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# Laser Physics - An Insight

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*List of Abbreviation

L- Light
A-Amplification by
S-Stimulated
E-Emission of
R-Radiation

## Light

Light is a form of electromagnetic energy that behaves as a particle and a wave. The basic unit of this energy is called a photon. Laser light and ordinary light are significantly different. Laser light is monochromic; in dental applications that color may be visible or invisible.[1]

Laser light possesses three additional characteristics:

- Collimation,
- Coherency,
- Efficiency.

Collimation refers to the beam having specific spatial boundaries, which insures that there is a constant size and shape of the beam emitted from the laser cavity.

Coherency means that the light waves produced in the instrument are all the same. They are all in phase with one another and have identical wave shapes; that is, all the peaks and valleys are equivalent.[2]

There are three measurements that can define the wave of photons produced by a laser.

**Velocity**: Speed of light.

**Amplitude**: Total height of the wave oscillation from the top of the peak to the bottom on a vertical axis.

**Wavelength**: Distance between any two corresponding points on the wave on the horizontal axis. Wavelength is measured in meters, microns or nanometers.

A property of waves that is related to wavelength is frequency, which is the measurement of the number of wave oscillations per second.

## Amplification

Amplification is a process that occurs inside the laser. An optical cavity is at the center of the device. The core of the cavity is comprised of chemical elements, molecules, or compounds, called the active medium. There are two gaseous active medium lasers used in dentistry: argon and CO2. The rest that are available are solid-state semiconductor wafers made with multiple layers of metals such as gallium, aluminum, indium, and arsenic or solid rods of garnet crystal grown with various combinations of yttrium, aluminum, scandium and gallium and then doped with the elements of chromium, neodymium, or erbium.[3]

There are two mirrors, one at each end of the optical cavity, placed parallel to each other.

Surrounding this core is an excitation source,either a flash lamp strobe device or an electrical coil, which provides the energy into the activemedium. A cooling system, focusing lenses, and other controls complete the mechanical components. [4]

Amplification occurs inside the laser.

The center of the laser is called the laser cavity. The laser cavity is made up of the following components.

## ACTIVE MEDIUM

Composed of chemical elements,molecules or compounds. Lasers are generically named for the material of the active medium which can be solid, liquid . gas or a semiconductor that is solid.

## PUMPING MECHANISM

Drives energy into the active medium,the electrons in the outermost shell of the active medium's atoms absorb the energy. These electrons have absorbed a specific amount of energy to reach the next shell farther from the nucleus, which is at a higher energy level. A population inversion occurs when more of the electrons from the active medium are in the higher energy level shell farther from the nucleus than are in the ground state The electrons in this excited state return to their resting state and emit that energy in a form known as a photon. This is called spontaneous emission.

## OPTICAL RESONATOR

Completing the laser cavity are two mirrors ,one at each end of the optical cavity, placed parallel to each other; or in the case of a semiconductor diode laser, two polished surfaces at each end. These mirrors or polished surfaces act as optical resonators, reflecting the waves back and forth, and help to collimate and amplify the developing beam.

A cooling system, focusing lenses ad other controlling mechanisms.

For example, in solid state Er:YAG lasers the erbium is stimulated by light from a flashlamp with optical pumping. As an erbium atom absorbs a photon, its electrons are elevated to higher energy level. When the electrons return to a lower energy state, two identical photons are emitted and these photons can further stimulate more atoms in a chain reaction, resulting in amplification of the light produced.

Mirrors surrounding the active medium is a resonator further increase this light energy. One of the mirrors called the output coupler is less than one hundred percent reflective. Light leaks from the output coupler, and these are the photons that form the laser beam.[5]

Once the beam is created it is carried to the target tissue by various types of beam transfer hardware.

Examples: Mirrors in articulated arms and optical fibers are common examples of this hardware.

## STIMULATED EMISSION

Stimulated emission is a phenomenon by which laser beams are produced inside the cavity. This theory was postulated by Albert Einstein in 1916. Additional quantam of energy may be absorbed by the already- energized atom, resulting in a release of two quanta. This energy is emitted, or radiated, as identical photons, travelling as a coherent wave. These photons in turn are then able to energize more atoms in a geometric progression, which further causes the emission of additional identical photons, resulting in an amplification of the light energy- producing a laser beam.[6]

Stimulated emission is a phenomenon that occurs within the active medium. For example, in solid state Er:YAG lasers the erbium is stimulated by light from a flashlamp with a process known as optical pumping. As an erbium atom absorbs a photon, its electrons are elevated to higher energy level. When the electrons return to a lower energy state, two identical photons are emitted and these photons can further stimulate more atoms in a chain reaction, resulting in amplification of the light produced. Mirrors surrounding the active medium called a resonator further increase this light energy. One of the mirrors called the output coupler is less than one hundred percent reflective.[7]

The different emission modes are described as follows:

- Continuous-Wave Mode
- Gated-Pulse Mode
- Free Running Pulsed Mode

**Continuous-Wave Mode**: The beam is emitted at only one power level for a long as the operator depresses the foot switch.

**Gated Pulse Mode**: This mode is achieved by the opening and closing of a mechanical shutter in front of the beam path of a continuous- wave emission.

Peak powers of approximately 10-50 times that of continuous-wave power measurements are produced, and charring of the tissue can be reduced.

**Free- running Pulsed Mode**: Referred to as true pulsed mode. This emission is unique in that large peak energies of laser light are emitted for microseconds, followed by a long time in which the laser is off.Free- running pulsed devices have a rapidly strobing flash lamp that pumps the active medium. With each pulse, high peak powers in hundreds or thousands of watts are generated. The average power that the tissue incurs is small. Free-running pulsed devices cannot have a continuous- wave or gated-pulse output.


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Light leaks from the output coupler, and these are the photons that form the laser beam. Once the beam is created it is carried to the target tissue by various types of beam transfer hardware. Mirrors in articulated arms and optical fibers are common examples of this hardware.[8]

## RADIATION

The laser radiation is manipulated by a pair of orthogonal rotating mirrors over an area that may range from 50 mm × 50 mm up to approximately 1000 mm × 1000 mm. In general, a larger working area implies a longer working distance and a larger spot size.18 It is possible to co-ordinate an assembly of a number of scanning systems to give a larger working area. In general, only two-dimensional welds can be produced.Radiation refers to the light waves produced by the laser as a specific form of electromagnetic energy.

Stimulated emission of a specific wavelength can occur, producing a monochromatic, collimated, and coherent beam of light. The light waves produced by the laser are a specific form of electromagnetic energy. The electromagnetic spectrum is the entire collection of wave energy ranging from gamma rays, with wavelengths of 1 x 10-12m, to radio waves, with wavelengths of thousands of meters.

The laser radiation is manipulated by a pair of orthogonal rotating mirrors over an area that may range from 50 mm × 50 mm up to approximately 1000 mm × 1000 mm. In general, a larger working area implies a longer working distance and a larger spot size. It is possible to co-ordinate an assembly of a number of scanning systems to give a larger working area. In general, only two-dimensional welds can be produced.

All currently available dental laser devices have emission wavelengths of approximately 500 to 10,600 nm, that is either a visible- wavelength or an invisible, infrared – light wavelength in the portion of the nonionising spectrum called thermal radiation.[9]

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