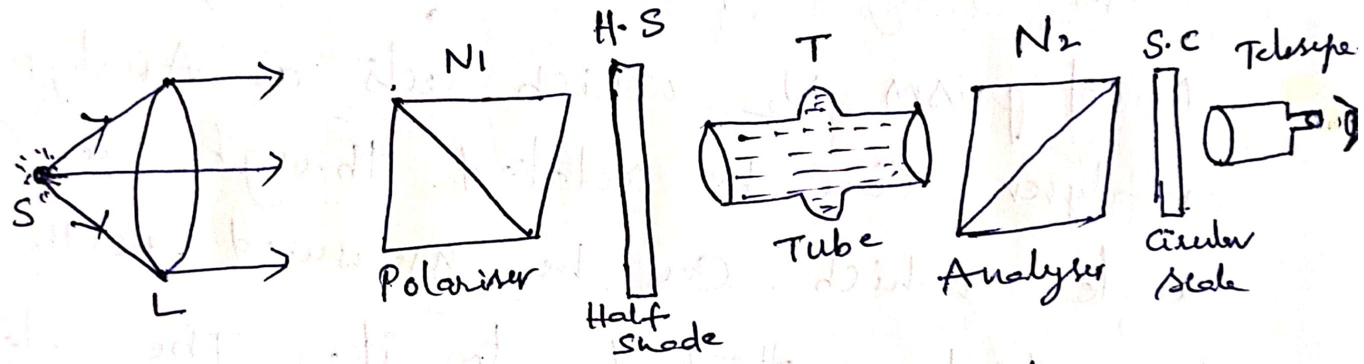
Specific rotation: specific rotation at given temperature and for a given wave length is defined as the angle through which the plane of vibration is rotated when the light travells through a solution of length 1 decimeter and of concentration 1 gm/c.c.

If 'θ' is the angle of rotation, 'l' is the length of solution in cm and 'c' is concentration in gm/c.c

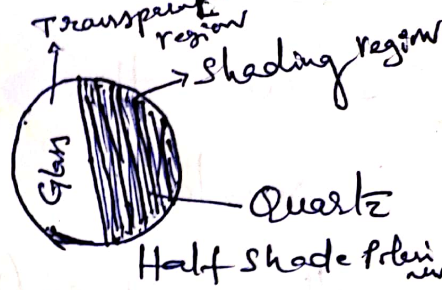
specific rotation, $\boxed{S = \frac{10\theta}{lc}}$

Laurent's half shade Polarimeter

Polarimeters are the instruments designed to measure the angle of rotation produced by a substance. Polarimeters are also used to find the specific rotation of sugar solution (or) if the specific rotation is known, we can find the concentration of sugar solution.



S is a monochromatic source of light. The light rays coming from the source are rendered parallel by means of a convex lens. The light rays enters the Nicol prism (N_1) which acts as Polariser. The emergent light coming from N_1 is plane polarised. This plane polarised light enters into half shade device. The half shade device is made up of two semi circular parts having equal radii and join together to complete the circular shape. It consists of two parts, one of which is made of glass and the other is Quartz. There is a glass tube, of nearly length 20cms having a larger diameter at its middle.



Hence, air bubbles can be minimised (or) avoid at the centre of the tube, when it is filled with sugar solution. The light enters into Nicol prism N_2 which acts as Analyser. This analyser can be rotated through a certain angle which can be measured with a circular scale attached to it. The intensity of emitted light from N_2 can be observed through a telescope.

Initially, the glass tube is kept empty. Since the principle sections of two Nicols N_1 and N_2 are perpendicular to each other, the field of view is completely dark, which can be observed through telescope. Now rotate the Nicol N_2 to an angle, and observe through the telescope, the field of view is not dark and again rotate the Analyser N_2 to some angle, then the two half shades of the device are of equal brightness. Now the reading on the scale is noted.

Now the glass tube is filled with sugar solution of known concentration. Rotate the Nicol N_2 to an angle, observe the two parts of half shade through a telescope one part is dark and the other is bright and again rotate the Nicol N_2 to certain angle the part-1 is bright and part-2 is dark. ~~Again~~ rotate the Nicol N_2 up to the the two parts are of equal brightness. The reading on the scale is noted. The difference of these two readings gives the angle of rotation. The experiment is repeated for different concentrations and graph is drawn between different concentrations (c) and angles of rotation (θ) and the value of 'θ/c' can be calculated.

The specific rotation 'S' can be calculated using formula, $\boxed{S = \frac{100\,\theta}{l\,c}}$, $l \rightarrow$ length of tube in cm.

LASERS

Laser is an acronym for light amplification by stimulated emission of radiation. Laser is a device to produce a powerful mono chromatic beam of light in which the waves are coherent. The beam emerges as a narrow beam which can travel over long distances without much loss of energy.

Characterstics of a Laser:- Laser when compared with any conventional light sources (sun light or tube light). Laser possesses few out standing characterstics, they are

Directionality:- During the propagation of a laser, its angular spreading will be less and occupies a less area where it incidents. Hence it possesses high degree of directionality. i.e the beam is very narrow and can travel to long distances with out spreading.

Mono chromaticity:- The property of exhibiting single wavelength by a light is called mono chromaticity. i.e when it is sent through a prism then a single line will be appeared in the optical spectrum

High intense (or) Brightness:- The beam is extremely intensive Due to its directionality many beams of light incident in a Small area, therefore the intensity of light is Very high. The beam Can produce a temperature of $10^4 °C$ at a focused point. So it is used for the welding

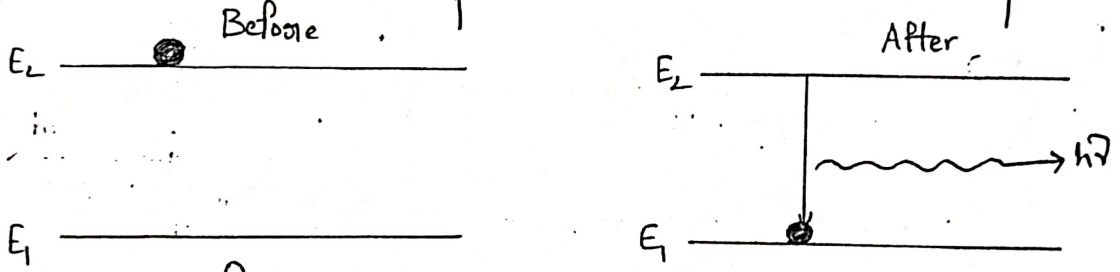
Coherence :- The property of existing either zero (or) Constant phase angle difference between two (or) more waves is known as Coherence. In a Laser, the property coherence exists between any two (or) more light waves of Same type

Basic definitions :- To understand the working part of a Laser System, One should have few fundamental Concepts They are ① Absorption ② spontaneous emission ③ stimulated emission ④ Life time ⑤ Meta stable state ⑥ population inversion ⑦ pumping

1. Absorption :- Let us Consider a System in which two active energy levels are present whose energies are "E_1" & "E_2" where E_1 is ground state and E_2 is excited state as shown. usually atoms are in the ground state as long as external forces are not applied. when a photon of energy "$h\nu$" ($= E_2 - E_1$) is incident on the atom lying in

the ground state then it excites to higher state E_2. this phenomenon is known as "absorption".

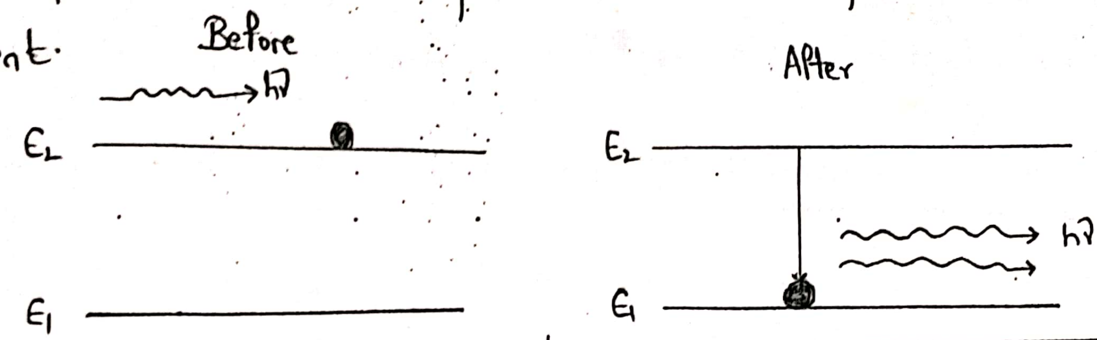
Spontaneous emission:- Let us assume that the atom is in the Excited state E_2. After the life time the atom de excited to its ground state Spontaneously emitting a photon of energy $h\nu\ (= E_2 - E_1)$ as shown. This phenomenon is known as Spontaneous emision.



The frequency of emitted photon $\nu = \frac{E_2 - E_1}{h}$,

where 'h' is planck's constant. The photons in this case have Various wave lengths and they are out of phase. Thus the photons are incoherent.

Stimulated emission:- Let us assume that the atom is in the excited state E_2, if a photon of energy $h\nu = E_2 - E_1$ is incident on it before the life time, it stimulates the atom from E_2 to E_1, then a photon of energy $h\nu$ is released along with the incident photon as shown in fig. These two photons have the Same energy and phase. This phenomenon is known as stimulated emission. The Emited photons in this case have the Single wave length and they are in Same phase, thus the photons are Coherent.



Spontaneous Emission	Stimulated Emission.
(1) Emission takes place on it's own accord.	* Emission takes place with the external incitement
(2) In Coherent radiation	* Coherent radiation
(3) Low intense & less directional	* High intense & more directional
(4) polychromatic radiation	* Mono chromatic radiation.
(5) postulated by Bohr	* postulated by Einstein
(6) Light from Sodium (or) Mercury lamp	* Light from He-Ne laser (or) Ruby laser.

Life time :- The duration of time Spent by an atom in the excited state is known as life time of that energy state.

Ex:- life time of Hydrogen atom is 10^{-8} Sec

Meta stable state:- The excited state which has long life time is known as meta stable state. According to Heisenberg's uncertainity principle metastable state is an excited state of an atomic system whose energy level width is very small, so that the life time of electron is very high

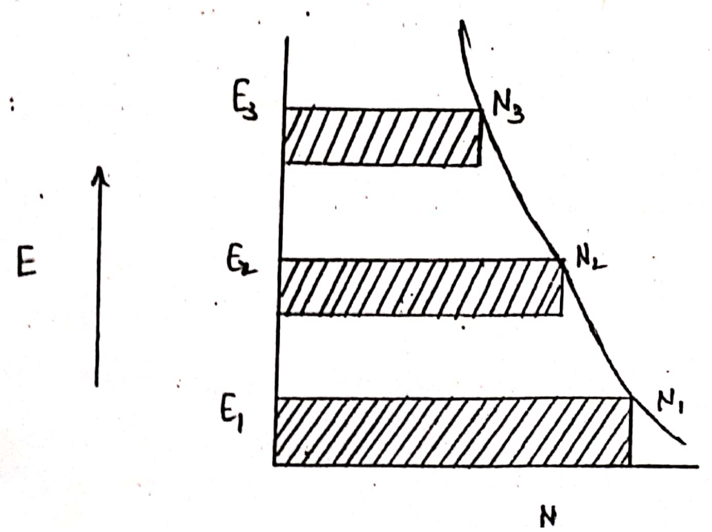
Population:- The no of atoms per unit volume in an energy state E is known as population of that energy level
If N is the no. of atoms per unit volume in an energy state E, then the expression for population can be written as $N = N_0 \cdot e^{-E/K_BT}$

N_0 - population in the ground state

T - temperature

K_B - Boltzmann's Constant

From the equation of population, population is maximum in the ground state and decreases exponentially as energy level increases as shown in fig

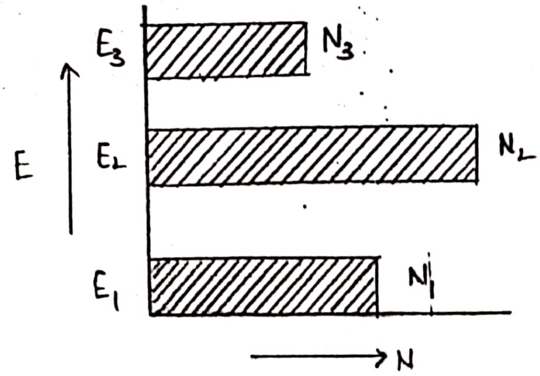


Population Inversion:- Consider 3 level System in which 3 active Energy levels E_1, E_2 & E_3 are present. The population in those energy levels are N_1, N_2 & N_3 respectively. In normal Conditions $E_1 < E_2 < E_3$ and $N_1 > N_2 > N_3$

E_1 is the ground state and the life time is unlimited. E_3 is the highest energy level, its life time is Very less and it is the most unstable state. where as E_2 is an Excited state and has more life time. Hence it is meta stable state.

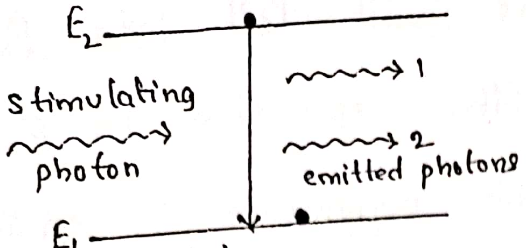
when Suitable form of energy is Supplied to a System, the atoms excite ground state (E_1) to E_2 and E_3 excited states

Due to unstability atoms will Come back to ground state after the life time of the respective energy states E_2 and E_3. If this process is Continued then atoms will excite Continuously to E_2 and E_3. Because E_3 is the most unstable state, atoms will fall into E_2 immediately. At a stage the population in E_2 will become more than the population in the ground state. This phenomenon is known as population inversion and is shown in the fig.

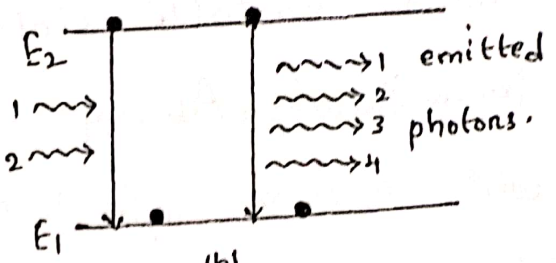


Pumping :- The population inversion Cannot be achieved thermally. To achieve population inversion Suitable form of energy must be supplied. The procen of Supplying Suitable form of energy to a System to achieve population inversion is called pumping

Lasing action (or) Principle of laser :- In stimulated emission, the emitted light travels in the same direction as that of incident photon as shown in fig. ⓐ. Now the two photons again stimulate two more photons.



(a)

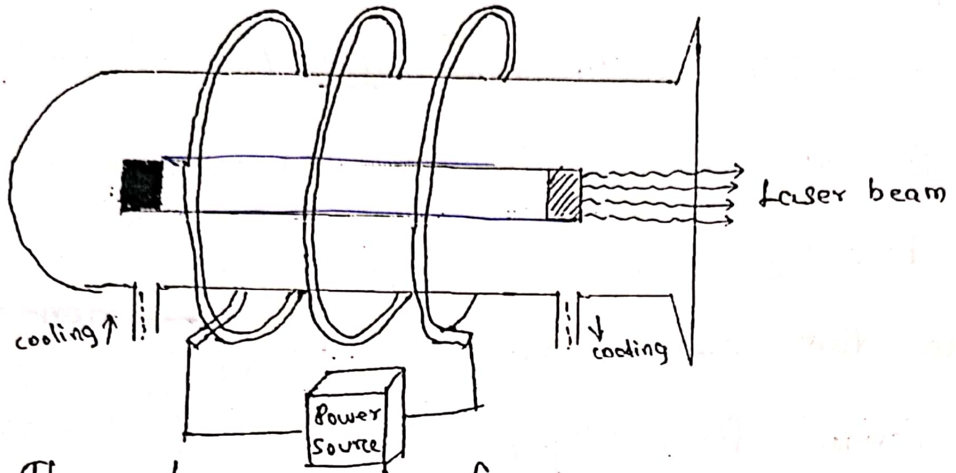


(b)

As a result, four photons are emitted as shown in fig. ⓑ. In this way a chain reaction (or) an avalanche effect is produced. This phenomenon is known as Lasing action. So a monochromatic, intense and coherent beams, which has the same frequency, as that of incident beam, are obtained. This is the principle of working of a laser.

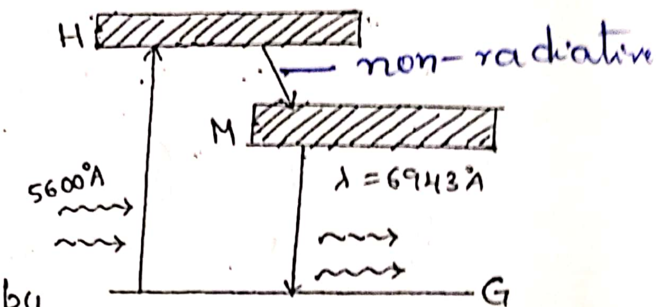
Solid State (or) Ruby laser

Ruby laser is the first laser developed in 1960. It is a solid state, three-level laser. Ruby is a crystal of Aluminium oxide, Al_2O_3 in which some aluminium atoms are replaced by Chromium atoms. The active material in the Ruby are Chromium (Cr^{+3}) ions. In a Ruby laser, a pink rod of length 4 cm and diameter of 0.5 cm is generally used.



The two end faces are coated with Silver in such a way that one end face becomes fully reflecting surface and the other partially reflecting surface. The ruby rod is surrounded by a helical xenon flash tube which provides pumping light (5600A°) to raise the chromium ions to upper energy level. Only a part of flash light is used for the pumping of Cr^{+3} ions, while the rest heats up the apparatus. A cooling arrangement is provided to keep the experimental setup at normal temperatures.

Working principle:- The chromium atoms have 3 active energy levels. They are named as ground state (G), metastable state (M) and higher state (H). The energy diagram of chromium is shown in fig.

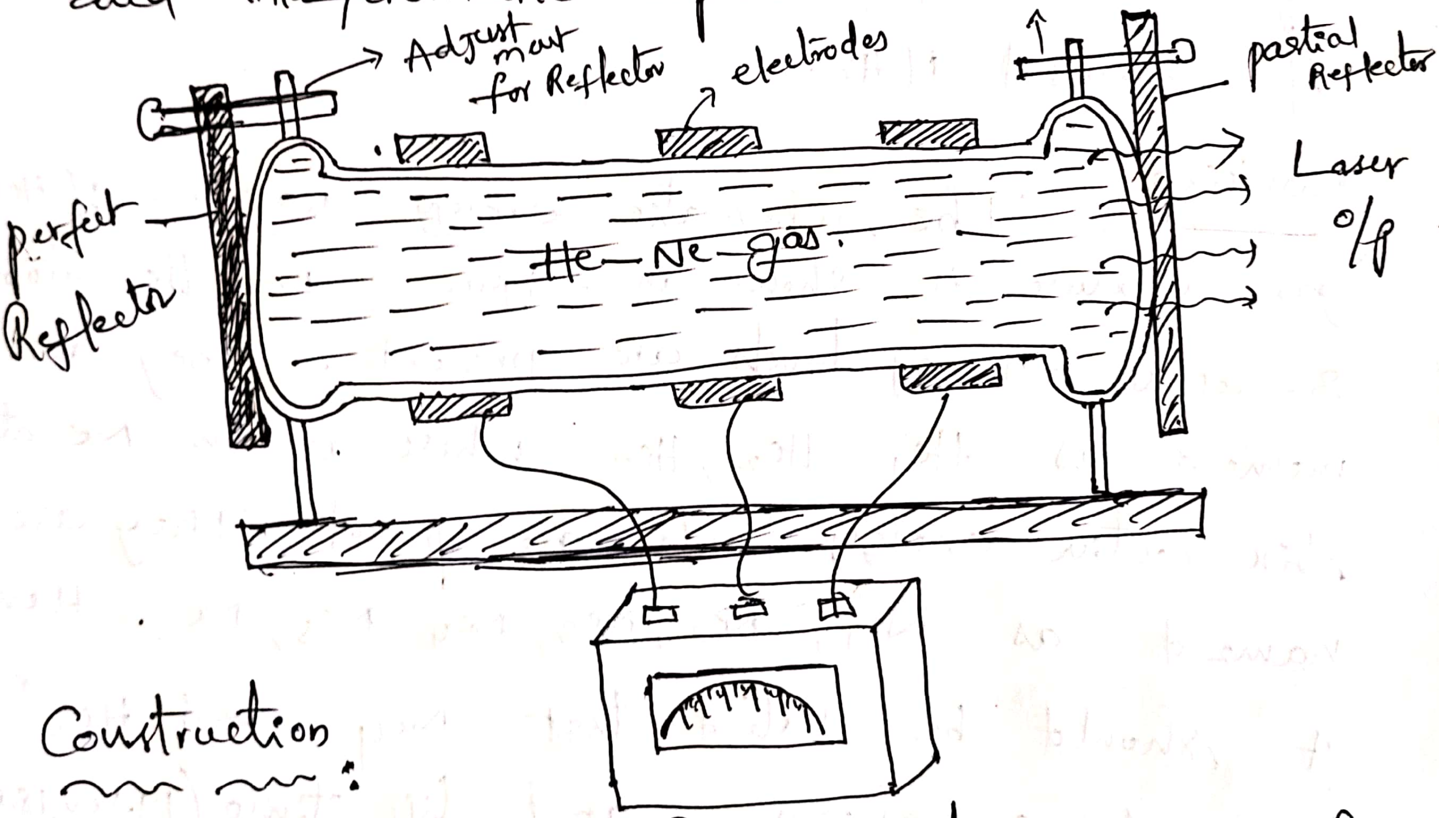


Due to the supply of Helical xenon flash light (white light) to the Ruby rod, the chromium atoms begin to excite from ground state to excited states 'M' and 'H'. Chromium atoms require two steps to return back to their ground state, G. First step is from higher state 'H' to metastable state, 'M' which is a shorter jump (the excited chromium atom releases part of its energy to the crystal lattice by collisions and decays to the metastable state)

and energy emitted in this process to the crystal lattice as heat. This transition is is called non-radiation transition. In metastable state the chromium ions remain for longer duration of the order of milliseconds. So after a few milliseconds, the level 'M' becomes more populated than level 'G'. So, population inversion takes place between 'M' and 'G' states. As a result, stimulated emission takes place and the chromium ions translate from 'M' state to 'G' state. The transitions give rise to emission of light of wavelengths 6929Å (wave length radiation) and 6943Å respectively. In these 6929Å wavelength radiation is very weak in intensity and the laser radiation is mostly due to 6943Å wavelength radiation. The laser beam then ceases till the next flash of Xenon tube repeats the process. Thus the Ruby laser is a pulsed, of course continuous wave lasers are also in use.

He-Ne Laser (or) Gaseous Laser

He-Ne Laser is a gaseous Laser system and it is used to produce a continuous Laser. It is a Four level laser system, because the 4 energy levels are involved actively in the production of Laser. This Laser is a highly directional, monochromatic, Coherent and stable. This Laser is very useful in making holograms and interferometric experiments.



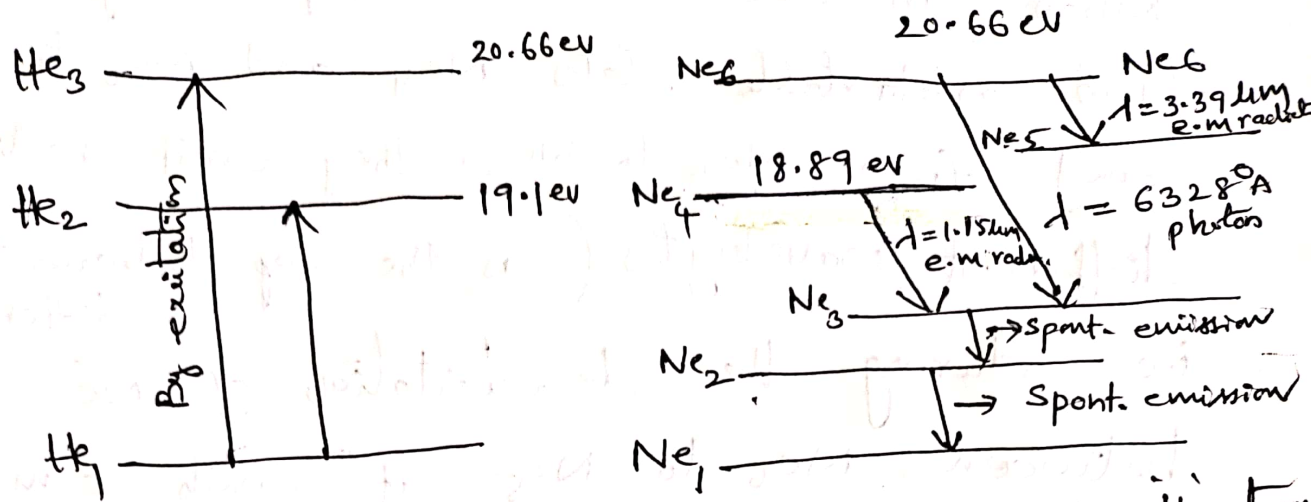
Construction:

The gas Laser Consists of a cylindrical glass tube of length 80cm and a diameter of 1.5cm. This tube is made up of Quartz because it absorbs low wavelengths of radiation.

This tube is filled with a mixture of Ne gas under a pressure of 0.1 mm of Hg and He gas under a pressure of 1 m.m of Hg. There is a majority of He atoms and minority of Ne atoms. At the end of the tube there is a partial Reflector while on the other end there is a perfect reflector. The active material is excited due to energy discharge through the gas mixture by means of R-F generator with a frequency of several MHz.

<u>Working</u>: The schematic energy diagram of He-Ne gas mixture is shown in figure. In He-atom 3- active energy levels are present. They are named as He_1, He_2, He_3 whereas in Ne atom six active energy levels are present. They are named as Ne_1, Ne_2, Ne_3, Ne_4, Ne_5, Ne_6. Here it should be noted that Ne_4 and He_2 have same energy and life time (19.1eV, 18.89eV) and Ne_6 and He_3 (20.66 eV, 20.63 eV).

When an electric discharge is passed through the gas, the electrons are accelerated towards the +ve electrode.



During their passage they collide with He atoms and excite them into their upper states He_2, He_3. These are meta stable states. Thus these atoms remain in these levels for a sufficiently long time. Now these atoms interact with the Ne atoms present in ground state and excite them into their meta stable states labelled as Ne4 and Ne6. i.e, due to interaction He atoms looses its energy and falls to ground level and that energy will be gained by Ne atoms and reaches to Ne4 and Ne6.

As the energy exchange continues, population of Ne atoms in the excited states increases more and more and hence the Ne atoms are more in Ne_4, Ne_6 and population inversion takes place between Ne_6 to Ne_5, Ne_6 to Ne_3 and Ne4 to Ne3.

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When an excited Ne- atom passes spontaneously from metastable states Ne_4 and Ne_6 to Ne_3 and Ne_5 and from Ne_6 to Ne_3, they emit radiation of different wavelengths (as the gap between them are different) i.e during the de excitation of 'Ne' atom between Ne_6 to Ne_5 it emits e.m radiation of 3.39 µm and 1.15 µm for Ne_4 to Ne_3 and a photon of wavelength 'λ' = 6328 Å during the excitation of Ne_6 to Ne_3. This photon having wavelength 'λ' travels through the gas mixture where as the other radiations of wavelengths will be absorbed by Quartz tube. If this photon is moving parallel to the axis of the tube it is reflected back and forth by two reflectors until it stimulates an excite 'Ne' atom and causes it to emit a fresh photon which is in same phase with stimulating photon. This process is continued and a Laser beam builds up in the tube and becomes sufficiently intense and escapes through partial reflecting surface.

Since 4- energy levels Ne_6, Ne_5, Ne_4, Ne_3 are involved during the production of a Laser, it is also called as 4-level Laser system.

Semiconductor Laser (Ga-As)

We know that when a current is passed through a p-n junction, p-region being positively biased, holes are injected from p-region into n-region and electrons from n-region into the p-region. The electrons and holes recombine and release of energy takes place at the junction (or) near the junction. The amount of this energy called the activation energy (or) energy gap. It depends on the particular type of semiconductor. In Si, Ge the activation energy is in the form of heat because the recombination of charged carriers of opposite sign takes place through interaction with the atoms of the crystal. But in case of other semiconductors such as Gallium Arsenide (Ga As), the energy is light energy, because the atoms of the crystals are not involved in the release of energy. The wavelengths of the emitted light depends upon the activation energy of the crystal. The photons emitted at the moment of recombination of an electron with a hole will stimulate the recombination of other carriers of electric charges. The result will be stimulated emission of radiation.

If these radiations moving in the plane of the junction are made to move back and forth, by reflection at opposite parallel sides, a very powerful laser beam of stimulated (emission) radiation can be produced.

For example consider a Ga-As crystal and is cut into a

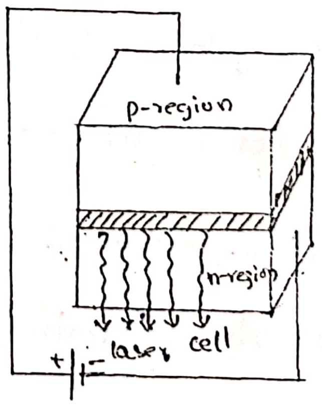

plate having a thickness of 0.5mm as shown. (17)

The platelet consists of two parts exhibiting hole conductivity and electron conductivity respectively. When exciting currents are small, only a small part of carriers undergo recombination. The process is spontoneous. The laser radiation is random and incoherent. But when the current density is increased the emission becomes more and more coherent and the radiation intensity markedly ~~by~~ increases.

Applications of Lasers:-

Due to its outstanding characterstics, they have wide applications in science and technology.

1. Lasers In communication:

a) Using a laser, it is possible to transmit (1000's) thousands of television programs to simaltaneously the entire world.

b) Using laser, it is possible to make communication between moon and Earth. Also the Earth-Moon distance has been measured, with the use of lasers.

c) Lasers are used in Optical fibre communications. In optical fibre communications, lasers are used as light source to transmit audio, video signals and data to long distances without attenuation and distorsion.

2. In Computers:-

a) By using lasers, large amount of data (or) information can be stored in C.D ROM.

b) Lasers are also used in computer printers.

3. Industrial Applications:-

a) In Industries, lasers are used in welding, drilling and cutting.

b) They can blast holes in diamond and hard steels

4. Medical Applications:-

a) Laser is used in Endoscopy to scan the Inner parts of the stomache.

b) They are used in the treatment of detached retinas. Laser surgery is common in the treatment of liver and lungs.

c) Since laser beam can be focussed on a very small areas, one harmful component can be destroyed without seriously damaging the neighbouring regions. Laser - therapy is completely painless and most advisable for children.

5. Chemical Applications:-

a) Lasers can be used in investigating the structure of molecules.

b) Laser beam can initiate (or) fasten the chemical reactions.

c) Lasers can be used in air pollution, to find the size of the dust particles.

6. Laser in Military:-

a) By focussing high energetic laser beam for few seconds to missiles, air crafts can be destroyed. So, these rays are called 'death rays' (or) 'War-weapons'.