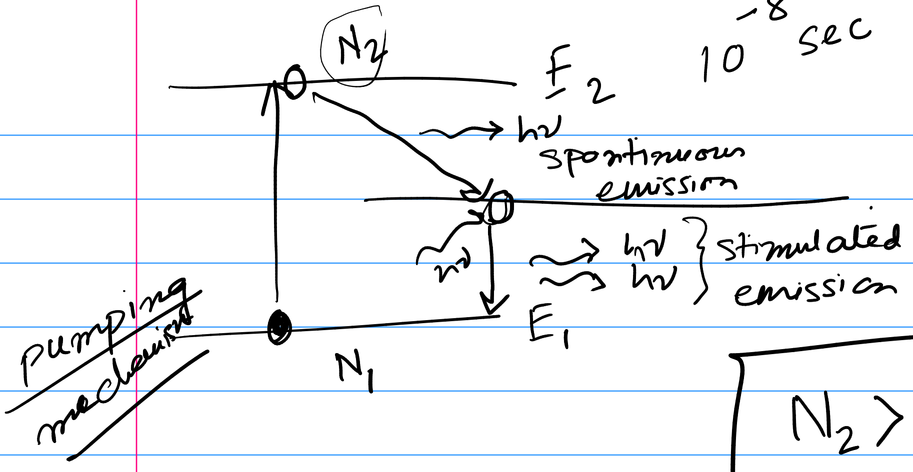
Metastable State



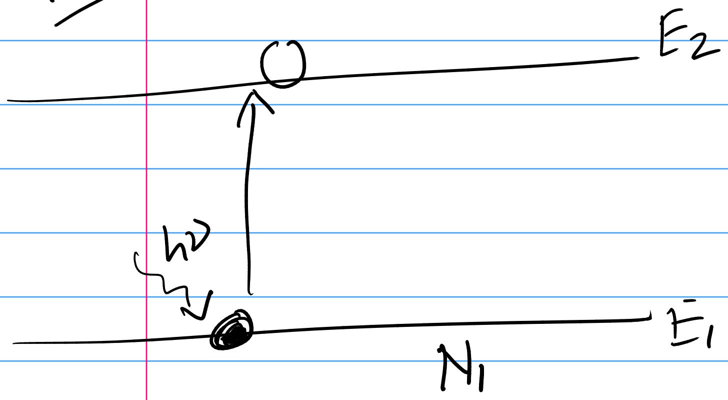
Metastable State

$\boxed{10^{-6} \text{ to } 10^{-3} \text{ sec}}$

$$\boxed{N_2 > N_1}$$

1. Optical pumping
2. Chemical pumping
3. Electric excitation

Absorption

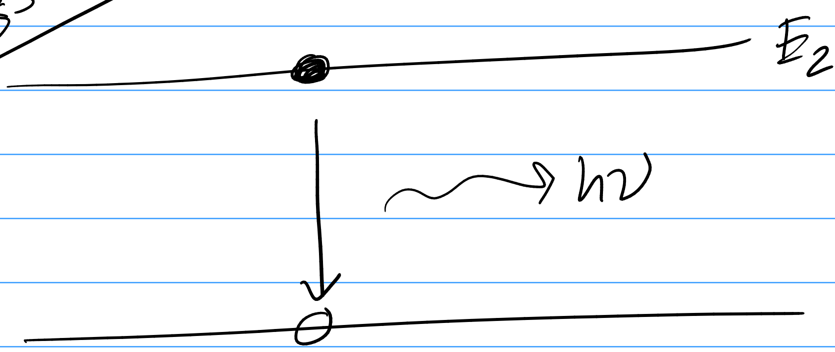


$$R_{ab} \propto N_1 u(\nu)$$

$$R_{ab} = B_{12} N_1 u(\nu) \quad \text{---(1)}$$

$B_{12} \rightarrow$ Absorption coefficient

Spontaneous Emission



$$R_{sp} \propto N_2$$

$$= A_{21} N_2 \quad \text{---(2)}$$

Stimulated Emission

$$R_{st} \propto N_2\, u(\nu)$$

$$= B_{21} N_2\, u(\nu) \quad \text{---(3)}$$

$u(\nu) \rightarrow$ density of radiation

$R_{ab} \rightarrow$ Rate of absorption

$R_{sp} \rightarrow$ " " spontaneous Emission

$R_{st} \rightarrow$ " " Stimulation Emission

N_1 & $N_2 \rightarrow$ # of atoms at E_1 & E_2 level

at Thermal Equillibrium,

Rate of absorption = Rate of Emission

$$R_{ab} = R_{sp} + R_{st}$$

$$B_{12} N_1 u(\nu) = A_{21} N_2 + B_{21} N_2 u(\nu)$$

$$A_{21} N_2 = B_{12} N_1 u(\nu) - B_{21} N_2 u(\nu)$$

$$u(\nu) = \frac{A_{21} N_2}{B_{12} N_1 - B_{21} N_2}$$

$$= \frac{A_{21} \cancel{N_2}}{B_{21} \cancel{N_2} \left(\frac{B_{12} N_1}{B_{21} N_2} - 1 \right)} \quad -(4)$$

Boltzmann's distribution Law

$$N_1 = N_0 e^{-E_1/kT}$$

$$N_2 = N_0 e^{-E_2/kT}$$

$$\frac{N_2}{N_1} = \frac{N_0 e^{-E_2/kT}}{N_0 e^{-E_1/kT}} = e^{-(E_2-E_1)/kT}$$

$$= e^{-h\nu/kT}$$

$$E_2 - E_1 = h\nu \quad -(5)$$

Substituting eqn (5) into eqn (4),

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

$$u(\nu) = \frac{8\pi h\nu^3}{c^2} \boxed{\frac{1}{e^{h\nu/kT} - 1}}$$

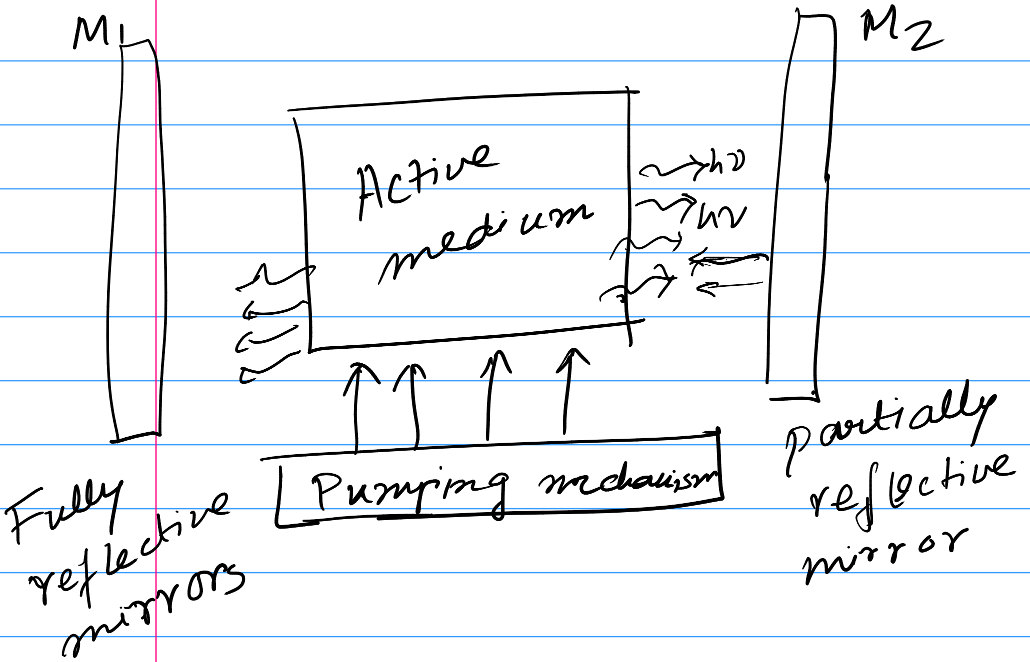
$$B_{12} = B_{21}$$

$$u(\nu) \cdot \frac{c^2}{8\pi h\nu^3} = \boxed{\frac{1}{e^{h\nu/kT} - 1}}$$

$$\boxed{\frac{A_{21}}{B_{21}} = \frac{8\pi h\nu^3}{c^2}}$$

Significance

Ratio of Einstein's co-efficient is proportional to ν^3. That means, at thermal equillibrium, probability of spontaneous emission increases with the difference between the energy levels.



Active medium

→ Population inversion takes place. It contains atoms to be excited.

Pumping mechanism

Used to excite atoms

Optical cavity

Two mirrors act as stimulator

~~2 level Laser~~