

1. What is laser?

Ans:

- Laser is a device for amplifying light waves.
- The name laser stands for the words Light Amplification by Stimulated emission of Radiation.
- Laser is a device which produces a highly coherent, unidirectional intense, monochromatic and parallel beam of light of particular frequency.

- Lasers of three kinds :
 - Those using solids
 - Those using liquids
 - Those using gases.

- In the case of liquid and gas lasers, a Fabry-Perot interferometer with silvered end plates is filled with fluid.
- In the case of Solid lasers, the ends of crystals are polished and silvered.

RUBY LASER is the first laser made up with a large single crystal.

2. State the properties of laser

Ans:

- 1) A laser beams is highly directional.
- 2) Lasers have excellent monochromaticity.
- 3) Laser beam is much more coherent.
- 4) Laser light can be polarized.
- 5) Laser beam is not easily absorbed by water.
- 6) The laser light is extremely intense.
- 7) The laser light is almost parallel and highly directional.
- 8) Laser beams are extremely collimators.

3. Give applications of lasers

- Ans:
- 1) Laser tools are used in repairing micro-electric circuitry for cutting, welding and drilling of circuits for calculators, computers etc.
 - 2) The extreme collimation and high intensity makes lasers useful for surveying .i.e. Measurement of the moon from the earth.
 - 3) Lasers are useful in eye surgery.
 - 4) Treatment of internal bleeding by coagulation can be done using laser.
 - 5) It can be used in treatment of Tumors.
 - 6) Drilling holes in the diamond can be possible using lasers.
 - 7) Aero planes and missiles can be destroyed by heating lasers.
 - 8) Useful in Studing Raman effect.
 - 9) Lasers can be used to forecasting earthquakes.
 - 10) Detection of the absolute rotation of the earth.
 - 11) The well defined directionality of laser beam makes it valuable in communications.
 - 12) Used in Doppler Effect to measure velocity of moving medium.
 - 13) Semiconductor laser are used in optical communication and optical computer design.

4. What are the properties of Laser? Explain it briefly.

Ans: The properties are as follows:

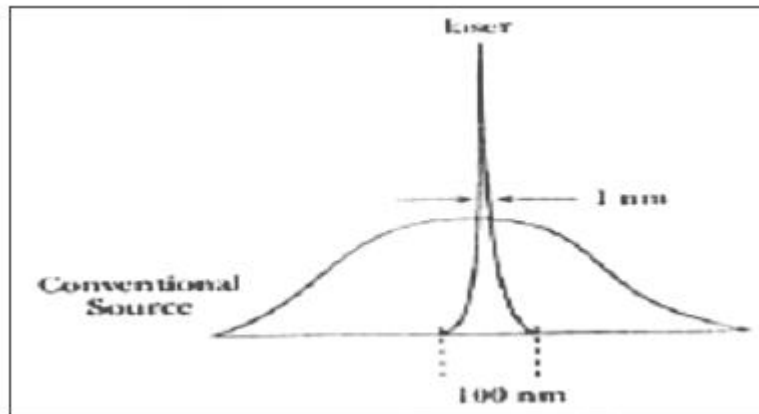
1. Monochromaticity
2. Coherence
3. Intensity and Power
4. Directionality

It can be explained as follows:

Monochromaticity:

- Laser light are highly monochromatic than that of any light source.
- Because of greater sharpness the laser lights are perfectly monochromatic. Its sharpness is 1 part in 10^{15} .

- Normal light source spread over a continuous range of wavelength.
- Laser can have a spectral width in the order 10^{-6} \AA^0 which very small compared to the width of order 0.1 \AA^0 of a sodium lamp (normal lamp).
- The comparison between the monochromaticity of laser and an ordinary conventional monochromatic source are shown as :
- Diag:



- Light from conventional source is more or less sharp, but has a spread over the wide frequency range. This spreading is thousand of megacycles /sec.
- Light from laser is sharp and has very little spread. This spreading is in the range of 100 nm.

Coherence :

- Laser light is highly coherent.
- All the emitted photons are in the same phase.
- The stimulated emission gives rise to the coherence in the radiated beam.
- Wave trains emitted by an individual laser can be several kilometers long.
- Typical bulb can generate the train wave less than a meter.

Intensity and Power :

- Laser light is highly intense.
- It is much brighter than that from any other source of light.
- The capacity of focusing high intense laser on a very small area makes extremely powerful tool.
- It can produce the temperature of the order 10^4 ° C at focused point.

- Highly intense laser can vaporize even the hardest metals.

Directionality :

- Laser light is highly directional.
- A laser beam is in the form of pencil of rays.
- This ray can propagate to long distance without divergence (spreading) [It can be less than 10^{-5} radians].
- The narrow width of laser beam brought extremely sharp focus.
- High directionality laser can be focused to extremely small region.

5. Give differences between Lasers and conventional source

Ans:

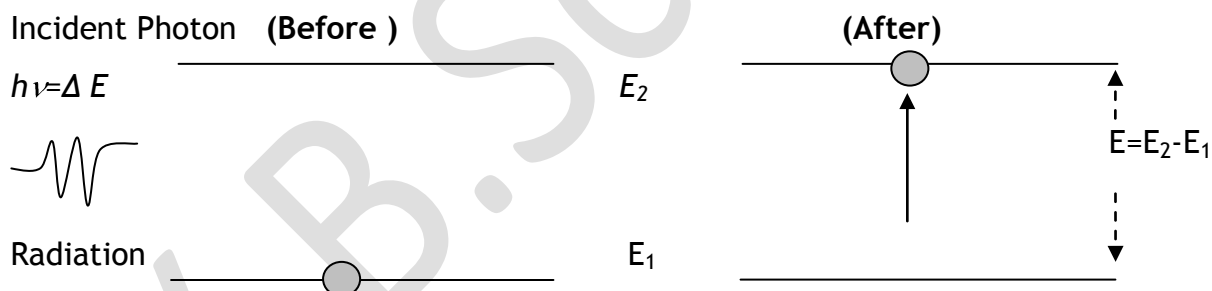
	Laser	Conventional Source
1	Highly Monochromatic	Spreads over a continuous range of wavelength.
2	Greater sharpness and has very little spread.	Less sharpen but spreads over wide range of frequency.
3	The spreading is in the range of 100 nm.	The spreading is thousand of megacycles /sec
4	Laser light is highly coherent	The source is not coherent here
5	Emitted photons are in the same phase.	Photon cannot maintain same phase.
6.	Generated Wave trains can be several Kilometers long.	Generated Wave trains can be less than a meter.
7.	It is much brighter than that from any other source of light.	Less brighter than laser
8.	High intensity and hence can vaporize metal.	Less intensity
9.	Highly directional	Directionality is very less.
10.	It can focused sharply over very small region	It spreads over small region.

6. Explain the following process with the help of neat label diagram

Ans: Absorption:

- Light is absorbed or emitted by atoms or molecules during their transition from one energy state to another.
- In the process of absorption, an atom in a low energy absorbs radiation of an appropriate frequency.
- AS a result it gets excited to an upper energy state.
- As shown in figure, an atom in a ground sate E_1 initially .The atom can absorb an amount energy $h\nu$.When it moves to higher energy level E_2 .
- Then $h\nu = E_2 - E_1$.

Diagram :

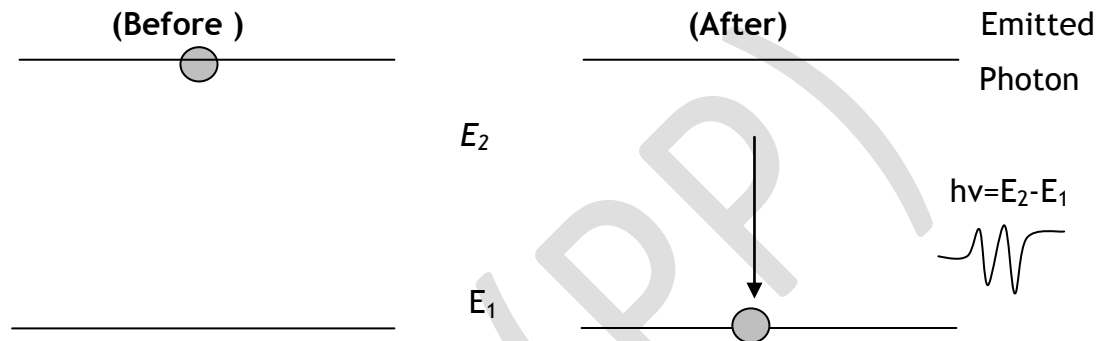


Spontaneous Emission:

- It is the process by which an excited atom returns to ground state very soon.
- An atom initially in an excited state of energy E_i decays on its own to a lower energy state of energy E_f by emitting a photon of energy .
- Thus $h\nu = E_2 - E_1$.
- This process of emission of photon is called spontaneous emission of photon.
- This photon can move in any direction.
- The radiation given out by is coherent.

- This process is spontaneous because no external triggering is required.
- Spontaneous emission process is opposite to that of absorption.
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Diagram :



Stimulated Emission:

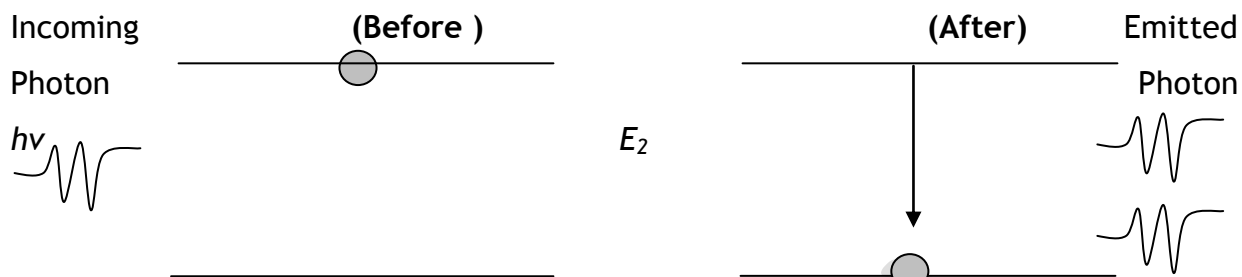
- It is the basic requirement in laser operation.
- Consider the upper energy state of energy E_i and lower energy state E_f .
- Thus a photon of light of correct frequency ν is given by-

$$\nu = \frac{E_i - E_f}{h}$$

An atom initially in an excited upper level (E_i) to make a transition to lower energy state E_f by emitting a photon of the same frequency ν . This is called stimulated emission of photon of light.

- In this process the transition generates additional photon and that is identical to the triggering photon.
- The rate of stimulated emission depends upon :
 1. The intensity of an external triggering radiation
 2. The number of atoms in the upper state.

Diagram:



7. Describe the construction and working of He-Ne laser.

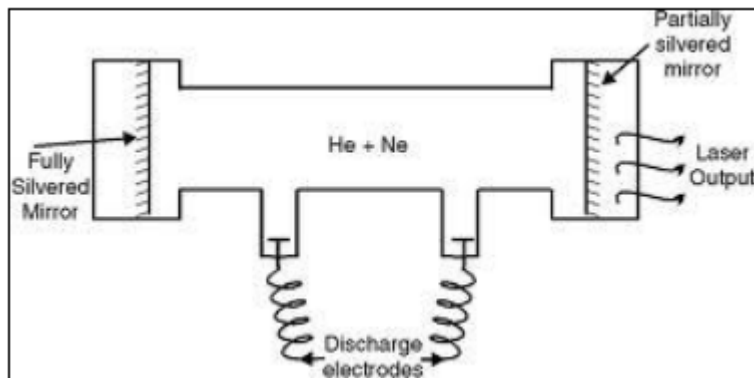
Ans: The first gas laser has been reported in 1961, since it was the first gas filled laser.

Construction:

- The He-Ne laser consists of a long, narrow quartz tube having diameter is about 1.5 cm and 80 cm long.
- It also has two electrodes in the tube which are connected to high voltage source about 4000 V d.c.
- The tube is called as 'plasma tube' because discharge occurs in the tube.
- The active material inside the tube is excited externally using high frequency generator (Frequency of several tens MHz)
- One end of the tube is a perfect reflecting (M_1) mirror; on the other end the mirror is partially reflecting (M_2).
- The active material is the mixture of He and Ne in a ratio of 10:01.
- Tube is filled with the helium (2.5 torr) and neon (0.5 torr) , while the pressure inside the tube is 1 torr.
- The partial pressure of He being about 5-10 times higher than Ne.
- The resonating cavity shows the mirrors M_1 and M_2 placed outside of the tube.
- M_1 is completely silvered while M_2 is partially.
- To minimize reflection losses, discharge tube edges are cut at the Brewster angle.

- Brewster windows, the laser output are linearly polarized.

Diagram :



Working :

- The mechanism of He-Ne laser is based on the interaction of atoms of two gases.
- When the current passes through the He-Ne mixture, the collision between electrons and helium atom takes place.
- Due to collision, these atoms jump from their ground state (E_0) to the excited states (E_1).
- The excited helium atoms then collide with Neon atoms in elastically.
- The collision transfers energy from He-atom to Ne-atom.
- This transition of atom emits photon which will pass through the active medium.
- These photons will reflect back by mirrors M_1 and M_2 .
- During this process they trigger other stimulated emission processes.
- This process produces multiple coherent photons that results in an emission of an intense, collimated, monochromatic laser through partially silvered mirror

Advantages:

- He-Ne laser produces power in the range of 0.5 to 50 mw.
- It is simple, powerful and less expensive.

- They are widely used in laboratories as a monochromatic source in the laser printing and bar code reading.

8. Explain the basic technique of holography

- Ans:**
- A procedure for producing three dimensional images is called Holography. It is a new method of recording of optical images.
 - The phenomenon is based on the reconstruction of electromagnetic waves reflected from three dimensional objects.
 - The information is the interference pattern with alternate dark, bright fringes formed by superposition of two coherent light beams.
 - When such holograph is observed by coherent source of light , a three dimensional image of original is formed .
 - It is because; according to the holography technique both the phase and intensity attributes of the wave are recorded using interferometric techniques.

Principle Techniques :

(a) Recording of the Hologram:

- This method involves transformation of the object into hologram.
- Object is illuminated by the coherent light; to form fringes in the photographic plate.

(b) Reconstruction of the images:

- This method involves formation of an image of the object.
- It is re-illumination of the developed interference pattern by light of the same wavelength to form the three dimensional image of the original object.

Applications :

Holography is becoming a very useful technique for -----

- ✓ For microscopic investigations of biological techniques.
- ✓ In Data processing and storage.

- ✓ It can use in Interferometry i.e. double exposure hologram.
- ✓ Formation of three dimension images in television and cinematography.

9. Write a short note on Lasers in medicine field.

- Ans:**
- Lasers have wide and very important applications in medicine.
 - They are successfully used in diagnostic.
 - The surgery and other medical treatments can also be done using laser.

Other than these following different lasers can be used in real life.

- He-Ne laser used in trophic ulcer treatment and preparation of holograms.
- CO₂ laser has applications in brain, oviduct and spinal surgery.
- Argon laser is used in angioplasty, brain and eye surgery.
- Nitrogen laser is used in DNA analysis and genetic engineering.
