LASER AND FIBER OPTICS

Introduction of LASER

We know that the current can be amplified by vacuum tubes or transistor amplifier. Similarly, light waves can also be amplified and is termed as 'LASER' which is an acronym for "***L**ight **A**mplification by **S**timulate **E**mission of **R**adiation*".

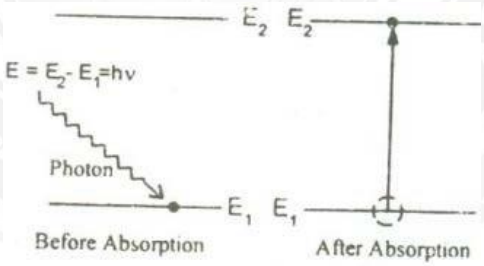
T.H. Maiman was discovered Ruby laser in 1960. After that a rigorous analysis was made, which lead to many types of lasers got due to the lasting action with atoms, ions, molecules, etc., in gases,

solids and liquids. The light beam from laser has frequency up to 10^{14} Hz leads to many applications in the scientific world and showed that the function of optics is alive.

Basic definitions

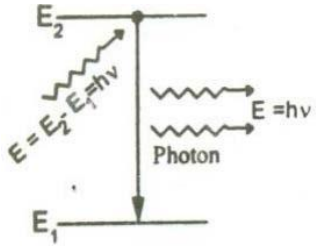
Stimulated Absorption:

When external photon energy is incident on the atom in the lower state, it can be raised to higher state by absorbing photon energy. This process is called the stimulated absorption.



Stimulated Emission

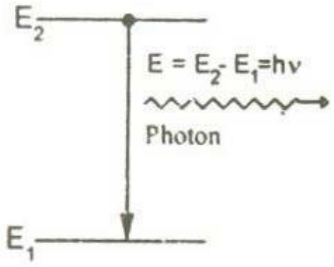
Induced emissions of photons are produced by the transformation of an atom from excited state to ground state with the applied external photon energy is known as



stimulated emission.

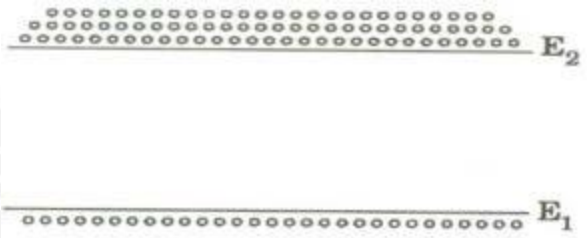
Spontaneous Emission

Induced emissions of photons are produced by the transformation of an atom from excited state to ground state without applied external photon energy is known as spontaneous emission.



Population Inversion

The establishment of a situation in which the number of atoms in higher energy level is more than that in lower energy level is called population inversion. It is an essential requirement for producing a laser beam. It is achieved by pumping action.



Active medium

The medium in which the population inversion takes places is called active medium.

Active centre

The material in which the atoms are raised to excited state to achieve population inversion is called as active centre.

Pumping action

The process of creating a population inversion in the atomic state is known as pumping action. It is essential requirement for producing a laser beam.

There are several methods by which the population inversion (pumping) can be achieved. Some of the most commonly used methods are

(a) Optical pumping
(b) Direct electron excitation (Electric discharge)
(c) Inelastic atom-atom collision.
(d) Direct conversion
(e) Chemical process

(a) **Optical pumping:** The atoms are excited with the help of photons emitted by an external optical source. The atoms absorb energy from the photons and raises to excited state. (e.g.) Ruby Laser, Nd-YAG Laser.

(b) **Direct electron excitation:** The electrons are accelerated to very high velocities by strong electric field and they collide with gas atoms and these atoms are raised to excited state (e.g) Gaseous ion lasers (argon laser), Helium-Neon (He-Ne) laser, CO_2 laser etc.

(c) **Inelastic atom-atom collision:** A combination of two types of gases are used, say A and B both having same and nearly coinciding excited states A* and B*. During

electric discharge 'A' atoms get excited due to collision with electrons. The excited A* atoms now collide with 'B' atoms so that B goes to excited state B* (e.g) Helium-Neon laser, CO_2 laser

$e^- + A \rightarrow A^*$

$A^* + B \rightarrow B^* + A$

(d) **Direct conversion:** Due to electrical energy applied in direct band gap semiconductor like GaAs etc, the combination of electrons and holes takes place and electrical energy is converted into light energy directly. (e.g.) Semiconductor laser.

(e) **Chemical method:** Due to some chemical reactions, the atoms may be raised to excited state. (e.g.) Dye laser.

Differences Between Stimulated and Spontaneous Emission of Radiation.

S.No	Stimulated emission	Spontaneous emission
1.	Emission of light radiation is triggered by external source.	Emission of light radiation is not triggered by external influence.
2.	The emitted photon move in same direction and is highly directional.	The emitted photons move in all directions and are random.
3.	The radiation is high intense, monochromatic and coherent.	The radiation is less intense and is incoherent.
4.	The photons are in phase.	The photons are not in phase.
5.	The rate of transition is given by R_{21} (St) = $B_{21}\ \rho_v\ N_2$	The rate of transition is given by R_{21} (Sp) = $A_{21}\ N_2$

Characteristics of laser

1. It is highly coherent.
2. It is highly powerful.
3. It is directional and monochromatic.
4. It is extremely bright.
5. It is not easily absorbed by the water.
6. It is travel long distance without energy loss.

Differences between Ordinary Light and Laser Beam

S.No	Ordinary light	Laser beam
1.	In ordinary light the angular spread is more	In laser beam the angular spread is less.
2.	They are not directional	They are highly directional
3.	It is less intense	It is highly intense
4.	It is not a coherent beam and is not in phase	It is a coherent beam and is in phase.
5.	The radiations are polychromatic.	The radiations are monochromatic
6.	Eg. Sunlight, mercury vapour lamp etc.	Eg. He-Ne laser, CO_2 laser etc.