Laser Physics in Medicine

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LASER

- Light Amplification by Stimulated Emission of Radiation
- Laser properties:

1- Coherence: that mean, there is a relation between the amplitude and phase of the wave at different points in time and space.

2-monochromaticity:all of the laser radiation is emitted at discrete narrow band wave lengths.

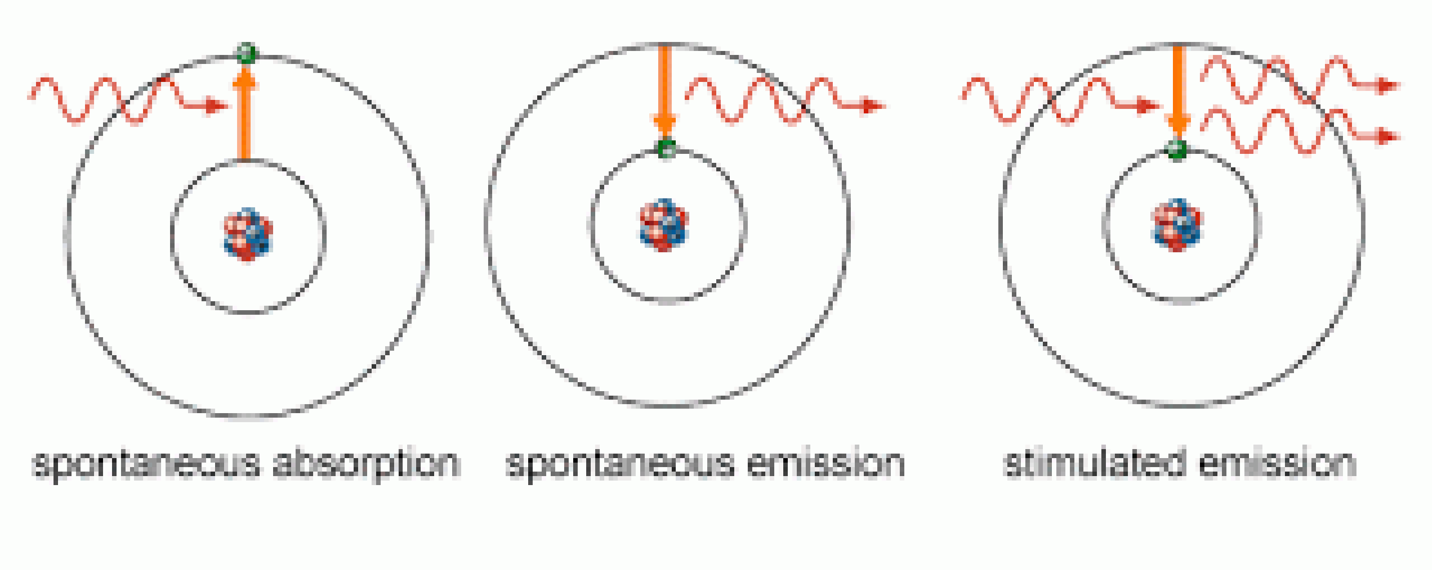
3- collimation: the laser beam is highly collimated, there is very little beam divergence. In laser surgery, the collimated beam is focused by a lens or mirror down small spot.

4-brightness.

5-high energy.

LASER

- In (1917) ,Einstein postulated that: The incident photons of energies equal exactly to the energy that an excited atom must eject if it falls to its lower energy state. These incident photons stimulate the excited atom to fall to the lower state and the photon ejected by the atom is in phase with the incident photon that stimulates it to make the transition.



Components of a typical LASER

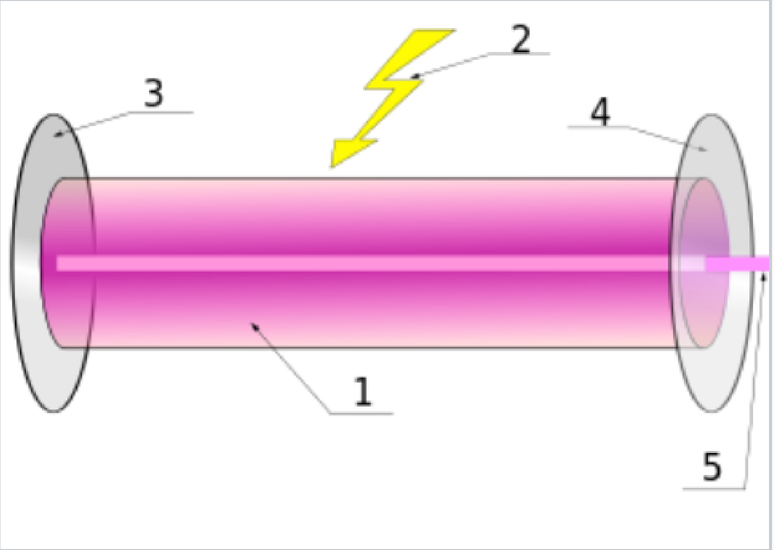
1. The gain medium is a substance that has the ability to magnify light through stimulated emission. Light of a particular wavelength is amplified as it travels through the gain medium (increases in power).

2. In order for the gain medium to amplify light, it must be fed with energy through a process known as pumping. The energy is usually provided in the form of an electric current or a particular wavelength of light.

3. The most common kind of laser receives feedback from an optical cavity, which consists of a pair of mirrors at each end of the gain medium. Light bounces back and forth between the mirrors, passing through the gain medium each time and being amplified.

4. The output coupler, which is usually one of the two mirrors, is partly transparent. This mirror allows some light to escape.

5. The light from the laser may spread out or create a narrow beam, depending on the shape of the cavity (whether the mirrors are flat or curved).



Components of a typical laser:

1. Gain medium
2. Laser pumping energy
3. High reflector
4. Output coupler
5. Laser beam

Types of LASER in medical field

1. CO_2 lasers
2. diode lasers
3. dye lasers
4. excimer lasers
5. fiber lasers
6. gas lasers
7. free electron lasers
8. semiconductor diode lasers

1. CO_2 LASERS

A. CO_2 lasers was one of the first gas lasers to be created and is still a powerful laser.
B. CO_2 lasers are the highest-power continuous wave lasers available. They are quite efficient, too.
C. The CO_2 laser produces an infrared beam that has wavelengths centered around 9.6 and 10.6 μm.

Due to water's ability to absorb this light frequency, CO_2 lasers have been helpful in surgical operations. Medical examples include laser surgery and skin resurfacing. It's the best laser for soft tissue with the ability to cut and to control bleeding. photo-thermally CO_2 lasers may replace a scalpel for most operations, and they're even utilized in sensitive regions where mechanical stress might harm the surgical site.

Applications range from gynecology to dentistry, as well as others.

2. Diode LASERS

A. Diode lasers are semiconductor devices like light-emitting diodes, except that diode lasers are pumped directly with electrical current.
B. Laser diodes can transform electrical energy into light.
C. Diode lasers are finding new applications in dentistry and medicine.

They are more appealing to doctors because to their decreased size and price, while also providing increased user friendliness. The wavelengths of diodes vary from 810 to 1,100 nm and are weakly absorbed by soft tissue. Soft tissue is not sliced by the laser's beam but is instead cut by touching a hot charred glass point.

Laser irradiation is very well absorbed at the tip's distal end, heating it to between 500°C and 900°C. The tip is so hot that it may be used to cut delicate tissue and even cauterize or carbonize tissue.

Diode lasers may harm the surrounding tissue if used on soft tissue.

3. Dye LASERS

A. Dye lasers utilize an organic dye solution as the lasing medium, typically as a liquid.
B. Dye lasing medium typically allows the use of a considerably broader range of wavelengths, which may cover 50 to 100 nanometers or more.
C. The broad bandwidth is excellent for tunable lasers and pulsed lasers. With light adjusted from red to yellow, pulses may be produced as brief as 16 femtoseconds.
D. Another kind of dye may be used to produce more wavelengths from the near-infrared to the near-ultraviolet, although this typically involves changing other optical components, such as dielectric mirrors or pump lasers.

Dye lasers has many applications in medicine, including dermatology, where they are used to level skin tone. The large wavelength range enables an accurate match to specific tissue spectra, such as melanin or hemoglobin, but the narrow bandwidth makes the surrounding tissue less susceptible to harm.

Port-wine stains, scars, and kidney stones are often treated with these kind of lasers. They are also often used for tattoos removal and in many other purposes.

LASER interaction with biological tissue

A laser beam is created and directed towards tissue to accomplish a particular job. When energy hits the biological contact, it will interact in one of four ways: reflection, transmission, scattering, or absorption.

- Absorption - Photons are absorbed by certain molecules in the tissue known as chromophores. To do function, the light energy is transformed into various kinds of energy.
- Reflection occurs when the laser beam bounces off the surface without any penetration or contact. Reflection is often an undesirable result, however a beneficial example of reflection may be seen when Erbium lasers reflect off titanium, allowing for safe gingiva cutting around implant abutments.
- Transmission is the ability of laser energy to penetrate through superficial tissues and interact with deeper regions. Retinal surgery is an example; the laser treats the retina by passing through the lens. Tissue transmission may also be observed in the deeper penetration achieved with diode lasers.
- Scattering - When laser energy reaches the target tissue, it scatters in a variety of ways. This phenomena is generally ineffective, but it may be beneficial with specific wavelengths' biostimulative characteristics.

LASER effects on biological tissue

The thermal effect of lasers on biological tissue is a complex process resulting from three distinct phenomena;

1. conversion of light to heat,
2. transfer of heat
3. and the tissue reaction, which is related to the temperature and the heating time .

This interaction leads to denaturation or to the destruction of tissue. The known factors are the parameters of the laser (wavelength, power, time and mode of emission, beam profile and spot size) and the tissue being treated (optical coefficients, thermal parameters and coefficients of the reaction of thermal denaturation).

LASER effects on biological tissue

Laser absorbed by tissue may causes;(Thermal effects).

1. Homeostasis: Any procedure that stop bleeding.
2. Photocoagulation: Heating a blood vessel to point where the blood coagulates and blocks the vessel.
3. Photo Vaporization: To make incisions and vaporize tissue.
4. Sonic: Membrane disruption.

Medical applications of LASER

1. Ophthalmology:

a. In ophthalmology lasers are primarily used for photocoagulation of the retina.

b. The amount of laser energy needed for photocoagulation depends on the spot size used.

In general; The minimum amount of laser energy that will do observable damage to the retina is called the Minimal Reactive Dose(MRD).

- Photocoagulation is useful for;

I. Repairing retinal tears or holes.

II. Diabetic retinopathy. (Complication of diabetes that effects the retina)

Medical applications of LASER

2. Dermatology:

a. Skin tumor therapy has been attempted by using high energy Focused laser beam.
b. Tattoos removal.

3. Dentistry:

a. Repairing the teeth decays.
b. Bleeding of gums.
c. Ulcers of the gums

Medical applications of LASER

4. Surgery:

a. Its used continuous lasers of high power.

Example: In Vascular organs such as the liver normal surgery produces a large amount of bleeding. The focused beam of light from laser tends to seal of the vessels and very much less bleeding occurs.

b. Lasers may be combined with fiber optics for some kinds of internal treatment.

Example: Lasers are used through gastroscopy in treating stomach ulcers and bleeding

Advantages of LASER Surgery

1. No-touch technique.
2. Dry surgical field.
3. Reduced blood loss.
4. Reduced edema.
5. Limited fibrosis and stenosis.
6. Precision.
7. Reduced post-operative pain.
8. It is effective, fast, safe.
9. Painless during its use especially when it is used in eye and dental treatment.
10. Anesthesia is not indicated in eye or dental or some other treatments

The End