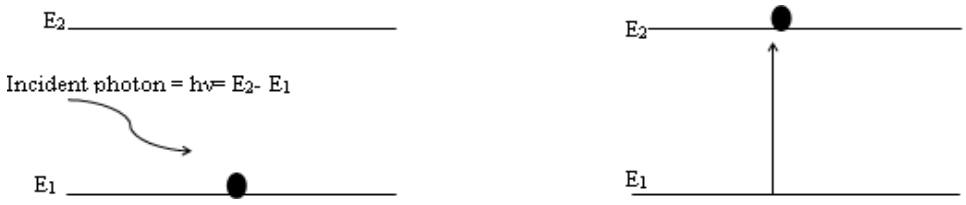
Introduction:

LASER is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. Laser device produces a beam of coherent, monochromatic, intense and directional light. Hence laser light is highly organized when compared with the ordinary light. This is because the waves of a laser beam move in phase with each other travel in a narrow path in one direction. In the case of an ordinary light it spreads out, travels in different directions and hence it is incoherent. On account of the special properties, lasers are the most versatile and exploited tools in different fields such as Engineering, Medicine, Defense, Entertainment, Communication etc., Other commonapplicationsoflaser include reading the bar code, cutting and welding metals, displays in light shows, playing music, printing documents, guidingmissile to its target and so on.



An atom in the lower energy state E_1absorbs the incident photon of energy (E_1-E_2) and goes to the excited state E_2.This transition is known as absorption.For eachtransition made by anatomone photon disappears from the incident beam.

foranatomA,

$As+hv \longrightarrow A^*$(excitedstate)

The number of absorption transitions per second per unit volume occurring in the material at any instant of time will be proportional to

(i) TheNumberofatomsinthegroundstateN_1

(ii) Energydensityoftheincidentradiation(Uν)

Rateofinduced absorption=$B_{12}U\nu N_1$

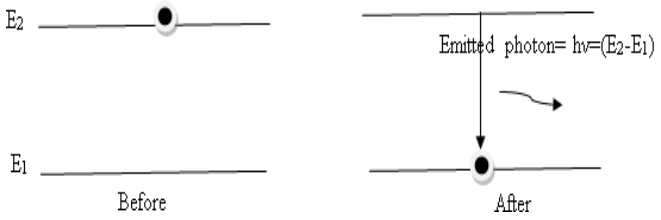
where $B_{12}$is proportionality constant which gives the probability of absorptions and it is called Einstein co-efficient ofabsorption. Since the number of atoms in the lower energy state is greater, the material absorbs more number of the incident photons.

Spontaneous Emission:

An atom which is at higher energy state E_2 is unstable, spontaneously returns to the lower energy state E_1 on its own during which a single photon of energy $(E_2-E_1) = h\upsilon$ is emitted, the process is known as spontaneous emission.

Thiss pontaneoustransition can be expressed as

$$A^* \longrightarrow A + h\upsilon$$



The number of spontaneous transitions per second, per unit volume depends on the number of atoms N_2 in the excited state.

Therefore,the rateofspontaneousemission=$A_{21}N_2$

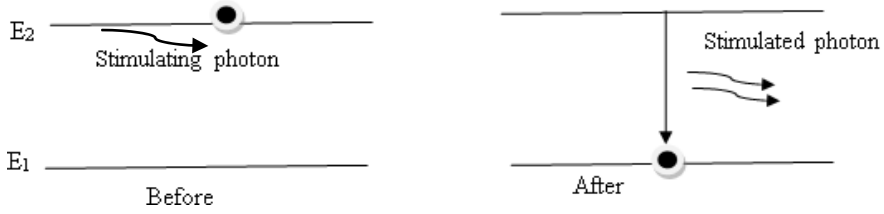
Where A_{21} is proportionality constant which gives the probability of spontaneous emission and it is called Einstein co- efficient of spontaneous emission of radiation.

The process has no control from outside.The instant of transition, directions of emission of photons, phases of the photons and their polarization states are random quantities.There will not be any correlation among the parameters of the innumerable photons emitted spontaneously bythe assemblyofatoms inthe medium.Therefore the light generatedbythesourcewillbe *incoherent*(ex: light emitted from conventional sources).

StimulatedEmission:

Emission ofphotons by an atomic system with an external influence is called stimulated emission.A mechanism of forced emission was first predicted by Einstein in 1916 in which an atom in the excited state need not wait for the spontaneous emissionto takeplace.Aphotonof energy $h\upsilon = (E_2-E_1)$, can induce the excited atom to make downward transition and emit light. Thus, the interaction of a photon with an excited atom triggers it to drop down to the ground state (lowerenergy) by emitting a photon.The process is known as induced or stimulated emission of radiation.

$$A^*+h\upsilon \longrightarrow A+ 2h\upsilon$$



The numberofstimulatedtransitionspersecondperunit volume inthe material is proportional to

(i) TheNumberofatomsinthe excited state N_2

(ii) Energydensityoftheincidentradiation (U_ν)

Somebasic definitions

1. **Atomic system :** It is a system of atoms or molecules having discrete energy levels.
2. **Active medium:** It is the material medium composed of atoms or ions or molecules supports the basic interaction of radiation with matter in thermal equilibrium condition.
3. **Energy density:** The energydensity U_ν refers to the totalenergy in the radiation field per unit volume per unit frequency due to photons.

1. **Population:** It is the number density (the number ofatoms per unit volume) of atoms in a given energy state.
    a. **Boltzmann factor:** It is the ratio between the populations of atoms in the higher energy state to the lower energy state under thermal equilibrium. IfN_2 isthe number densityofatoms inthe energystate E_2andN_1isthenumberdensityofatomsinthegroundstate(E_1),

b. Population inversion: It is the condition such that the number of atoms in the higher energy (N_2) state is greater than the number of atoms in the ground state (N_1). i.e, $N_2 > N_1$

If $N_2 > N_1$, it is non-equilibrium condition and it is called population inversion.