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

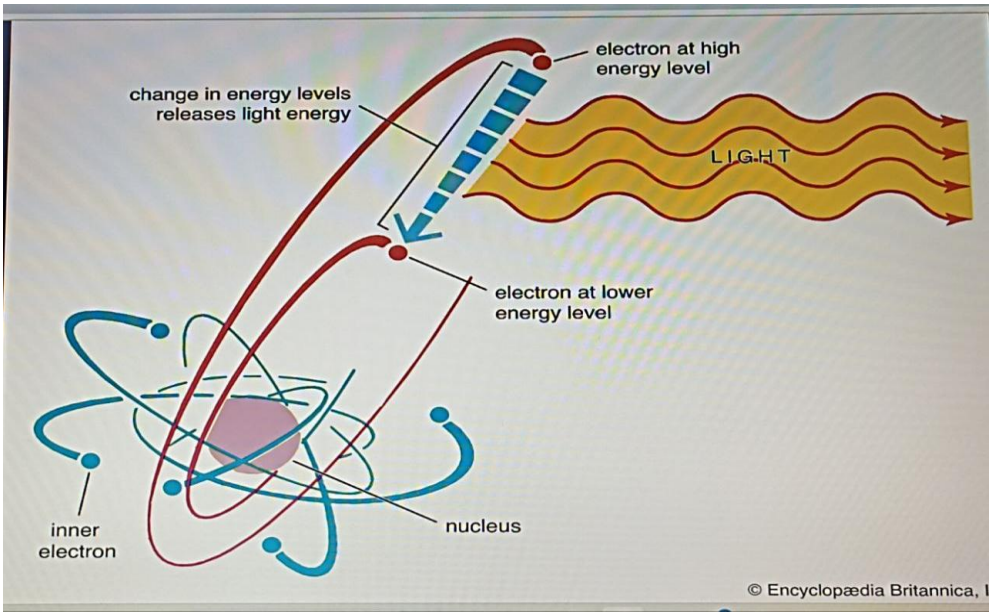
What is Absorption and Emission of light ?

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.

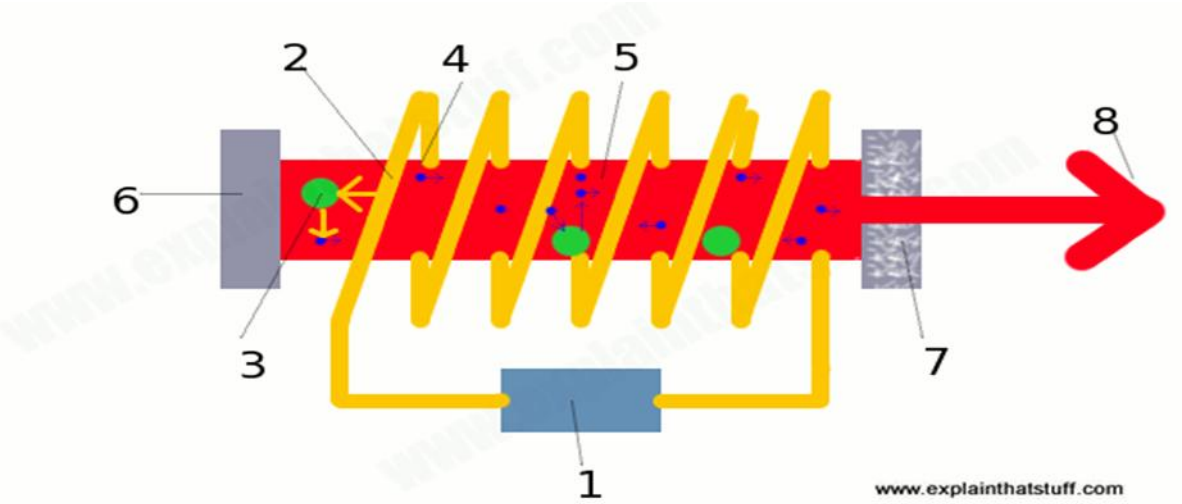
What is Absorption and Emission of laser ?

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

1. What is absorption of light?

A) Giving off photons

B) Electrons taking up energy from light

C) Atoms losing electrons

D) Random scattering of photons

E) Conversion into heat

☑ **Answer: B**

2. What is emission of light?

A) Electrons absorbing energy

B) Photon absorption

C) Photon scattering in random directions

D) Heat generation

E) Substance giving off electromagnetic radiation

☑ **Answer: E**

3. In absorption or emission, the energy of the photon is determined by:

A) Frequency of the photon

B) Mass of the atom

C) Size of the nucleus

D) Temperature of the atom

E) Magnetic field strength

☑ **Answer: A**

4. Which law governs the energy of absorbed or emitted photons?

A) Conservation of mass
B) Conservation of charge
C) Conservation of energy
D) Conservation of momentum
E) Conservation of spin

☑ **Answer: C**

5. According to modern theory, emission of light occurs when:

A) Electrons disappear

B) Atoms absorb photons

C) Electrons move to higher energy levels

D) Electrons fall to lower energy levels

E) Protons move in nucleus

☑ **Answer: D**

6. Absorption in lasers occurs when:

A) Atoms in higher level lose photons

B) Atoms in lower level absorb photons

C) Photons scatter in the medium

D) Random radiation is released

E) Crystal reflects photons

☑ **Answer: B**

7. What is spontaneous emission?

A) An external photon excites emission

B) Atom in upper level decays by itself and emits photon

C) Atom absorbs photon and moves up

D) Random scattering of photons

E) Amplification of photons

☑ **Answer: B**

8. Photons from spontaneous emission have:

A) Random direction and phase

B) Identical to incident photons

C) Zero energy

D) Opposite direction always

E) Infinite wavelength

☑ **Answer: A**

9. What is stimulated emission?

A) Atom absorbs photons

B) Random decay of electrons

C) Incident photon causes emission of identical photon

D) Nucleus releases energy

E) Light scatters in all directions

☑ **Answer: C**

10. Which property makes stimulated emission unique?

A) Random direction

B) Identical phase and direction to incident photon

C) Reduced frequency

D) Opposite polarization

E) Longer wavelength only

☑ **Answer: B**

11. The principle of laser operation depends on:

A) Heat conduction

B) Stimulated emission

C) Photon scattering

D) Nuclear fission

E) Spontaneous absorption

☑ **Answer: B**

12. What does a flash tube do in a ruby laser?

A) Reflects photons
B) Produces heat only
C) Pumps energy into the crystal
D) Emits laser beam directly
E) Reduces wavelength

☑ **Answer: C**

13. When atoms in ruby crystal absorb energy, their electrons:

A) Move to lower levels

B) Stay in ground state

C) Jump to higher energy levels

D) Escape the atom

E) Form new atoms

☑ **Answer: C**

14. What is the state of an atom after absorbing photon energy?

A) Stable

B) Excited and unstable

C) Ionized

D) Neutral

E) Reflected

☑ **Answer: B**

15. What happens when excited electrons return to original level?

A) Heat emission

B) Photon absorption

C) Spontaneous emission of photon

D) Ionization

E) Electron disappearance

☑ **Answer: C**

16. Photons moving inside the ruby crystal travel at:

A) Speed of light
B) Speed of sound
C) Half speed of light
D) Random velocity
E) Zero speed

☑ **Answer: A**

17. Stimulated emission occurs when:

A) Spontaneous photon is lost

B) An excited atom is hit by an incident photon

C) Atom absorbs random photon

D) Crystal reflects light

E) Atom moves to ground state by itself

☑ **Answer: B**

18. In stimulated emission, one photon produces:

A) Zero photons

B) One photon only

C) Two identical photons

D) Random energy

E) Heat energy

☑ **Answer: C**

19. What does "laser" stand for?

A) Light absorption by stimulated energy radiation

B) Light amplification by spontaneous emission of radiation

C) Light amplification by stimulated emission of radiation

D) Laser absorption by stimulated emission radiation

E) Long amplified source of emitted radiation

☑ **Answer: C**

20. What is the function of the full mirror in laser tube?

A) Keeps photons bouncing back
B) Allows all photons to escape
C) Absorbs photons
D) Produces heat
E) Changes photon frequency

☑ **Answer: A**

21. What is the function of the partial mirror?

A) Absorbs photons completely

B) Blocks photons

C) Converts light into heat

D) Generates photons itself

E) Reflects some photons and lets some escape

☑ **Answer: E**

22. The escaping photons from the laser form:

A) Scattered light

B) Heat energy

C) Random incoherent radiation

D) Concentrated laser beam

E) Microwave radiation

☑ **Answer: D**

23. The amplification of light in laser arises due to:

A) Spontaneous emission

B) Absorption only

C) Stimulated emission of identical photons

D) Heat pumping

E) Random scattering

☑ **Answer: C**

24. What is the initial step in laser operation?

A) Energy pumping into crystal

B) Stimulated emission

C) Photon reflection

D) Photon escape

E) Mirror alignment

☑ **Answer: A**

25. Which type of emission produces coherent light in lasers?

A) Absorption

B) Stimulated emission

C) Spontaneous emission

D) Random scattering

E) Thermal emission

☑ **Answer: B**
