Laser in Ophthalmology and Neurosurgery

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ABSTRACT

It was concluded that the laser is today's weapon towards technological progress in the field of medicine and other fields. The laser can treat the most dangerous diseases and reach the most accurate areas of the body, and by means of it the surgery ends without blood and without pain, and the patient can resume his work immediately after the operation

Keywords: phthalmology , Neurosurgery, blood , without pain

Introduction: *A*t the outset, we talk about the reality of this modern technology, which man began to be trained to use more than twenty years ago. The first person to realize this technology was not a scientist or a researcher. He was one of the Western pioneers in the year 1898 in one of his exciting novels, The Planetary War, where he imagined an army of aliens. Coming to invade Earth from other planets of the universe and armed with unique weapons that release a terrible beam capable of exploding rocks, burning trees, and cutting metal and iron as if they were paper.

After this event, scientists turned to interpreting this fantasy and bringing it down to reality, until they reached an interpretation of the laser beam technology . Experiments on the possibility of using lasers in the treatment of refractive defects began nearly twenty years ago.

In 1985, Dr. Seiler in Berlin performed the first laser operation on a blind human eye, with the aim of ascertaining its feasibility and identifying the complications that follow. In 1986, the first operation was performed on a sighted eye with cancer by the same doctor, and the complications resulting from this operation were the beginning.

At the end of the eighties, laser operations spread all over the world, and this technology obtained the approval of many official bodies, including the US Food and Drug Administration, which is the legislative body that gives the necessary licenses for all new drugs and operations to perform this operation in the United States of America.

Neurosurgeons using lasers to treat brain cancer have also discovered that the technology breaches the blood-brain barrier, a discovery that may lead to other .new treatment options for patients with the deadly disease.

The study of the use of lasers in treating people with brain cancer is currently going through what is called the second phase, in which treatment is provided to a group of patients larger than the first phase in order to know its impact and evaluate its safety.

The laser technology includes a small probe that heats and kills the tumor. The US Food and Drug Administration approved laser brain cancer treatment technology in 2009. After the laser, patients take powerful chemotherapy, which is the least likely to be able to penetrate the barrier.

Stages of the development of lasers , at the beginning of the fifties of this century, laser radiation was discovered, which is one of the great scientific achievements in the modern era, and its wide applications entered all peaceful and military fields. Where he showed that a photon of light falling on an atom can force it to emit a photon in the same direction as the frequency and phase of the incident photon.It was found, after about thirty years, that in the case of an atomic system that is not thermally parallel, electromagnetic radiation was generated stationed by the method of *stimulated emission*.

In 1954 AD, Townes C.H. Townes and his team at Bell Laboratories in the United States of America generated and amplified interconnected microwaves by stimulated emission. He called the radiation emitted by a maser, and obtained an ammonia gas maser with a frequency of 24000 Hz, as the word *MASER* is an abbreviation for the following English phrase *Micro Wave Amplification by Stimulated Emission of Radiation* . In 1956, it was called Laser, which is an acronym for the following English phrase, *LASER Light Amplification by Stimulated Emission of Radiation*. In 1960 AD , Miman designed a ruby laser in Hughes laboratories, consisting of a chromium-doped sapphire crystal, with a chemical composition $(ALO_3 + Cr_2O_3)$.[1] In 1961 AD , A.Java designed a *Ne-gas* laser at Bell Labs, and used a radio- electromagnetic field to excite the active substance, and obtained a laser beam in the infrared field.Semiconductor lasers were also designed in 1962 AD, after which solid, gas, continuous and Nabatean lasers were developed, in addition to plastic chemical lasers.The laser is a quantum generator that contains chemical, thermal, electrical or optical energy into focused electromagnetic radiation energy or works to amplify the radiation within the wave field 0.4 μm < 2 < 100m. [1]

Research objectives :

1- To identify the laser beams (its history - its elements - its properties).
2- Provide information and facts on how to use laser beams in eye, brain and neurosurgery.
3- Coming up with recommendations that contribute to the increased development in the use of laser beam technology in ophthalmic, brain and neurosurgery.

Research Limits :

Spatial Limits : Al-Karkh University for Science / Department of Medical Physics Temporal Limits : 2023

2-1 Laser definition :

The pulse of the laser beam can be likened to the military battalion, where all the soldiers advance in consistent, regular steps. While an ordinary lamp radiates light in irregularly scattered light waves, it does not have the energy of a laser, so it is like people in the street, each of whom has a different direction than the other.

LASER ***Light Amplification by Stimulated Emission of Radiation*** is electromagnetic radiation that results from an optical electronic device , as this device generates a very narrow radiation of one color, whose photons are equal in frequency and identical in wave phase, as they overlap constructively between their waves to transform into a light pulse of high energy and very coherent in time and space with a very small diffraction angle, about 100 million watts per square centimeter, and can travel great distances without being scattered. [2]

2-2 The interaction of electromagnetic radiation with matter:

Electromagnetic radiation (***EMR***) is energy that propagates through vacuum (free space) or through material media in the form of an advancing interaction between electric and magnetic fields. It can make itself manifest by its interaction with matter. Light and thermal energy are examples of EMR. Besides by radiation, thermal energy may travel by conduction and convection. [3]

2-3 Basic conditions for obtaining a laser :

To obtain a laser, the active substance must be excited by absorption of the rays, and then the nucleus returns to the stable state by means of spontaneous emission and stimulated emission of the rays, then the distribution must be obtained Reverse or population inversion of atoms.

2-3-1 Absorption :

We assume that an atom exists in the first (ground) level, its energy is E1, so the atom will remain in this level unless an external influence affects it, according to Bohr's assumption, and let us assume that an electromagnetic wave of energy **(hv = E2-E1)** falls on this atom, it will absorb it and then transmit Electrons to the higher level E2 where the atom becomes excited and this process is called absorption.

2-3-2 Spontaneous emotion :

Electrons surrounding an atom or molecule can exist at more than one energy level. They are usually found at the lowest energy level or resting state where they are stable. Energy can be absorbed or lost from a molecule in the form of a quantum of EMR (or light), called a photon, with a corresponding change in the energy level of the electron . An electron in the resting state can absorb a photon of light of the correct wavelength, changing to the excited state. It is unstable in the excited state and will usually drop to the resting state, Therefore, the spontaneous emission is characterized by the emission of a photon of energy **(hv = E2-E1)**, the liberated energy in the form of electromagnetic waves, and

the process is called spontaneous emission and energy is produced without an external field . [4]

2-3-3 Stimulated emission :

If the number of atoms in the excited level (E2) that can move to the ground level is (1) under the influence of an external field after losing energy by positive **(1-E2),** then it must take place according to a certain probability because the external field will induce the atoms to move to the level It differs from the spontaneous transition in that the phase, polarization, direction, and energy of the emitted photons are identical to the photons of the external atomic field (induced) with the intensity of the applied field. As for the stimulated emission , it does not depend on the external field.

2-3-4 Inverted enumeration :

The emission of laser beams requires increasing the number of atoms in the higher energy levels, i.e. increasing their number than the normal state in them using external energy, for example, and when the number of atoms in the higher energy levels is more than the number of atoms in the lower energy levels, we can say that there has been a reversal in Enumeration or reverse enumeration, and under these conditions the probability of induced emission occurring is large and correlated photons can be obtained in phase with each other.

An external source of energy must be used to increase the proportion of excited atoms in the population to a level where stimulated emission is a frequent occurrence, a process called pumping.

These mechanisms lead directly to an un- derstanding of the construction of a laser (Fig.2). An external source of energy is needed to create a population inversion in the laser chamber. Photons of energy in the axis of the chamber can be reflected off mirrors at either end and in turn stimulate further emissions in the same axis. One of the mirrors is only partially reflective, allowing some of the energy to escape, and this leakage forms the laser beam.

The solid, liquid, or gas contained in the laser chamber determines the wavelength of the emitted light. There are also various ways of pumping the system from an external power source .

2-4 Basic Laser Components:

Any laser device consists of the following elements: -

1- The active medium : Is the main source of photons inside the laser, as it emits photons depending on the inductive and spontaneous emission of electronic or molecular transitions when moving to lower energy levels after the inverse housing condition is achieved by the pumping process.

Examples of active media include:

- Crystalline media, usually doped with rare earths (such as neodymium, ytterbium, or erbium) or transition metal ions (titanium or chromium) ,sometimes yttrium aluminum garnet (Y3Al5O12), yttrium orthophandite (YVO4), or sapphire (Al2O3) , [5] and sometimes cadmium cesium bromide (CsCdBr3) .
- Glass media, for example silicates or phosphorous oxides .[6]
- Gases, for example a mixture of helium and neon (HeNe), nitrogen, argon, carbon monoxide, carbon dioxide or metal vapors. [7]
- Semiconductors, eg gallium arsenide (GaAs), indium gallium arsenide (InGaAs), or gallium nitride (GaN). [8]
- Liquids, such as those used in liquid lasers. [9]

2- The pumping source : Is the part that supplies power to the laser system. Examples of pumping methods (photo-pumping, electrophoresis, chemical reaction, application of continuous difference potential, excitation by plasma,

pumping by electron beams) Helium- neon laser (HeNe) uses electrophoresis in a mixture of helium and neon gases, while the Nd:YAG laser It uses the optical pumping method by xenon flash or semiconductor laser, and the excitation laser uses the chemical reaction method. [10]

3- The resonator : It is the vessel containing and activating the enlargement process. It is usually used either :-

A- External resonator : It consists of two parallel mirrors at the end of the tube containing the active substance, working on multiple reflections The basis in the process of optical zoom as in gas lasers .

B- Internal resonator : It is represented in coating the ends of the active substance to make the surface woman work as in the sapphire crystal laser and the aluminum garnet laser and glass in the solid lasers in general. In both cases, one of the two mirrors must be completely reflective of the optical photons, and the other allows partial penetration in order to allow the laser beam to exit from it outside the resonator. An example of this Sapphire crystal laser.

2-5 Properties of laser light :

The generation of laser radiation is based on the stimulated emission of light in an active material which is in an excited state caused by a pumping source.

Laser characteristics: [11]

1- *Directivity:* It is one of the most important characteristics of lasers, as the diffraction angle of laser beams is very small, and therefore it can travel long distances without its energy dissipating or changing its direction. This property is used in many applications that depend on Measuring near and far distances, and identifying targets with extreme accuracy, such as survey

systems.

2- *Monochromatic:* Laser light differs from other types of light, in that it consists of a band of narrow optical frequencies, where laser light appears in one color, and with a high degree of purity, while other types of light consist of visible spectrum colors, so this property is exploited, and Laser light in fiber optic communication systems, as a carrier of information.

3- *Beam intensity:* The laser beam is characterized by the fact that its cross-sectional size is very small, as it does not exceed several square micrometers, and since all the light energy emitted by the laser is concentrated in this small cross section, it will appear in the form of illumination or intense beam, so that the intensity of the beam emanating from the laser is greater. From the intensity of the light emanating from the sun, or lamps, and these rays can travel long distances without decreasing the intensity of their illumination, and this property is used in delicate surgical operations, and in treating diseases of the skin and eyes, and in drilling and cutting materials.

4- *Coherence and coherence of photons:* The optical frequencies resulting from laser beams are characterized by the fact that the photons of these rays are interconnected and coherent.

Because it has the same structural phase and the same size of polarization, which are properties not found in any other type of light, and this property is used in optical interference, three-dimensional imaging, the study of the composition of materials, and the measurement of speed and distance.

5- *The possibility of controlling the laser:* the rate of the laser pulses that are fired can be controlled, and the width of these pulses can be controlled, so that it becomes suitable for some applications. Such as melting metals, or vaporizing them, or cutting materials that cannot be cut by other means, or accelerating nuclear or chemical reactions.

2-6 Types of lasers :

1- ***Solid state laser:*** It is a laser that is produced by a substance or a mixture of solid materials such as ruby or neodymium: yttrium-aluminum. It is called the TAG laser for short, and its wavelength is in the infrared region.

2- ***Gas laser:*** It relies on a gaseous substance such as helium, neon, and carbon

dioxide gas, and its wavelengths are in the infrared range, and it is used to cut solid materials due to its high energy.

3- ***Excimer laser:*** It refers to the types of lasers that use inert gases such as chlorine, fluorine, krypton, or argon. These gases produce laser radiation with wavelengths in the ultraviolet range.

4- ***Dyes laser:*** It consists of complex organic materials such as rhodamine 6G dissolved in an alcohol solution and produces a laser whose wavelength can be controlled.

5- ***Semiconductor laser:*** It is sometimes called a diode laser, and it depends on semi- conductive materials. It is characterized by a small laser size and consumes little energy. Therefore, it is used in precise devices such as CDs and laser printers.

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