

**Spontaneous Emission,
Stimulated Absorption,
& Stimulated Emission Keys
of Laser Action:
B.Sc. Part-2, Hons. & Sub.**

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Spontaneous emission

An electron in the upper state can spontaneously relax to the lower state and in doing so will emit a photon.

Conservation of energy means the photon energy will equal the change in electron energy, i.e.

$$h\nu = E_2 - E_1$$

where h is Planck's constant

The average time an electron will remain in one state before relaxing is called the lifetime (τ)

The exact time at which the electron "chooses" to relax is totally random and therefore the radiation emitted will be **incoherent**.

The spontaneous emission 'flow' of electrons from the state 2 to state 1 is given by:

$$\frac{dN_2}{dt} = -\frac{N_2}{\tau_2}$$

where

τ_2 = lifetime of state 2

N_2 = population of state 2, (no. m⁻³)

Alternatively, we write this as:

$$\frac{dN_2}{dt} = -A_2 N_2$$

where

$$A_2 = \text{Einstein 'A' coefficient} = \frac{1}{\tau_2} \quad [1]$$

Stimulated absorption

Similarly, an incoming photon can be absorbed by the system and an electron will be excited from the lower to the upper state. The frequency of the photon must be such that:

$$h\nu = E_2 - E_1$$

The spontaneous absorption 'flow' of electrons from state 1 to state 2 is given by:

$$\begin{aligned} \frac{dN_2}{dt} &= B_{12} N_1 \\ &= D \quad h \end{aligned}$$

where

B_{12} = Einstein 'B' coefficient

= Photon energy density at frequency

D = Photon number density at frequency

Stimulated emission

An incoming photon can **cause** an electron in the upper state to relax and an additional photon will be emitted. The two photons not only have the same frequency but also the same phase, i.e. they are **coherent**.

The stimulated emission 'flow' of electrons from state 2 to state 1 is given by:

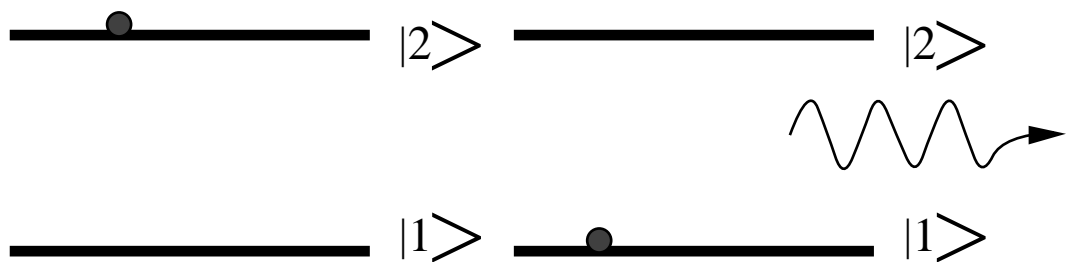
$$\frac{dN_2}{dt} = -B_{21} N_2$$

where

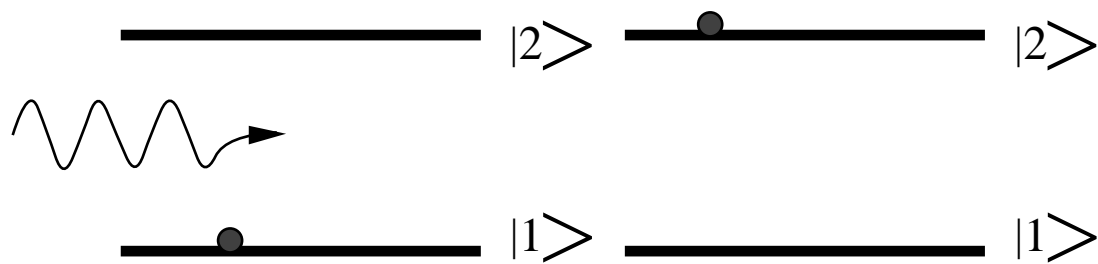
B_{21} = Einstein 'B' coefficient

It is stimulated emission that's the key to laser action.

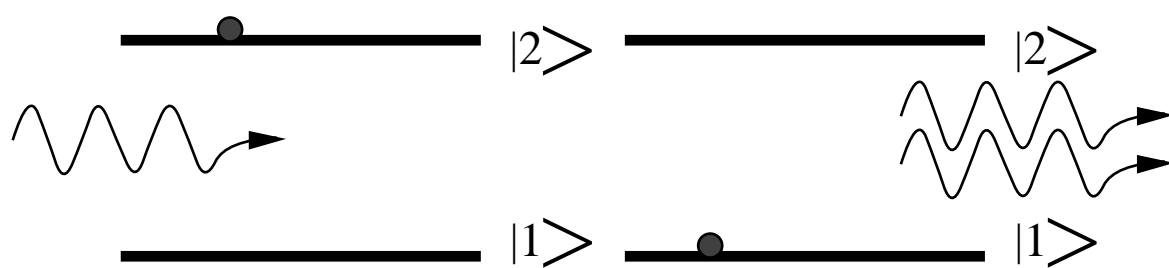
The three processes.



Spontaneous emission



Stimulated absorption



Stimulated emission