



classmate

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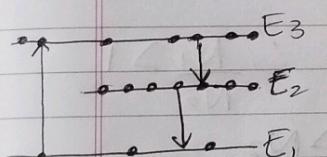
Condition for laser action

1) metastable state

Metastable state is a state in which energy states are characterized by comparatively longer life time of atoms of the order 10^{-3} sec. Hence the atoms can stay for a longer time.

Therefore metastable state allows accumulation of large no. of atoms of excited state and hence population inversion takes place.

Consider energy levels E_1, E_2, E_3



E_2 is the metastable state.

When energy is supplied atoms get excited

to E_3 from E_1 , where the life time of atoms is around 10^{-8} sec. So the atoms transmit to metastable state at E_2 where their life time is 10^{-3} sec. Here E_2 is intermediate b/w E_1 & E_3 .

Population inversion occurs b/w E_2 & E_1 , which leads to stimulated emission. This increases to a large no. and build up the laser light.

$$8 \times 10^{-23} \times 300 \times \ln(1.059 \times 10^6)$$

$$10^{-9} \text{ m}$$

2] Population inversion
Accⁿ to Boltzmann's eq/ⁿ $\frac{N_2}{N_1} = e^{\frac{hv}{kT}}$

$$N_1 = e^{\frac{hv}{kT}}$$

N_2

if $\frac{hv}{kT}$ is true then

$$e^x = 1 + x + \frac{x^2}{2} + \frac{x^3}{3} + \frac{x^4}{4} + \dots$$

let $x = 0.01$

$$e^x = 1 + 0.01 + \frac{(0.01)^2}{2} + \frac{(0.01)^3}{3} + \dots$$

$$e^x \approx 1 + x \therefore e^x > 1$$

$$\therefore e^{\frac{hv}{kT}} > 1$$

$$\frac{N_1}{N_2} = e^{\frac{hv}{kT}} \therefore \frac{N_1}{N_2} > 1$$

$$\therefore N_1 > N_2$$

at normal temp i.e. $T = 0^\circ\text{K}$

This situation needs to be inverted for $N_2 > N_1$ for laser action.

The artificial method in which no. of excited state atoms are greater than the ground state atoms is called population inversion. This population inversion can be achieved by 3 ways.

$$\lambda = 696 \times 10^{-9} \text{ m} \times 300 \times \ln(1.059 \times 10^3)$$

$$= 696 \text{ nm}$$



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- a. Thermal pumping → this is a process in which population inversion is achieved by using heat energy
- b. Optical pumping → by light energy
- c. Electrical pumping → by electrical energy.