UNIT-12

## LASER

[Light Amplification by Stimulated Emission of radiation.]
Laser is a light source but it is different from traditional light source. Lasers produce a highly directional and high intensity beam with a narrow frequency range.

We may say laser is generator of light. Lasers are based on the amplification of light by means of stimulated radiation of atoms or molecules.

## Population —

The number of atom per unit volume that occupy a given energy state is called population of that energy state

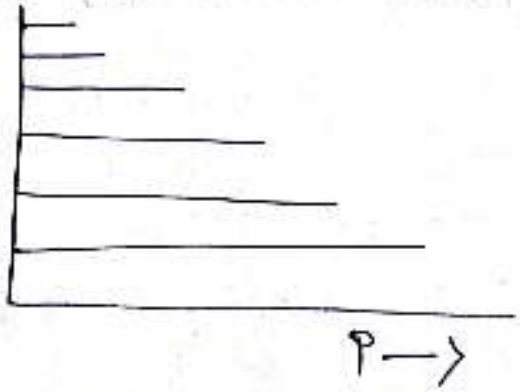
$$N = e^{-E/KT}$$

Boltzmann's Equation.

E = Energy
T = temprature
K = Boltzmann's Equation Constant

## Thermal Equilibrium —

At thermal equilibrium the number of atoms at each energy level decreases with increase of energy level.



but in thermal equilibrium,

the number of atomic transitions upward must be equal to the number of atomic transition downward

## Stimulated Emission

According to this Emission process, the excited atoms can make downward transition. But the photons in the light field include the exited atoms to fall to lower energy state and gives up their excess energy in the form of photons. This is called stimulated Emission.

An atom in the excited state neednot wait for spontaneous emission to occure. If a photon with appropriate energy interact with exited atom it can trigger the atom to undergo transition to the lower level and to emit another photon.

The process of emision of photons by an exited atom through a forced transitio occuring under the influence of an external ag is called stimulated emission.

→ Stimulated emission (S.E) is controlled from outside.

→ Emitted photon in (SE) has exactly the same frequency, plane of polarization and phase as those of the incident photon.

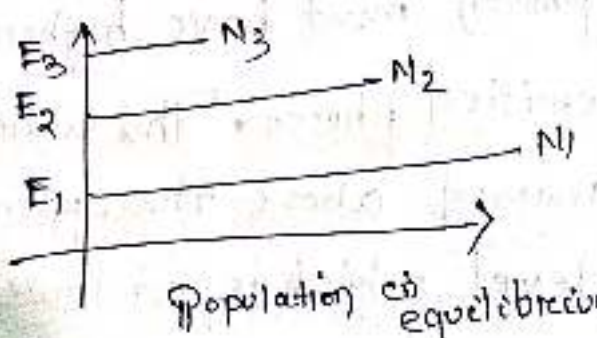
→ light produce in (SE) is unidirectional, coherent and mono-chromatic.

→ Light Amplification means process of multiplication of photons is the main feature of (SE).

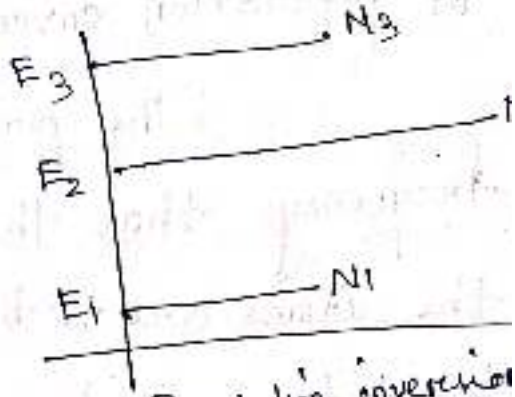
## Condition required for SE

→ Population inversion —

The population at excited level should be greater than that at the lower energy level, is called population inversion. It is a non-equilibrium state. If population at lower level becomes equal to or longer than that at the excited state population inversion ends and stimulated emision ceases.




Population in equilibrium




Population inversion of E2 with respect to E

02 → A very high density of radiation should present in the medium.

## * Pumping METHODS

Its a method which implimented to achieve population inversion to particular Energy level.

→ optical pumping
→ Electrical pumping
→ Direct Conversion

### optical pumping

In optical pumping photons are used to excite the atom. A light source such as a flash discharged tube is used to illuminate the lasere medium. The photons of appropriate frequency excite the atoms to an uppermost level.

From uppermost level they drop to the metastable upper laser level to create the state of population inversion.

The pump photon must have higher frequency than the emitted photon. This is because the atoms are to be raised above the upper laser level from a lower level which is at lowere

Laser level. This is one of the factors which reduces the laser efficiency. The pump level of the atom must not be a narrow level. It must be sufficiently wide.

Therefore light source emitting a broad range of wavelengths like a flash lamp can be used to excite atoms.

optical pumping is used for solid state -Crystalline lasers and liquid-tunable dye lasers.

## Active Medium

-An active medium is thus a medium which, when excited, reaches the state of population inversion, and eventually causes light Amplification. -The active medium may be solid, liquid and gas.

## Metastable States

As we know excited state have short lifetime. But for population inversion they stay at higher excited state for appreciable time. Such longer-live upper levels from where an excited atom does not return to lower level at once but remain excited for appreciable time are known as metastable states

Property of Laser —

01 → Directionality
02 → Intensity
03 → Coherence
04 → Mano-chromaticity
05 → Polarization
06 → Speckles.

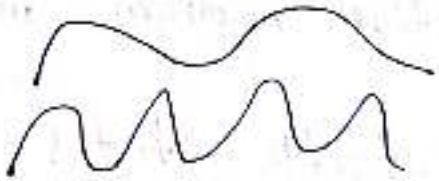
(01) Conventional light source emit light in all directions. But in laser emitted light in one direction

(02) Intensity of beam $I = \left(\frac{D}{\lambda}\right)^2 P$.

P = Power radiation
$\lambda = 632.8 \times 10^{-10}$ m
(He-Ne laser)

(03) Light waves are said to be Coherent if they are in phase with each other.

Coherent wave



Non-Coherent.

(04) If light coming from a source has only one frequency of oscillation the light is said to b monochromatic.

Polarization —
Laser output is linearly polarized.

(06) Laser beam appears to be granular.

## Application of Laser

→ Industrial
→ Medical
→ Nuclear Energy
→ Defence
→ Holography