LASER : (Light Amplification by Stimulated Emission of Radiation.)

A laser beam is extremely intense, coherent and highly parallel beam of light. A device which produces this kind of beam is quite often called a Laser.

Principle of LASERS → Stimulated Emission; Spontaneous emission.

→ A LASER system can be generated from all three states of medium (i.e solid, liquid or a gas)

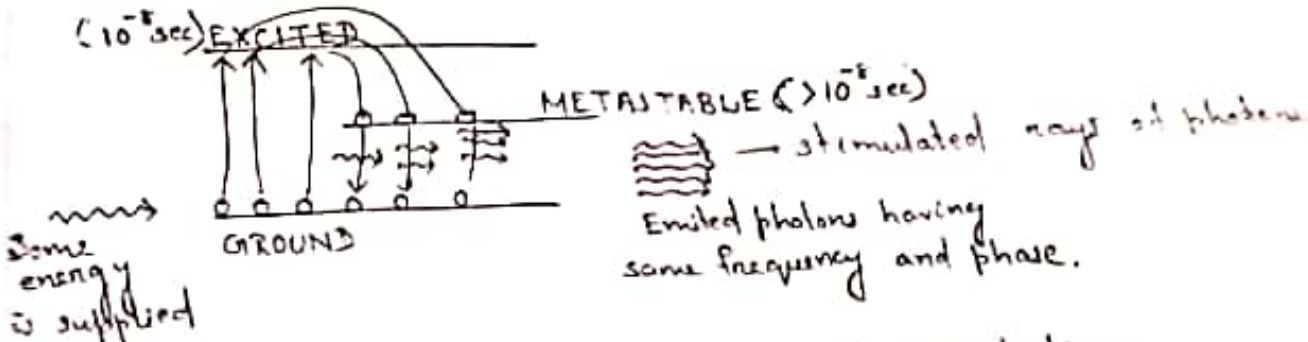
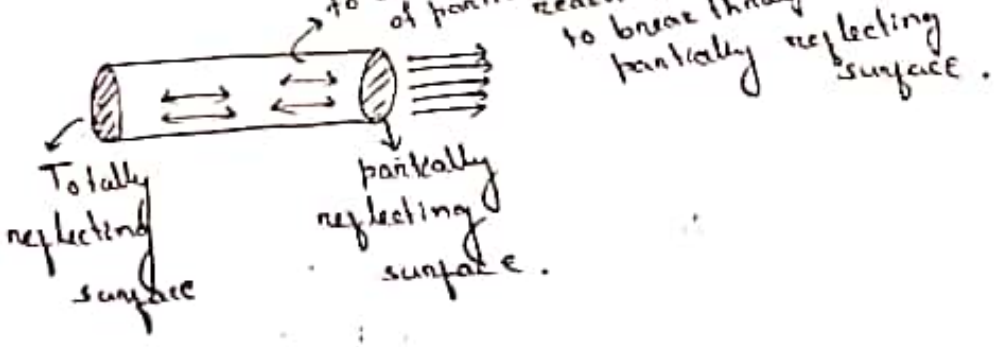


fig: Showing the stimulated emition of radiation.



⇒ We know that the excited atoms under ordinary conditions de-excite within 10^{-8} sec sending the radiations in random directions. (i.e the atoms in excited state) The kind of emission is known as spontaneous emission.

⇒ On the other hand if the atoms are made to stay a little longer in that state (lets calls it a metastable state) and are stimulated by external energy source (here photons) to get deexcited. This kind of emission is called stimulated emission.

⇒And the principle of laser is solely based on how the existance of metastable state help in obtaining the stimulated emission.

- Every LASER system consists of an active-medium (solid, liquid or gas) having ions or atoms possessing at least one metastable state.
- The active medium is placed in resonating cavity having electrical or optical pump to excite the atoms of the medium.
- The basic principle of all lasers is to first bring about population inversion (i.e more atoms in metastable state than that in the ground state)
- This is done by supplying the required amount of energy to the atoms of the active medium, known as optical pumping.
- Out of all the atoms present in the metastable state one atom has to de-excite and results in the emission of photon.
- And this emitted photon interact with other one and make it excite & similarly these two does with others.
- These emitted photons are made to move in that active medium to & fro, and making an intense beam, which has same frequency, direction and speed, as that of stimulating photons. This constitutes the laser beam.

Properties or Characteristics of LASER Beams-

(i) Directionality: General photon emitters face the problem of spreading in all directions, But in case of LASERS the emission is apparently in a single direction upto some specific distance which depends on the diameter of the aperature & the wavelength of the photon beam passing through it.

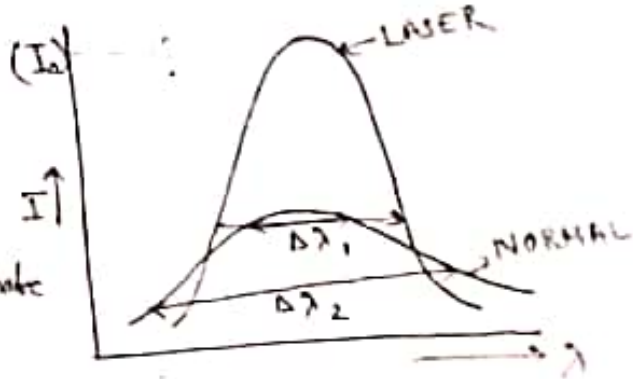
Let 'd' be the diameter of the aperature of beam & 'λ' be the wavelength of the beam.

Then the beam will pass undeviated upto a distance $\sim \frac{d^2}{\lambda}$

(ii) Intensity: As a laser beam has the ability to focus over as small an area as 10^{-6} cm^2, therefore, it is highly intense.

(iii) Monochromaticity:

Light emitted from a laser is vastly more monochromatic than that emitted from a conventional mono-chromatic source of light. From the λ−I graph it can be observed that the line width of laser is more compared to the other.



(iv) Coherence: The laser light is highly coherent (i.e consistent or no break) in space & time. This property enables us to realize a tremendous spatial concentration of light power.

Application of LASERS

(i) LASER in surgery: LASER beam can be carried from source using optical fibre from one place to another & and can be focused over an extremely small area. As the beam (which is carried by optical fibre to the internal area of body) is very powerful it can cut the flesh & seal the blood. And that even with less pain & stitches.

Painless cleaning & drilling of tooth cavities have become possible with laser beams.

(ii) LASER in industry: As Laser beam is very high power beam, it is employed in melting, cutting, drilling and welding metals.

→ In industrial chemistry, laser beam is employed to decompose noxious substances from industrial waste to convert them to harmless substances for living beings.

→ Laser beam is used in photography industry for high speed photography.

→ Future source of energy seems to be thermo-nuclear energy (fusion $_1H^2 + {}_1H^2 \rightarrow {}_2He^4$). To carry out the fusion a very high temperature ($\sim 10^7$ K) is required & pressure too. So the LASER source can be a good option for it.

(iii) LASER in other branches in Science:

→ In chemistry laser are used to break the bond in molecular level for study.

→ In astronomy rode-astronomers are frequently using it to determine distance of planets & sub-planets.

→ LASER are being preferred in communication system due to its high directionality signals.

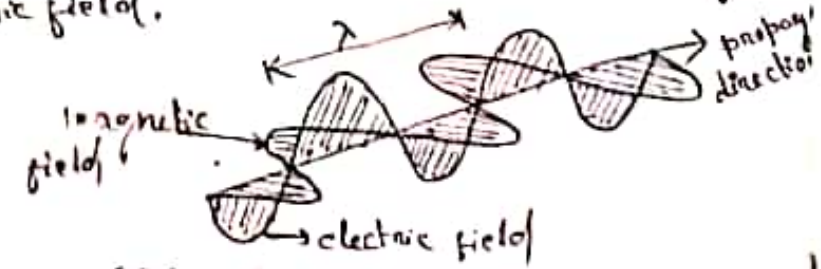
(iv) LASER in Warfare: Very intence LASER beams are capable of destroying enemy war planes.

Wireless transmission:

⇒ As the name suggests it does not require any specific medium for its transmission.

⇒ Like the E.M (Electromagnetic wave or photons or the light wave)

→ Electromagnetic waves are oscillations produced due to crossing over of an electric & magnetic field.



⇒ The direction of propagation of such wave is perpendicular to the direction of for of either of these fields as can be seen in figure.

⇒ These waves are not deflected by electric or magnetic field.

⇒ These waves do not require any medium for propagation.

⇒ Then one of the best examples of this transmission is X-rays. Which are electromagnetic waves having wavelength range from 0.001 nanometers to 10 nanometers.

→ We know the different layer of earth : Mesosphere, Troposphere Ionosphere etc. EM wave travels through these layers basically using <u>three methods</u> as discussed below.

(a) <u>Ground Wave</u> :

→ Used for low-frequency range transmission, mostly less than 1 MHz.

→ These type of propagation employ the use of large antenna order of which is equivalent to the wavelength of the waves.

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→ This use ground or "troposphere" for its propagation.

→ Signals over large distances are not sent using this method.

→ It causes severe attenuation which increases with increased frequency of waves.

(b) <u>Sky Wave</u>:

→ Used for the propagation of EM waves with a frequency range of 3-30 MHz.

→ This uses the "ionosphere" for its propation, which gives the advantage of presence of charged particles in the layer.

→ These ions provide a reflecting medium to the radio or communication waves within a particular frequency range.

→ We use this property of the ionosphere for long distance transmission of waves without much attenuation and loss of signal strength.

c. Space wave :

→ Used for a line of sight communication known as LOS.

→ Space satellite communication and very high frequency waves use this propagation method.

→ It basically involves sending a signal in a straight line from the transmitter to the receiver.