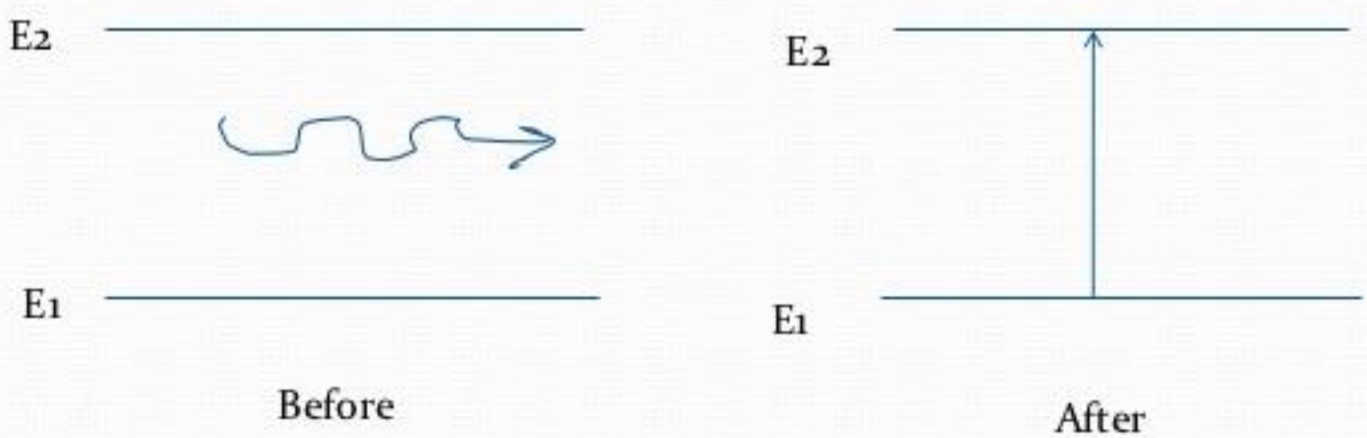
Optical Sources

Induced absorption (stimulated absorption)

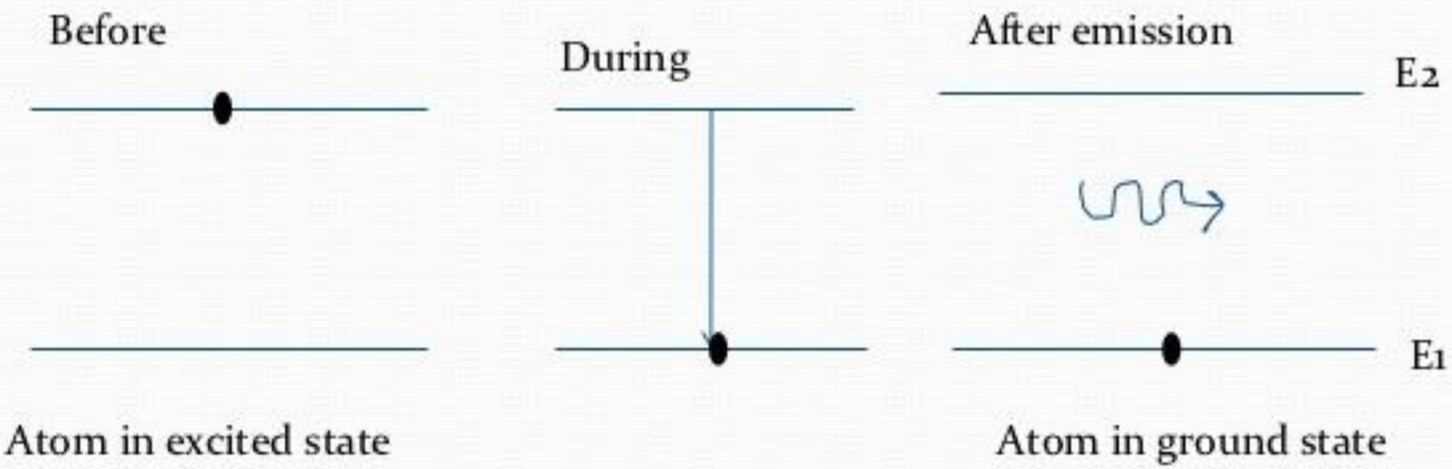
The process in which an atom sized system in lower energy state is raised in to higher energy state by electro magnetic radiation which is quanta of energy is equal to the difference of energy of the two states is called stimulated absorption.

i.e., $h\nu = E_2 - E_1$



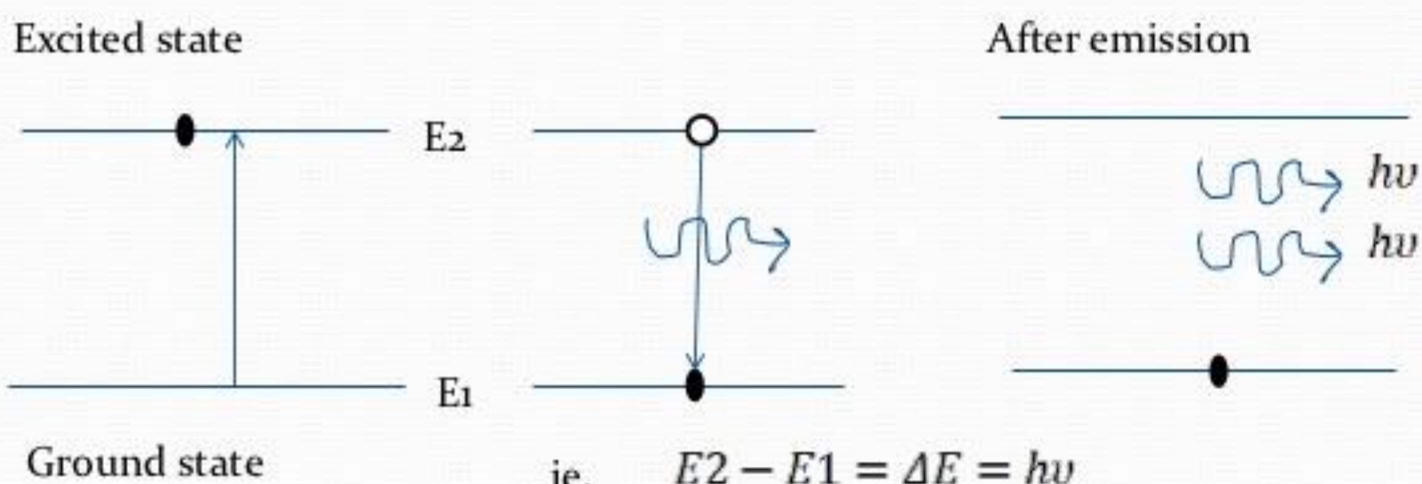
Spontaneous emission

In the atom initially at upper state E2, it can brought to E1 by emitting photon of energy hv.This is known as spontaneous emission.

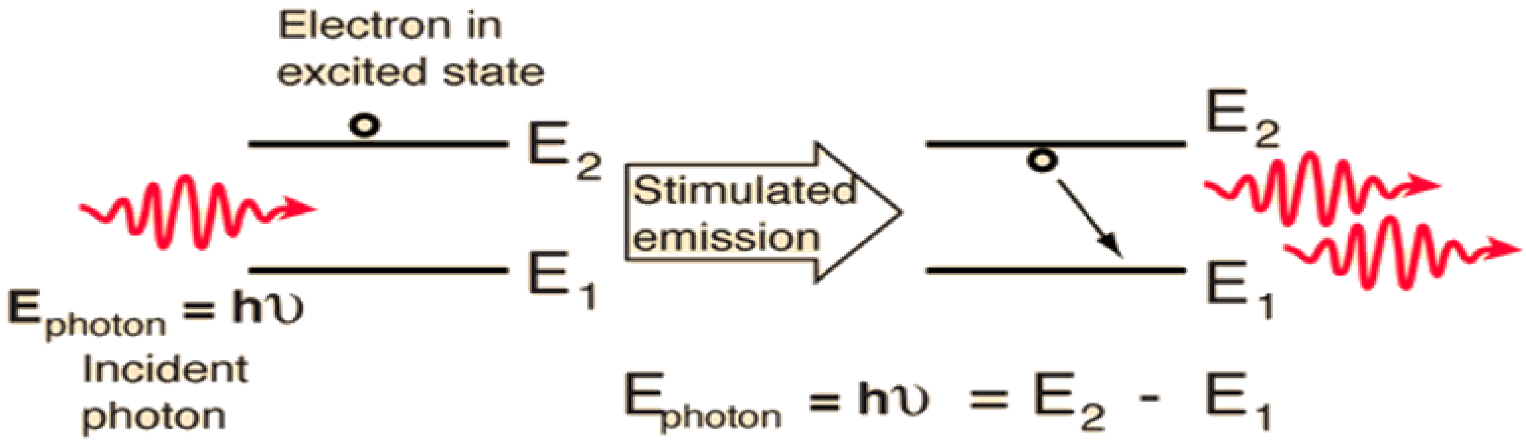


Stimulated emission

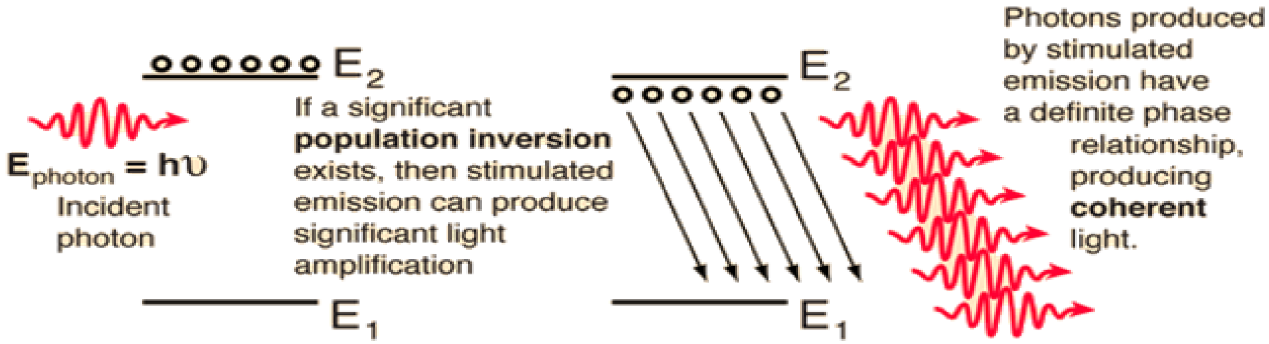
According to Einstein's, under certain condition it is possible to force an excited atom emit a photon by another photon and the incident light wave must be in same phase .hence we get an enhance beam of coherent light



ie, $E2 - E1 = \Delta E = h\nu$



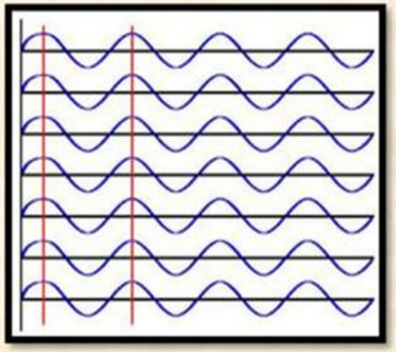
Electron in
excited state
E2
E1
Stimulated
emission
E2
E1
Ephoton = hυ
Incident
photon
Ephoton = hυ = E2 - E1



E2
E1
Ephoton = hυ
Incident
photon
If a significant
population inversion
exists, then stimulated
emission can produce
significant light
amplification
E2
E1
Photons produced
by stimulated
emission have
a definite phase
relationship,
producing
coherent
light.

DIFFERENCE

LASER LIGHT



1. **Coherent :** in phase (in harmony)

2. **Collimated:** parallel
very narrow beam
no divergence

3. **Monochromatic:** single wavelength
single color

4. **Directional:** unidirectional

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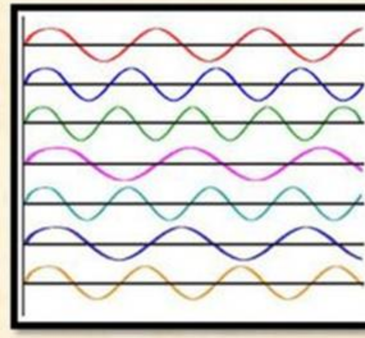
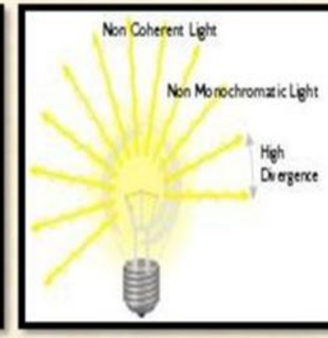
5. **Brightness :** extremely very high
power density

ORDINARY LIGHT





1. Incoherent : random phase

2. Not collimated: unparallel
very wide beam
high divergence

3. Many wavelength
Many color

4. Multi directional

5. Brightness : very low power density

Relation between Einstein’s A and B Coefficient

Einstein's coefficient and Einstein's relation

Let N_1 & N_2 be the no. of atoms in the ground state and excited state and $\rho(r)$ is the energy density per unit volume

Then the ratio of absorption per unit volume $= B12.\rho(r).N1$

Ratio of spontaneous emission per unit volume $= A21.N2$

Ratio of stimulated emission per unit volume $= B21.\rho(r).N2$

Where B_{12},B_{21} and A_{21} are Einstein's coefficient under thermal equilibrium, the rate of absorption = rate of emission

$$B12.N1.\rho(r) = A21.N2 + B21.\rho(r).N2$$

$$\rho(r)[B12.N1 - B21.N2] = A21.N2$$

$$\rho(r) = \frac{A21.N2}{B12.N1 - B21.N2}$$

$$\rho(r) = \frac{A21/B21}{\frac{B12}{B21}.\frac{N1}{N2}} - 1$$

$$N1 = \text{No.}\, e^{\frac{-E1}{KT}} \qquad N2 = \text{No.}\, e^{\frac{-E2}{KT}}$$ (Boltzman,s Distribution)

$$\frac{N1}{N2} = e^{\frac{(E2-E1)}{KT}}$$

$$\rho(r) = \frac{A21}{B21}\left[\frac{1}{\frac{B12}{B21}\,[e^{\frac{(E1-E2)}{KT}}] - 1}\right]$$

$$u(\nu) = \frac{A_{21}}{B_{21}} \frac{N_2}{e^{\frac{h\nu}{KT}} \left(\frac{B_{12}}{B_{21}}\right) - 1}$$

$$u(\nu) = \frac{8\pi h\nu^3}{c^3} \frac{1}{e^{\frac{h\nu}{KT}} - 1}$$

- **B_{12} = B_{21}**, The probability of stimulated emission is same as that of induced absorption. This means that if these two processes will occur at equal rates, so that no population inversion can be attained in a two-level system.

$$\frac{A_{21}}{B_{21}} = \frac{8\pi h\nu^3}{c^3}$$

- The ratio of spontaneous emission and stimulated emission is proportional to v^3. This implies that the probability of spontaneous emission dominates over induced emission more and more as the energy difference between the two states increases.

THANK YOU