SNS COLLEGE OF ENGINEERING

Coimbatore-641 107

(An Autonomous Institution)

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Affiliated to Anna University, Chennai

DEPARTMENT OF PHYSICS

COURSE NAME :23PYT101 – ENGINEERING PHYSICS

I YEAR / I SEMESTER

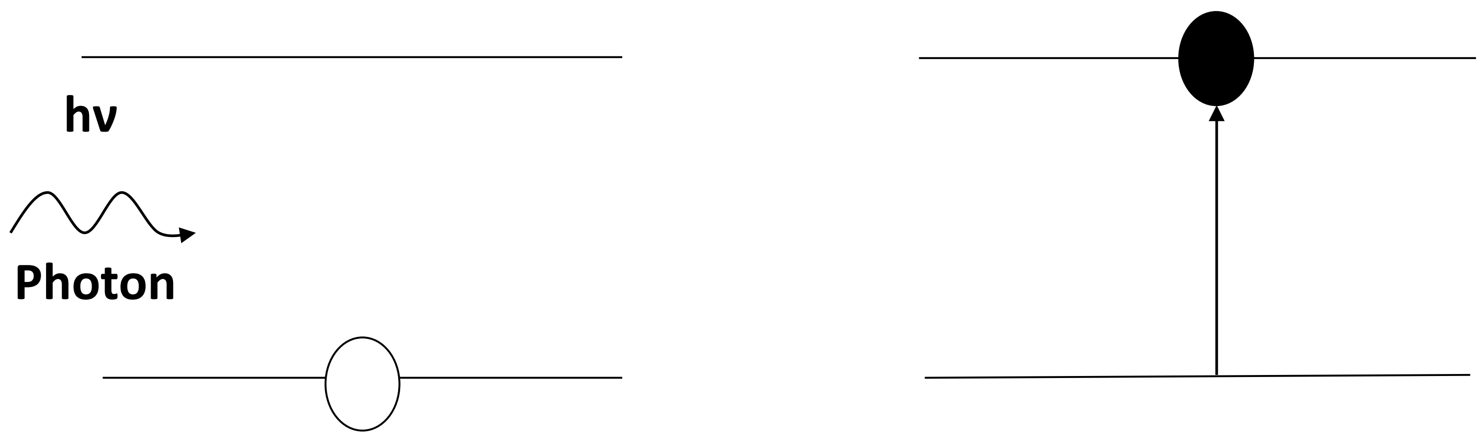
UNIT 2 – LASER AND FIBER OPTICS

TOPIC 2 – EINSTEIN'S A AND B COEFFICIENTS-DERIVATION

Introduction of Einstein coefficients

The **Einstein** A **coefficients** are related to the rate of spontaneous emission of light, and the **Einstein B coefficients** are related to the absorption and stimulated emission of light.

Stimulated absorption



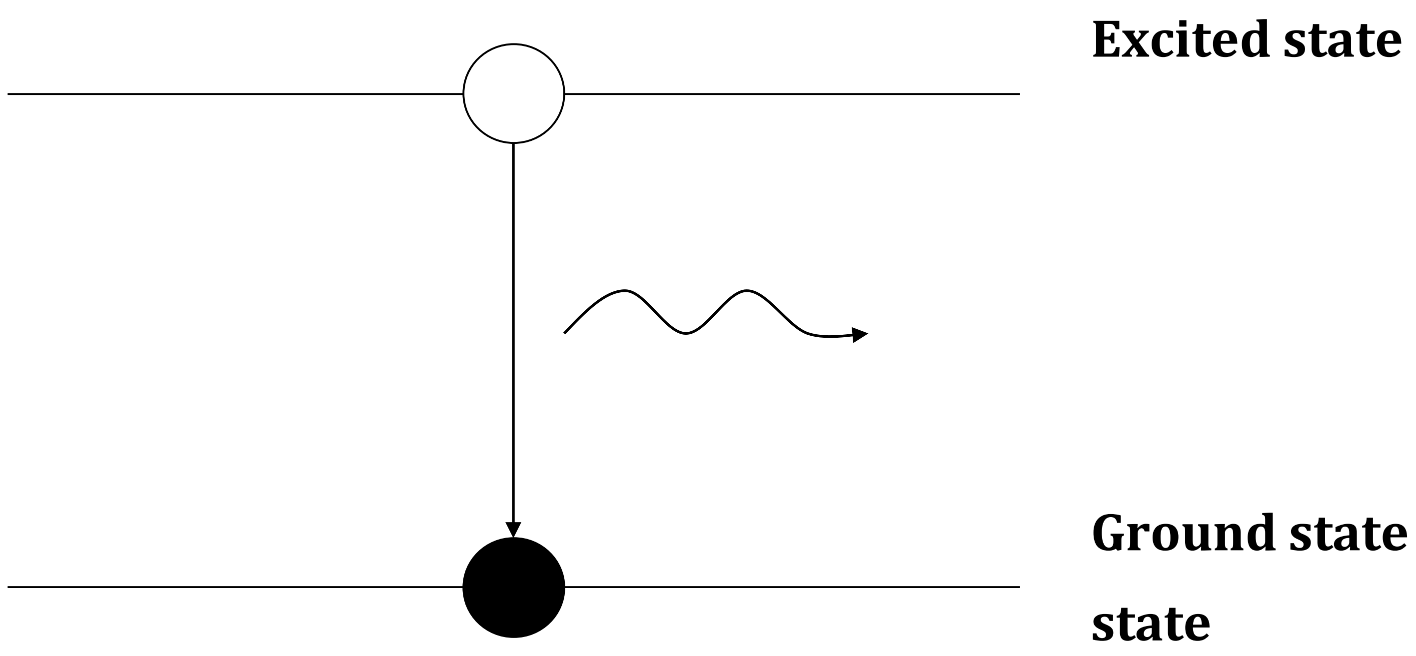
Before absorption **After absorption**

Rate of absorption is given by,

$R_{AB} \propto \rho N_1$

$R_{AB} = B_{12} \rho N_1$

Spontaneous emission

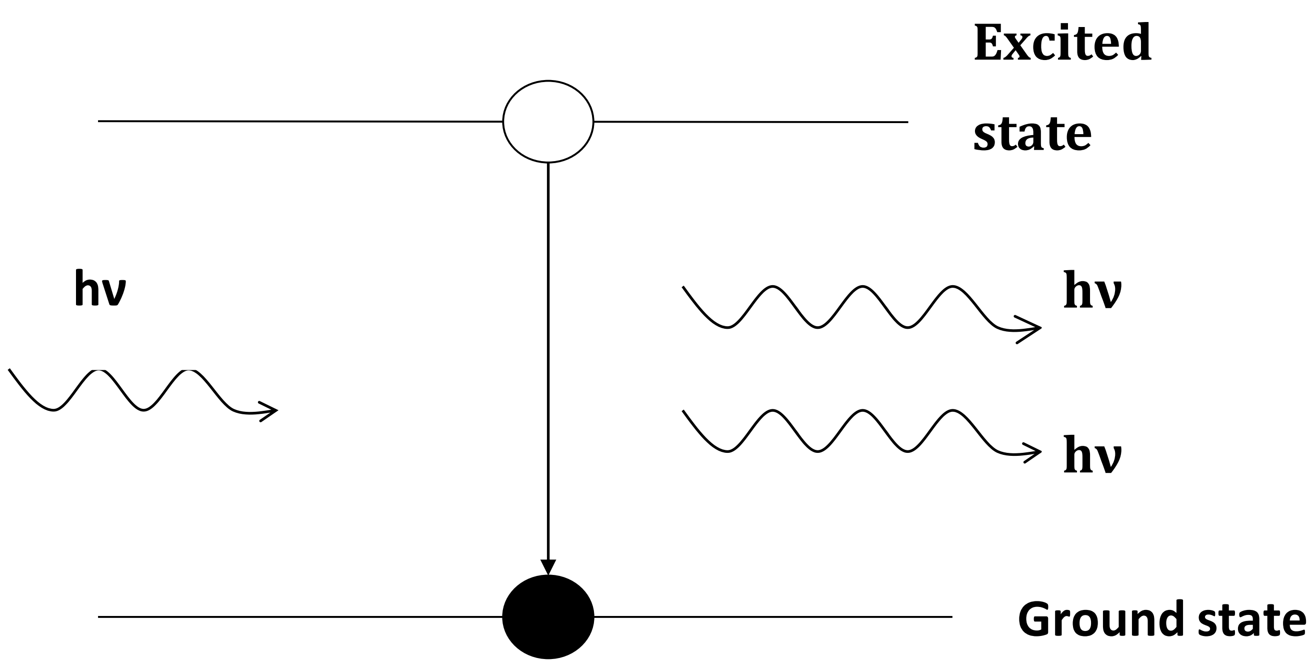


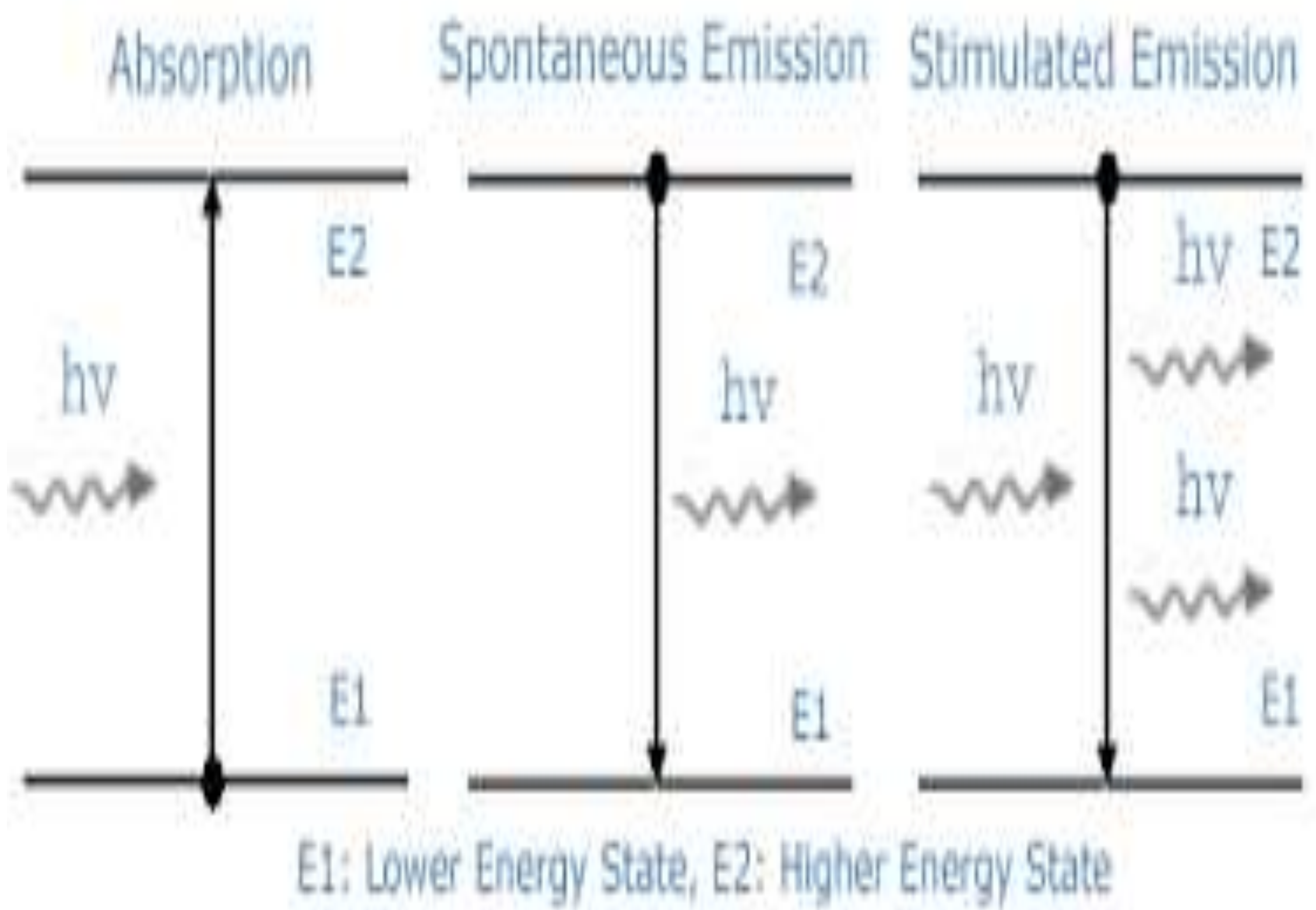
Rate of spontaneous emission is given by,

$R_{SP} \propto \rho N_2$

$R_{SP} = A_{21} \rho N_2$

Stimulated emission





Rate of stimulated emission is given by,

$R_{ST} \propto \rho N_2$

$R_{ST} = B_{21} \rho N_2$

Einstein A & B Coefficients (or) Einstein's Quantum theory of Laser Radiation:

Under thermal equilibrium, the mean population N_1 and N_2 in the lower and upper energy levels respectively remains constant.

This condition requires that the number of transition from E_2 to E_1 must be equal to number of transition from E_1 to E_2

Thus, The rate of absorption = The rate of emission

$$R_{AB} = R_{SP} + R_{ST}$$

$$B_{12}\,\rho N_1 = A_{21}\,N_2 + B_{21}\,\rho N_2$$

$$\rho[B_{12}\,N_1 - B_{21}\,N_2] = A_{21}\,N_2$$

$$\rho = \frac{A_{21} N_2}{B_{12} N_1 - B_{21} N_2}$$

$$\rho = \frac{A_{21}}{B_{21}} \cdot \frac{1}{\left(\frac{B_{12}}{B_{21}} \frac{N_1}{N_2} - 1\right)} - - - - \rightarrow (1)$$

From Boltzmann distribution law, the relative population

Where,

Photon Energy (E)=hν = E_2-E_1------------- (2)

$$\frac{N_1}{N_2} = e^{(h\gamma)/KT} - - - - - - - - \rightarrow (3)$$

Where

$K \rightarrow$ Boltzmann constant

$T \rightarrow$ absolute temperature

$$\therefore \rho = \frac{A_{21}}{B_{21}} \cdot \frac{1}{\left(\frac{B_{12}}{B_{21}} e^{h\gamma/KT} - 1\right)} \text{--------}\rightarrow (4)$$

According to Planck's theory of radiation, the energy distribution is given by

$$\rho = \frac{8\pi h\gamma^3}{C^3} \cdot \frac{1}{(e^{h\gamma/KT} - 1)} \text{-------}\rightarrow (5)$$

On comparing equations (4) and (5), we can write

$$\frac{A_{21}}{B_{21}} \cdot \frac{1}{\left(\frac{B_{12}}{B_{21}} e^{h\gamma/KT} - 1\right)} = \frac{8\pi h\gamma^3}{C^3} \cdot \frac{1}{(e^{h\gamma/KT} - 1)}$$

Where

$$B_{12} = B_{21} = B \text{-------}\rightarrow (6)$$

$$\frac{A_{21}}{B_{21}} = \frac{8\pi h\gamma^3}{C^3} \text{-------}\rightarrow (7)$$

$$A = B\left(\frac{8\pi h\gamma^3}{C^3}\right) \text{-------}\rightarrow (8)$$

Equation (6) and (7) known as Einstein relations and (8) gives the relation between the A and B Einstein's coefficients.

References

- https://images.app.goo.gl/B6e7AajvyRANdJEX9