Calculation Of Einstein Coefficient

- Using principle of detailed balance

$$\rho(h\nu_{12}) = \frac{A_{21}}{B_{12}} \left(\frac{e^{-h\nu_{12}/kT}}{1 - \left(\frac{B_{21}}{B_{12}} e^{-h\nu_{12}/kT} \right)} \right)$$

This equation can be written as,

$$\rho(h\nu_{12}) = \frac{A_{21}}{B_{21}} \left(\frac{1}{\left(\frac{B_{12}}{B_{21}} e^{h\nu_{12}/kT} \right) - 1} \right)$$

On comparing with Planck's radiation law

$$B_{21} = B_{12}$$

$$A_{21} / B_{21} = 2h\nu_{12}^{3}/c^{2}$$

Relation between Einstein Coefficients

- $B_{21} = B_{12}$,which means

Rate constant of absorption = Rate constant of stimulated emission

So, stimulated emission and absorption are equal probable.

- $A_{21} / B_{21} = 2h\nu_{12}^{3}/c^{2}$

Since h, c are constant so

Rate of spontaneous emission/Rate of stimulated emission $\propto \nu^{3}$

So at high frequencies spontaneous emission dominate than stimulated emission. LASER action require stimulated emission so it is easier to achieve laser action at lower frequencies.

Condition For LASER Action

Rate of Stimulated Emission / Rate of absorption = $B_{21}N_2\rho/B_{12}N_1\rho = N_2/N_1$

- Various cases are
  - $N_2/N_1 < 1$ Absorption dominates than emission
  - $N_2/N_1 = 1$ Saturation
  - $N_2/N_1 > 1$ Stimulated emission dominates

For LASER action, gain must be higher than the loss which in other words means stimulated emission must dominate the absorption process. From above relation it is clear that this condition is satisfied only when population of excited state is more than ground state.

Properties of Stimulated Emission

- The stimulated emitted photon have
    - Same frequency as incident photon
    - Same direction
    - Same phase

Due to this features of the stimulated photon LASER are Highly Monochromatic, Directional, Coherent.