AL- Mustaqpal University
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Medical physics
Third Stage

Lec 3

Absorption and Emission of light

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Absorption and Emission of light

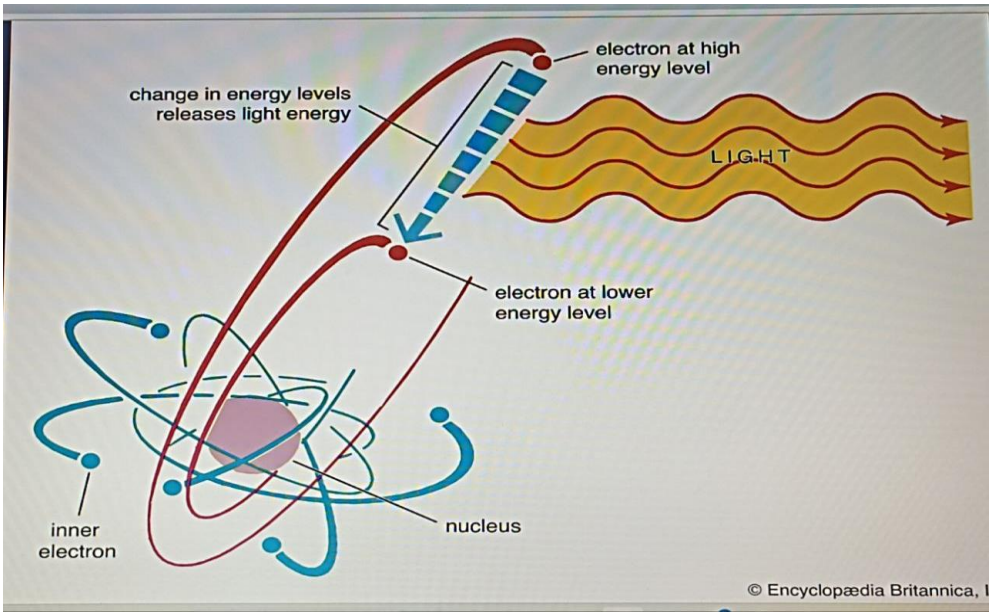
What is Absorption and Emission of light ?

Absorption is when electrons in a substance take up energy from electromagnetic radiation or types of light.

Emission is when a substance gives off electromagnetic radiation.

The electromagnetic radiation in both cases has some type of energy with a specific wavelength.

In other words, an atom can absorb or emit one photon when an electron makes a transition from one stationary state, or energy level, to another. Conservation of energy determines the energy of the photon and thus the frequency of the emitted or absorbed light.



Modern theory explains the emission of light by matter in terms of electronic energy levels. An electron of relatively high energy may jump to a condition of lower energy, giving off the energy difference as electromagnetic radiation.

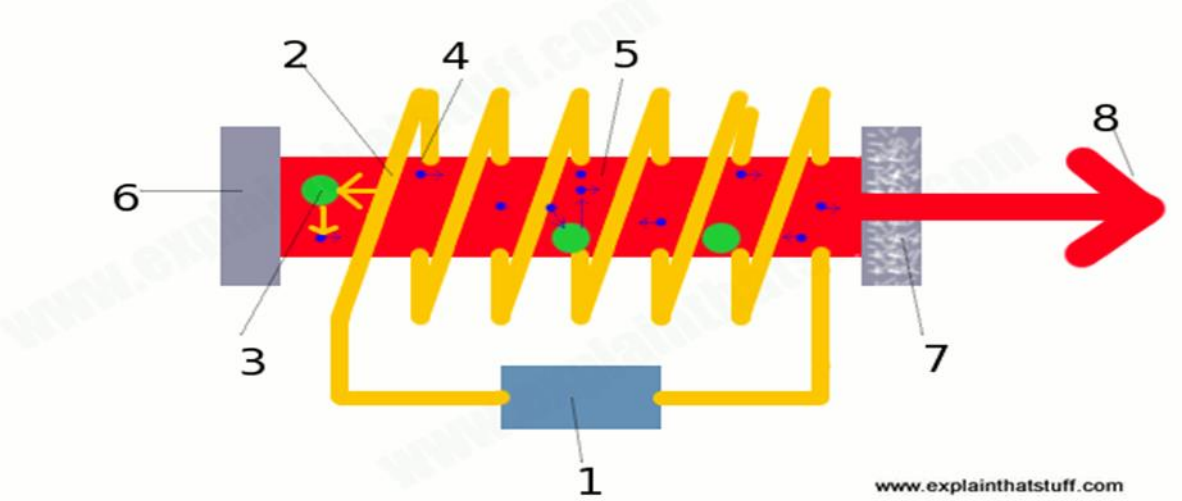
What is Absorption and Emission of laser ?

Absorption: An atom in a lower level absorbs a photon of frequency **f** and moves to an upper level. Spontaneous emission: An atom in an upper level can decay spontaneously to the lower level and emit a photon of frequency **f**

The emission - absorption principle

The three different mechanisms are :

1. Absorption: An atom in a lower level absorbs a photon of frequency (**f**)and moves to an upper level.
2. Spontaneous emission: An atom in an upper level can decay spontaneously to the lower level and emit a photon of frequency (**f**) if the transition between E2 and E1 is radiative. This photon has a random direction and phase.
3. Stimulated emission: An incident photon causes an upper level atom to decay, emitting a "stimulated" photon whose properties are identical to those of the incident photon. The term "stimulated" underlines the fact that this kind of radiation only occurs if an incident photon is present. The amplification arises due to the similarities between the incident and emitted photons.



How do the flash tube and the crystal make laser light?

1. A high-voltage electric supply makes the tube flash on and off.
2. Every time the tube flashes, it "pumps" energy into the ruby crystal. The flashes it makes inject energy into the crystal in the form of photons.
3. Atoms in the ruby crystal (large green blobs) soak up this energy in a process called **absorption**. When an atom absorbs a photon of energy, one of its electrons jumps from a low energy level to a higher one. This puts the atom into an excited state, but makes it unstable. Because the excited atom is unstable, the electron can stay in the higher energy level only for a few milliseconds. It falls back to its original level, giving off the energy it absorbed as a new photon of light radiation (small blue blob). This process is called**spontaneous emission**.
4. The photons that atoms give off zoom up and down inside the ruby crystal, traveling at the speed of light.

5. Every so often, one of these photons hits an already excited atom. When this happens, the excited atom gives off two photons of light instead of one. This is called **stimulated emission**. Now one photon of light has produced two, so the light has been amplified (increased in strength). In other words, **"light amplification"** (an increase in the amount of light) has been caused by **"stimulated emission of radiation"** (hence the name "laser", because that's exactly how a laser works!)
6. A **mirror** at one end of the laser tube keeps the photons bouncing back and forth inside the crystal.
7. A **partial mirror** at the other end of the tube bounces some photons back into the crystal but lets some escape.
8. The escaping photons form a very concentrated beam of powerful laser light.

Disscusion

Q/ 1

What is absorption in the context of light?

A) When a substance gives off electromagnetic radiation.

B) When electrons in a substance take up energy from electromagnetic radiation.

C) When an atom moves to a lower energy level.

D) When a photon is reflected from a surface.

E) None of the above

Q/ 2

What is spontaneous emission?

A) An atom in a lower level absorbs a photon of frequency f and moves to an upper level.

B) An atom in an upper level can decay spontaneously to the lower level and emit a photon of frequency f.

C) An incident photon causes an upper level atom to decay, emitting a "stimulated" photon.

D) The emission of light by matter in terms of electronic energy levels.

E) None of the above

Q/ 3

What happens to the energy absorbed by atoms in the ruby crystal?

A) It is stored for later use.

B) It is converted into heat.

C) It is given off as a new photon of light radiation.

D) It is used to pump energy into the flash tube.

E) None of the above

Q/ 4

What is the result of stimulated emission in a laser?

A) The light is absorbed by the crystal.

B) The light is amplified (increased in strength).

C) The light is reflected back into the crystal.

D) The light is converted into heat.

E) None of the above

Q/ 5

What is the purpose of the partial mirror at one end of the laser tube?

A) To absorb the photons.

B) To reflect all the photons back into the crystal.

C) To bounce some photons back into the crystal but let some escape.

D) To convert the photons into heat.

E) None of the above

Q/ 6

What is the final result of the process described in the text?

A) A weak beam of light.

B) A very concentrated beam of powerful laser light.

C) A beam of heat.

D) A beam of electromagnetic radiation.

E) None of the above

Q/ 7

What is the energy source for the ruby crystal?

A) The flash tube.

B) The crystal itself.

C) The electric supply.

D) The photons emitted by the crystal.

E) None of the above

Q/ 8

What happens when an electron in an atom jumps from a low energy level to a higher one?

A) The atom becomes stable.

B) The atom becomes unstable.

C) The atom emits a photon.

D) The atom absorbs a photon.

E) None of the above

Q/ 9

What is the role of the mirror at one end of the laser tube?

A) To absorb the photons.

B) To reflect some photons back into the crystal but let some escape.

C) To keep the photons bouncing back and forth inside the crystal.

D) To convert the photons into heat.

E) None of the above

Q/ 10

What is the name of the process by which an incident photon causes an upper level atom to decay, emitting a “stimulated” photon?

A) Absorption.

B) Spontaneous emission.

C) Stimulated emission.

D) Emission.

E) None of the above