Laser

Light amplification by stimulated emission of radiation

Properties of laser

→ coherent → monochromatic
→ unidirectional → intensed (energetic)

Basic principles of laser

1] Stimulated absorption

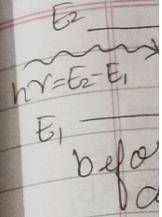
points to be written

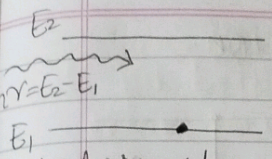
→ defination, energy level diagram, representation in terms of eqⁿ, rate of stimulated absorption

When an atom is in its grnd state gets excited to a higher state by absorbing an external photon. This process is known as st. absorption.

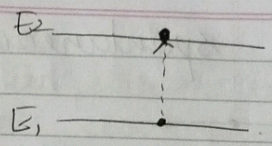
or

When an atom in its ground state E_1 interacts with an ext photon of energy $h\nu = E_2 - E_1$, the atom absorbs the photon & gets excited to a higher state E_2. This process is known as st. absorption or induced ab.





before st. ab.



after st. ab.

Representation of process
atom + photon → atom* atom
where atom ⇒ ground state
atom* ⇒ excited state atom

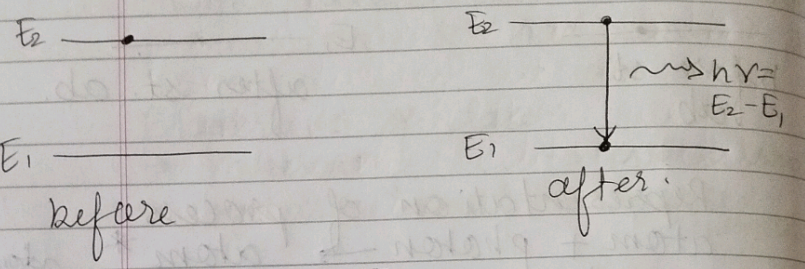
Rate of st ab. $\propto$ ~~N,E(ν)~~ $N_1 E(\nu)$
$= B_{12} N_1 E(\nu)$
where no of atoms per unit volume.
N_1 = population of atoms in lower state E_1
$E(\nu)$ = energy density of radiation

B_{12} is proportionality constant of Einstein's co-efficient of st. ab.

2) Spontaneous emission
When an atom in its excited state E_2 gets de-excited by its own ~~occurred to~~ to the lower state E_1, it emits a photon of energy $h\nu = E_2 - E_1$, This process is known as

B=3]

spontaneous emission.



Representation

Atom* → atom + photon

where

atom ⇒ lower energy level (E_1)

atom* ⇒ higher energy level (E_2)

Rate of sp. emission $\propto N_2$

$= A_{21} N_2$.

N_2 → population of atoms in excited state E_2

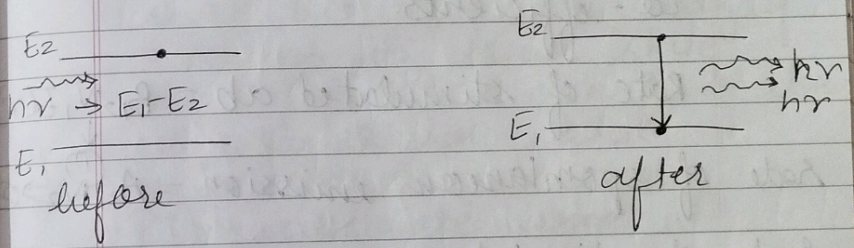
A_{21} → Einstein co-efficient of sp. em.

Note!:

The photons emitted by this process will move in random dir's & also out of phase with one another.

3] Stimulated emission

When an atom in its excited state E_2 interacts with external photon of energy $h\nu = E_2 - E_1$, under the influence of this photon, the ~~action~~ atom gets de-excited to the lower state E_1, thereby emitting another photon of same energy in the same direction. This process is known as stimulated emission



Representation

$atom^* + photon \rightarrow atom + photon + photon$

Rate of st. emission $\propto N_2 E(\nu)$

$= B_{21} N_2 E(\nu)$

where

B_{21} is the einstein co-efficient of stimulated emission.

[$\alpha = 2$ $\beta = 3$]

Note:-
The photons emitted by this process will move in the same dir^{n} & all are in phase with one another. Therfore, the beam constitutes laser beam.

Q) Obtain an expression for energy density of radiation or Deduce a relation b/w einstein co-efficients.

Rate of stimulated ab. $= B_{12} N_1 E(\nu)$ ①

Rate of spontaneous emission $= A_{21} N_2$ ②

Rate of stimulated emission $= B_{21} N_2 E(\nu)$ ③

At thermal eq^{m},
rate of absorption = rate of emissions

$$B_{12} N_1 E(\nu) = A_{21} N_2 + B_{21} N_2 E(\nu)$$
$$B_{12} N_1 E(\nu) - B_{21} N_2 E(\nu) = A_{21} N_2$$
$$E(\nu)(B_{12} N_1 - B_{21} N_2) = A_{21} N_2$$
$$E(\nu) = \frac{A_{21} N_2}{B_{12} N_1 - B_{21} N_2} = \frac{A_{21} N_2}{B_{21} N_2 \left(\frac{B_{12} N_1}{B_{21} N_2} - \right.}$$