Medical Laser

Ch . 1

The Nature of light: Electromagnetic Waves

The Electromagnetic waves (EM) cover the range from long radio waves through the visible out to γ-ray as shown in figure 1.

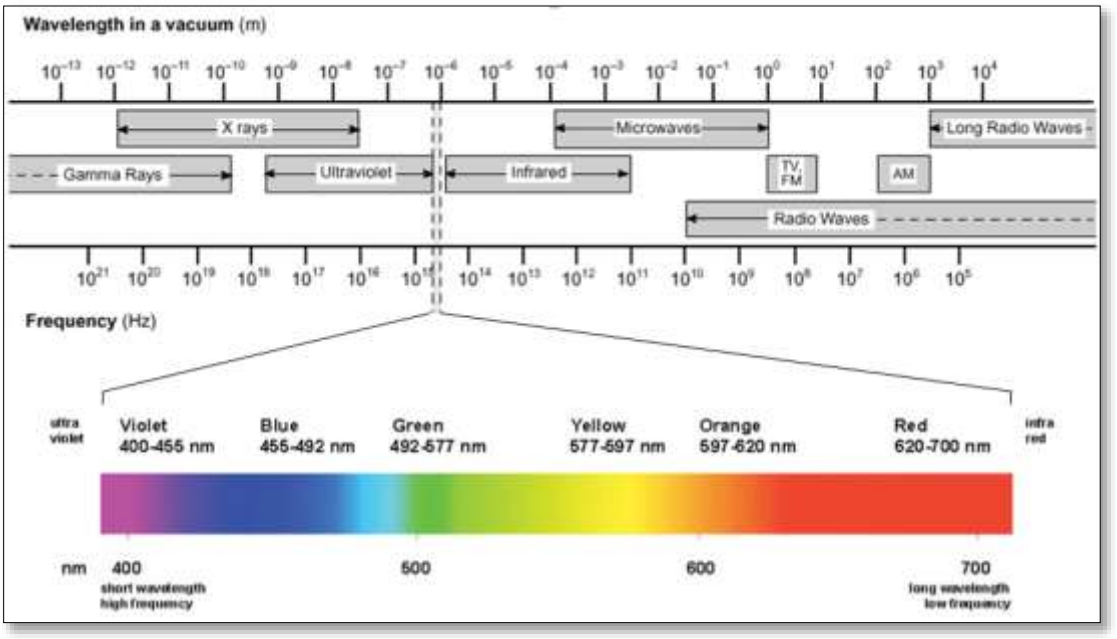


Figure (1) Electromagnetic waves

Light and also all electromagnetic waves are consisting of electric and magnetic vectors oscillating at right angles to each other and to the direction of propagation of light.

Clerk Maxwell found that the speed of the light (*c)* in free space gets by a simple relationship between the dielectric constant ($\boldsymbol{\varepsilon_o}$) and the magnetic permeability($\boldsymbol{\mu_o}$) the relationship was expressed in equation.

$$\mathbf{c} = \frac{\mathbf{1}}{\sqrt{\boldsymbol{\mu_o \varepsilon_o}}}$$

$$\boldsymbol{c = \lambda \nu}$$

The electromagnetic waves are typically described by any of the following three physical properties: **Frequency** ($\boldsymbol{\nu}$) , **wavelength** (λ), or **photon energy** (*E*).

This relation is known as the *Planck postulate*, that electromagnetic energy could be emitted only in quantized form**:**

$$\boldsymbol{E = h\nu} \quad \textbf{or} \quad E = \frac{hc}{\lambda}$$

Where h is Planck constant.

Definition of Laser

Laser is abbreviation of **Light Amplification by the Stimulated Emission of Radiation**. It is a device that creates a narrow and low-divergent beam of coherent light, while most other light sources emit incoherent light, which has a phase that varies randomly with time and position.

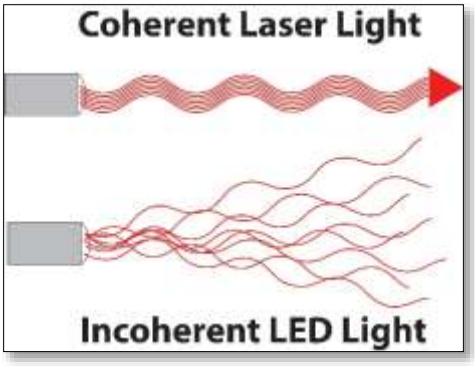


Figure 2: coherent light sources

Laser light behaves very differently than light from other sources or special "in-phase" light; and most of lasers emit nearly "monochromatic" light or very pure in color, with a narrow wavelength spectrum.

Properties of the Laser Beam

Laser radiation is characterized by an extremely high degree of: **monochromaticity**, **coherence, directionality**, and **brightness**. To these properties a fifth, can be added, a **short time duration**. We shall now consider these properties in some detail.

1. Monochromaticity

It is well known that lasers produce very pure colors. If they could produce exactly one wavelength, laser light would be fully monochromatic. This is not possible, in principle as well as for practical reasons.

2. Directionality

Lasers emit light that is highly directional. Laser light is emitted as a relatively narrow beam in a specific direction. Ordinary light, such as coming from the sun, a light bulb, or a candle, is emitted in many directions away from the source, as figure 3.

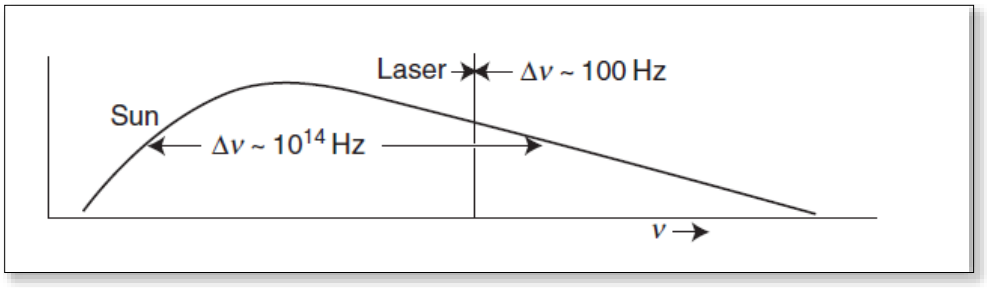


Figure 3: The light frequency emits from sun light and laser.

3. Spectral Brightness

Spectral brightness which is defined to be the power flow PV per unit area (A), unit is the spectral bandwidth in the frequency domain Δυ, and solid angle ΔΩ. The laser brightness is:

$$B = {P^{\upsilon}}/{A\Delta\Omega\Delta\upsilon}$$

Notice that $P^{\upsilon}/A\Delta\upsilon$ is the spectral intensity (I).

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4. Coherence and Temporal coherence

The light from a laser is said to be Coherent, which means the wavelengths of the laser light are in phase in space and time, see figure 4(d).

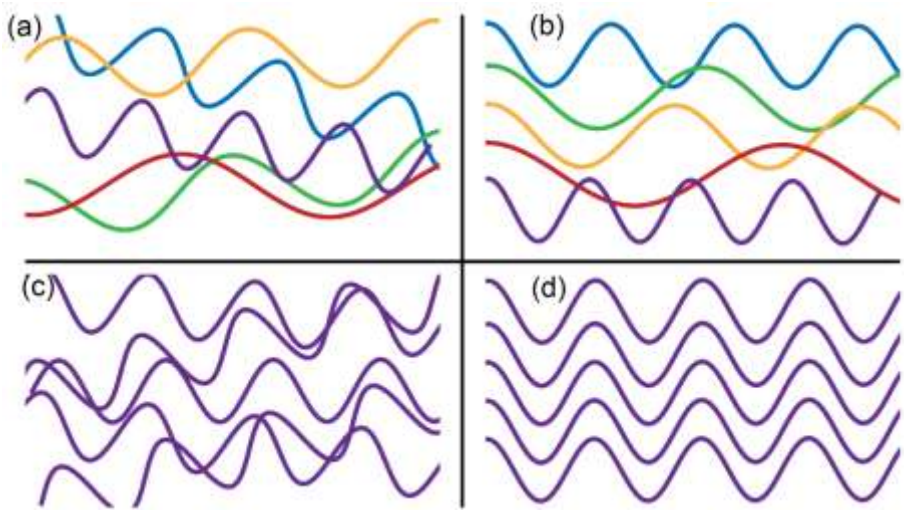


Figure 4: Coherent light waves

- In figure 4(a): the waves on the top left have neither a combined wavelength nor a combined direction of propagation. They are temporally and spatially incoherent.

- In figure 4(b): although all waves on the top right propagate in the same direction, they have different wavelengths. They are temporally incoherent but spatially coherent.

- In figure 4(c): on the bottom left one can watch monochromatic waves which all have the same wavelength. Spatially, however, the waves are incoherent since they propagate in different directions.

- In figure 4(d): on the bottom right both the propagation directions and the wavelengths are identical. Therefore, the waves are spatially and temporally coherent

a) Coherence Time:

The time required for two oscillations differing in frequency by Δυ to get out of phase by a full cycle is obviously 1/Δυ.

After this amount of time the different frequency components in the beam can begin to interfere destructively, and the beam loses "coherence." Thus, Δt=1/Δυ is called the beam's coherence time, see figure 5 and 6.

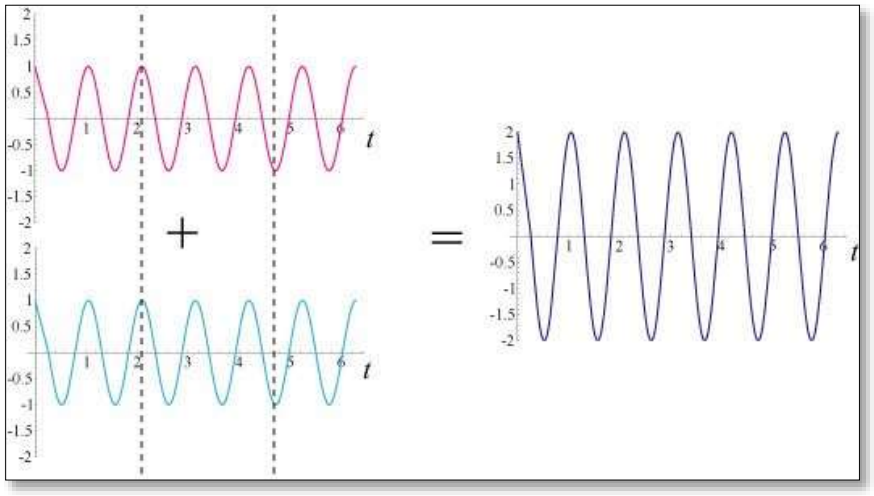


Figure 5: Constructive interference

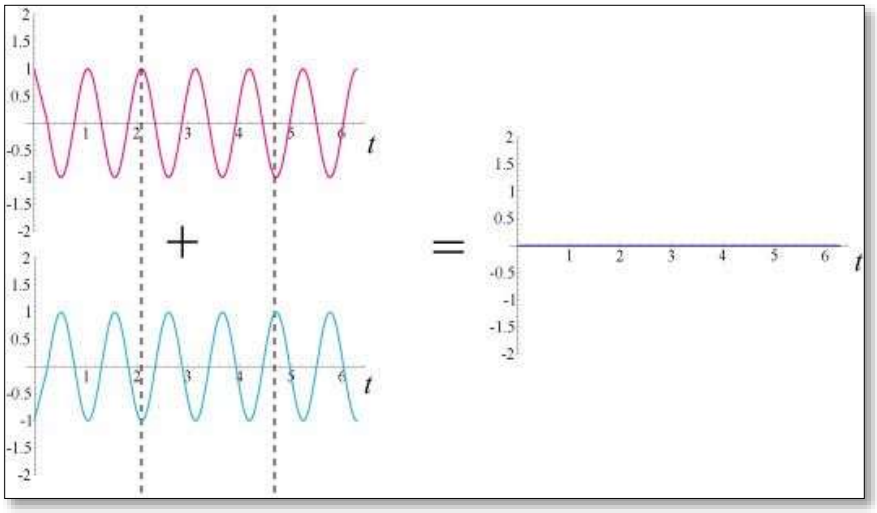


Figure 6: Destructive interference

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b) Coherence Length

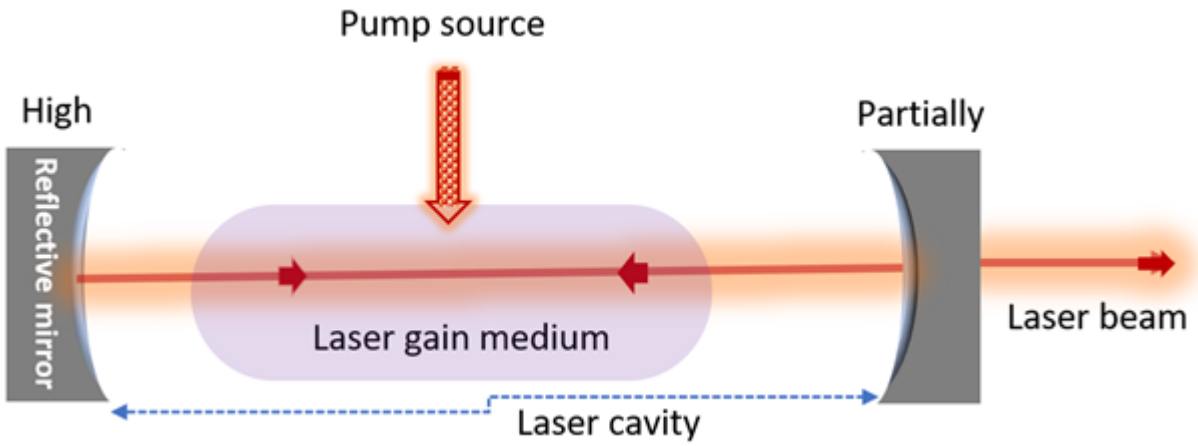
The coherence length; is the propagation distance over which a coherent wave (e.g. an electromagnetic wave) maintains a specified degree of coherence. For example, within $\Delta t \approx 1\ \mu s$ light travels:

$\Delta z = (3\times 108\ m/s)\times(1\ \mu s) = 300$ m.

The distance ($\Delta z = c\times\Delta t$) is called the Beam's coherence length. Helium–neon lasers have a typical coherence length of 20 *cm*, while the coherence length of single-mode lasers can exceed 100 *m*. Semiconductor lasers reach some 100 *m*.

Basic Concepts of Laser System

1. Laser gain medium.
2. Laser pumping.
3. Optical resonator (Laser Cavity)



1. Laser gain medium

The active laser medium (also called gain medium or lasing medium) is the source of optical gain within a laser.

Atoms such as in the red helium-neon (HeNe) laser, the visible and ultraviolet argon ion and helium-cadmium (HeCd) lasers, and the green and yellow copper vapor lasers (CVL)

Molecules such as in the infrared carbon dioxide (CO_2) laser, the ultraviolet excimer lasers such as ArF and KrF, and the pulsed N_2 laser

Liquids such as those involving various organic dye molecules diluted dissolved in various solvent solutions

Dielectric solids such as those involving neodymium atoms doped in YAG or glass to make the crystalline Nd:YAG or Nd:glass lasers

Semiconductor materials such as gallium arsenide or indium phosphide crystals or various mixtures of impurities blended with those and other semiconductor species.

2. Laser pumping

- Population inversion (three and four levels laser system).
- Einstein relations and criteria for lasing processes.
- Laser Pumping methods.

Population inversion (three and four levels laser system)

Under normal conditions, more electrons are in a lower energy state than in a higher energy state. Population inversion is a process of achieving more electrons in the higher energy state than the lower energy state.

In order to achieve population inversion, we need to supply energy to the laser medium. The process of supplying energy to the laser medium is called pumping.

N_1 is the number of electrons in the lower energy state, N_2 is the number of electrons in the excited state.

The process of making $N_2 > N_1$ is called population inversion. The distribution of the atoms between the levels is given by Boltzmann's Law:

$$\frac{N_2}{N_1} = exp\left[\frac{-(E_2 - E_1)}{kT}\right] \ldots$$

Where K is Boltzmann's constant equal to 1.38064852 × 10-23 m^2 kg s^{-2} K^{-1}, This equation means that at thermal equilibrium, $N_1 > N_2$. To achieve laser operation, one must upset the thermal equilibrium $N_2 > N_1$ in some way so as to produce the nonequilibrium situation of a population inversion.

With three energy levels the energy population ($E_1<E_2<E_3$) and a number of electrons N_1, N_2, and N_3 .respectively (see Fig.7a) initially, the system is at thermal equilibrium, and the majority of electrons stay in the ground state. Then external energy is provided to excite them to level 3, referred to as pumping.

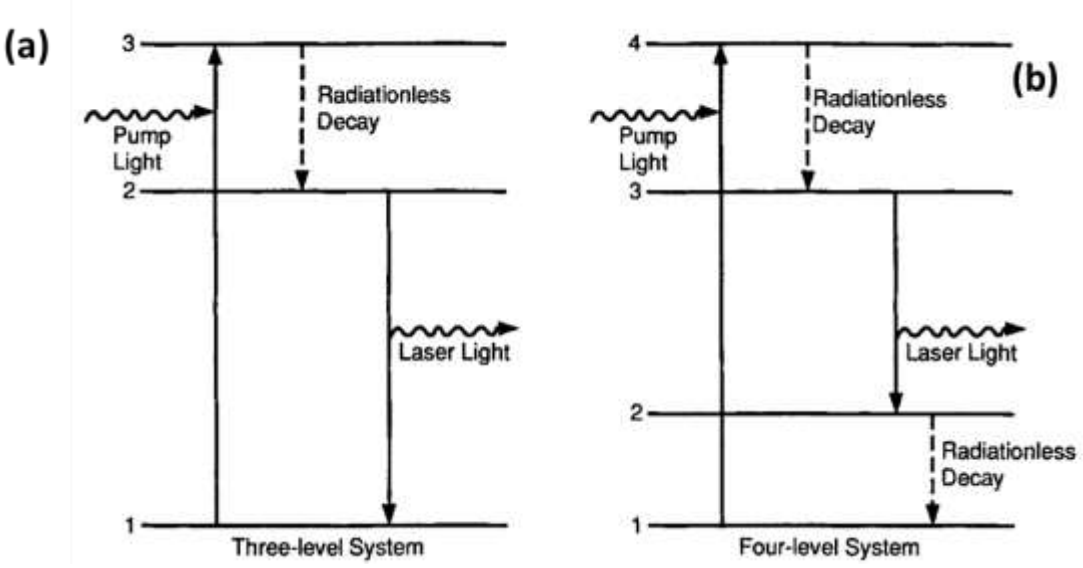


Figure: Electron Transitions within (a) 3-level gain medium; and (b) 4-level gain medium

The excited atoms quickly decay to level 2, transferring the energy to the phonons of the lattice of the host material. This wouldn't generate a photon, meaning radiationless. Then electrons on level 2 will decay by spontaneous emission to level 1, meaning laser. When level 2 hosts over half of the total electrons, a population inversion be achieved.

For four-level laser system. The population of level 2 and 4 are 0 and electrons just accumulate in level 3. Laser transition takes place between level 3 and 2, so the population is easily inverted.

1. Spontaneous Emission and Stimulated Emission

There are three types of processes involving the interaction of light beams with atoms that have electrons residing in various energy levels. Examples of those are depicted in figure 1.

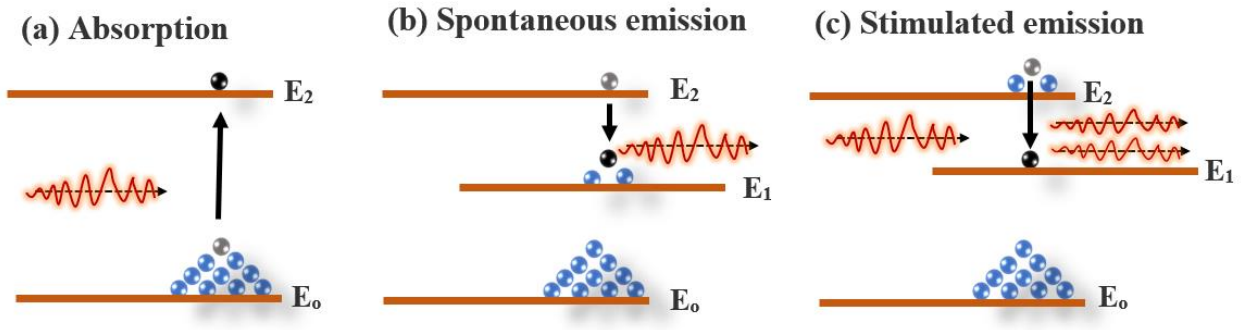


Figure 1. The interaction of light with matter via: (a) absorption, (b) spontaneous emission, and (c) stimulated emission.

The photon radiated during spontaneous and stimulated emission has the exact wavelength λ_{21} and frequency ν_{21} corresponding to the difference in energy ΔE_{21} of the two involved energy:

$$\Delta E_{21} = (E_2 - E_1) = h\nu_{21} = \frac{hc}{\lambda_{21}} \ldots\ldots (5)$$

Where h is Planck's constant

2. Laser Pumping Methods/ Methods of Achieving Population Inversion

- Optical pumping.
- Electric discharge or excitation by electrons.
- Thermal pumping.
- Chemical reactions.

Optical pumping

When light source provides enough energy to the lower energy state E_1 electrons in the laser medium, they jump into the higher energy state E_3 (see channel 2 from the figure 2). The processes of 3-level gain medium start and the population inversion can be achieved. As explained above (see channel 3 from the figure 2).

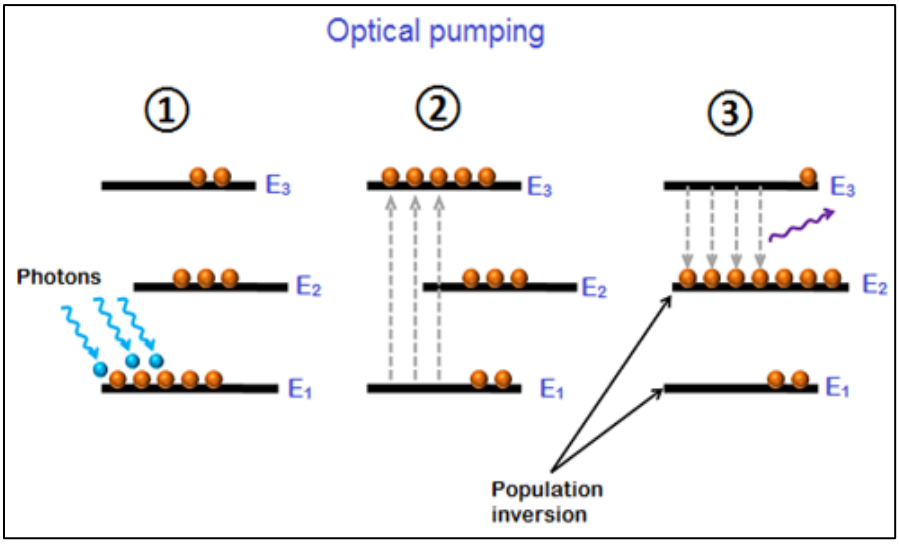


Figure 2 : Optical pumping process

An example of optical pumping is flashlamp or pumping with another laser.

To calculate the pumping efficiency: (i) the emission of radiation by the lamp P_r; (ii) the transfer of this radiation to the active medium P_t.; (iii) the absorption in the medium P_a,; (iv) the transfer of the absorbed radiation to the upper laser level. Consequently, the pumping efficiency can be written as the product of four terms, namely,

$$\eta_p = \frac{P_r}{P_p} \cdot \frac{P_t}{P_r} \cdot \frac{P_a}{P_t} \cdot \frac{P_m}{P_a} = \eta_r \cdot \eta_t \cdot \eta_a \cdot \eta_{pq} \ \ldots.$$

P_m here is minimum pump power, and P_p *is* electrical pump power entering the lamp.

Electric discharge or excitation by electrons

In this method, a high voltage electric discharge (flow of electrons, electric charge, or electric current) is passed through the laser medium or gas. The intense electric field accelerates the electrons to high speeds and they collide with neutral atoms in the gas. As a result, the electrons in the lower energy state gains sufficient energy from external electrons and jumps into the higher energy state which can achieve the population inversion conditions. This method of pumping is used in gas lasers such as argon lasers.

Thermal pumping

Sometimes we can achieve population inversion by heating the laser medium. In thermal pumping, heat acts as the pump source or energy source. In this method, population inversion is achieved by supplying heat into the laser medium. When

heat energy is supplied to the laser medium, the lower energy state electrons gain sufficient energy and jumps into the higher energy level and lasing process start.

Chemical reactions

If an atom or a molecule is produced through some chemical reaction and remains in an excited state at the time of production, then it can be used for pumping. An example is hydrogen fluoride molecules in figure 3.

$$F + H_2 \rightarrow HF^* + H\,,$$

$$H + F_2 \rightarrow HF^* + F\,,$$

$$HF^* \rightarrow HF + h\upsilon$$

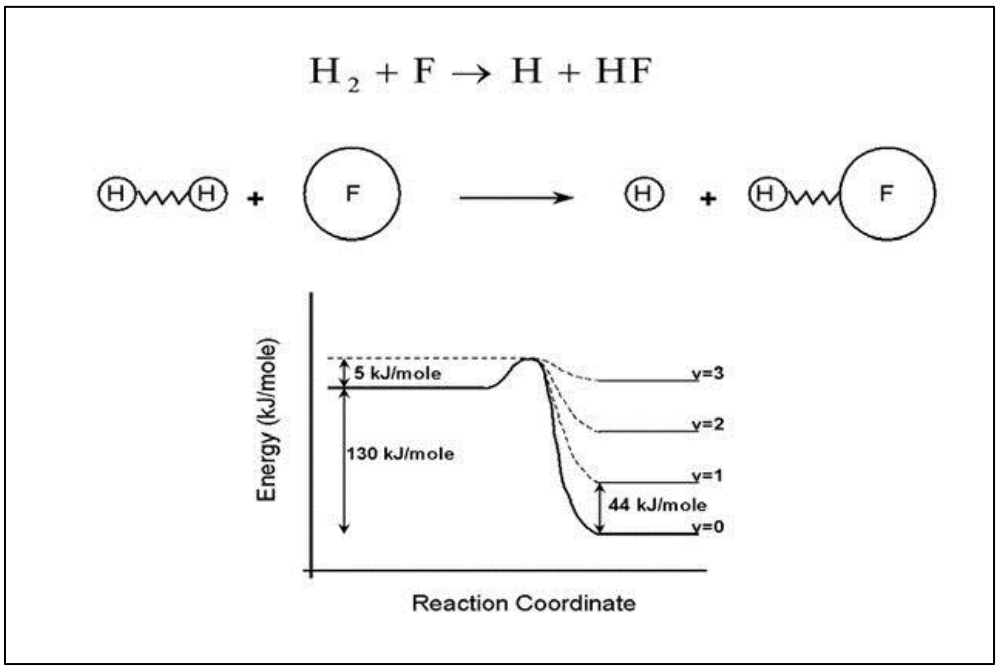


Figure 3. The reaction of atomic fluorine with molecular hydrogen produces vibrational excited hydrogen fluoride. The reaction coordinate represents the breaking of the H_2 bond as the fluorine atom approaches and the subsequent formation of the HF bond as the product hydrogen atoms departs the collision center.

3. Optical Resonator (laser cavity)

The optical resonator or cavity or mirror arrangement that reflects the beam of light back and forth through the gain medium for further amplification. A useful laser beam is obtained by allowing a small portion of the light to escape by passing through one of the mirrors that are partially transmitting.

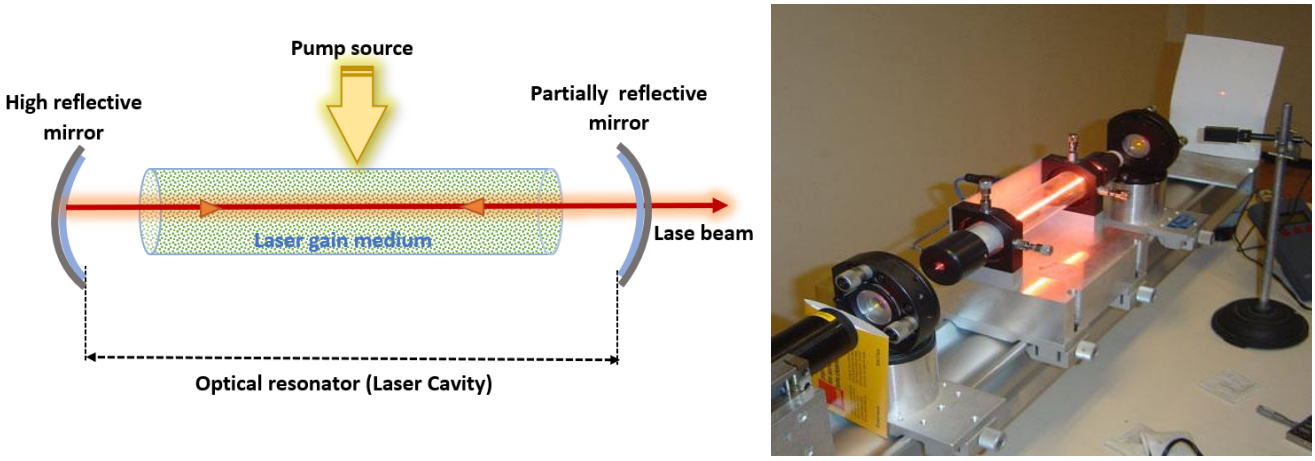


Figure 10: Basic laser components including a gain medium, pumping source, and mirror cavity

It is surrounding the gain medium and providing feedback of the laser light. Light confined in the cavity reflects multiple times producing standing waves for certain resonance frequencies. Optical resonator also has a function of wavelength selector. It just makes a standing wave condition for the photons:

$$L=n\lambda/2 \qquad (8)$$

Where L is the length of the resonator, n is some integer and λ is the wavelength. Only wavelengths satisfying will get resonated and amplified.

Laser Beam Profile

The TEM_{00} mode and the longitudinal mode is mathematically described by a Gaussian profile.

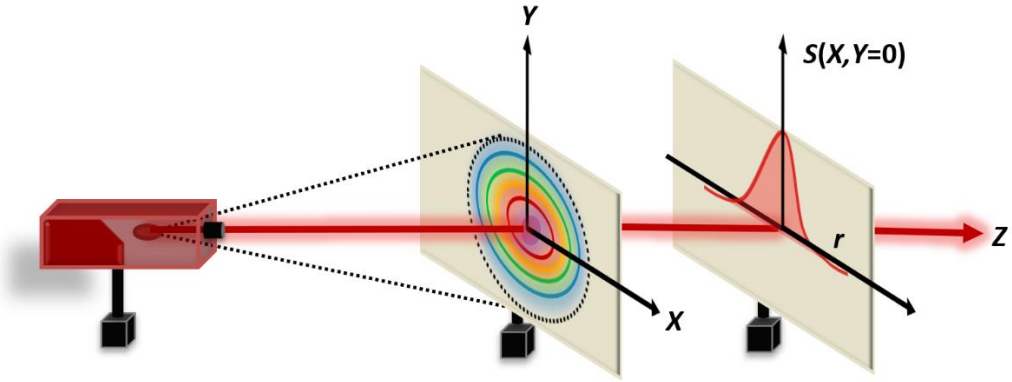


Figure 23: Intensity distribution in the plane perpendicular to the propagation direction

$$I(r) = I_0 \exp\left(\frac{-2r^2}{w^2}\right) \dots\dots (38)$$

Where w is beam waist, r is the distance from the center, where I_0 is the intensity on the beam axis at any location. The laser light propagation is shown in figure 24.

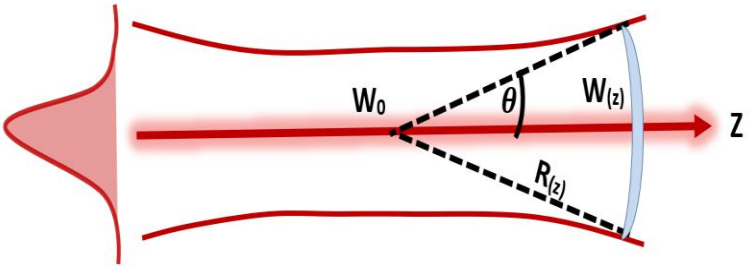


Figure 24: Schematic structure of a Gaussian light beam in the vicinity of a focal volume. The y-axis is perpendicular to the paper sheet. The z = 0 origin is at the minimum radius W_0 of the beam.

Pulsed laser

Pulsed lasers are lasers which emit light not in a continuous mode, but rather in the form of optical pulses (light flashes). The term is most commonly used for Q-switched lasers, which typically emit nanosecond pulses.

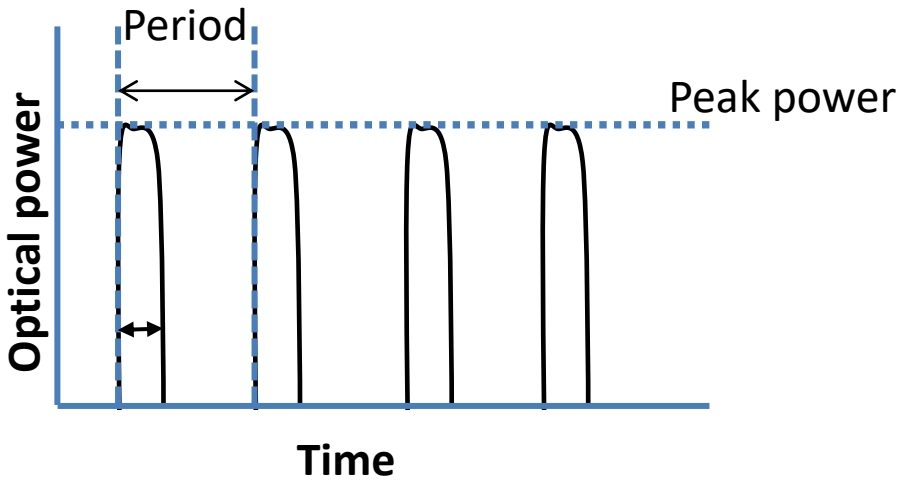


Figure : Pulsed lasers emit bursts of light, spaced in time. There is no emission between pulses.

The properties of the pulsed laser are:

- Bursts of light (light flashes) cause different effects than constant streams of light. Pulsed lasers emit bursts of light spaced in time.
- Between pulses, the laser emits no light.
- The period is the time from the start of one pulse to the next.
- The pulse duration (pulse width) is the time measured across a pulse, often at its full width half maximum (FWHM)

Continuous wave (CW) laser

Lasers emit light that is optical power is approximately constant with time this kind of laser is Continuous wave (CW) lasers provide steady emission.

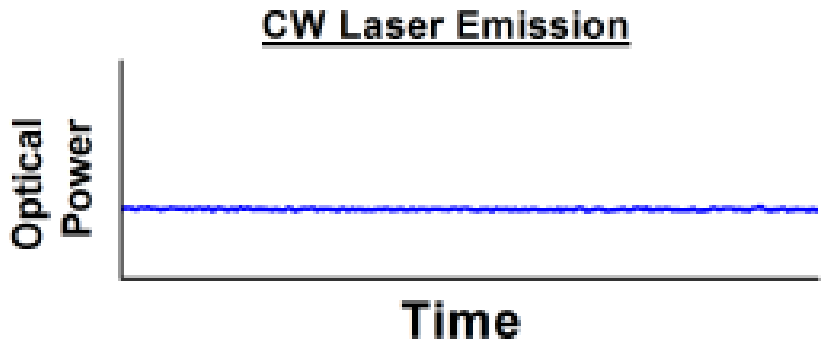


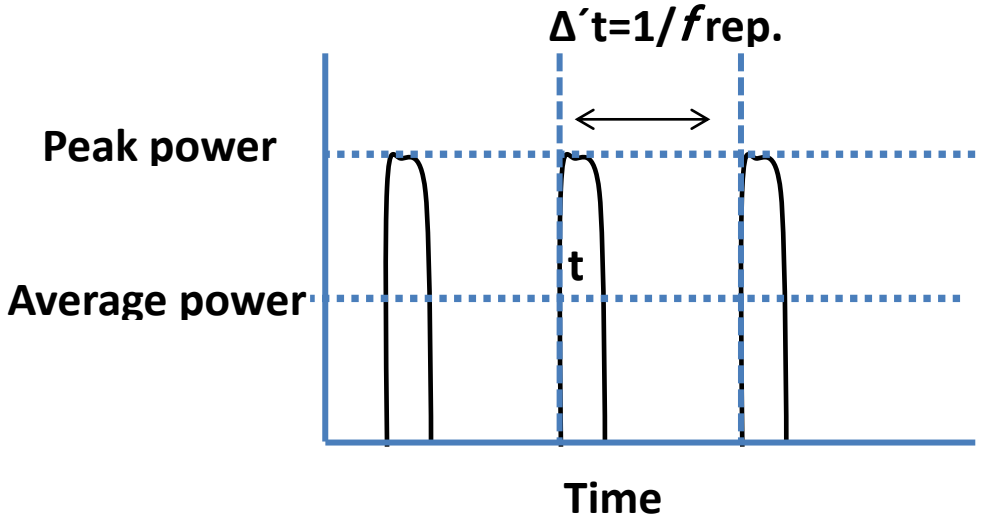
Figure: CW lasers emit light that is optical power is approximately constant with time.

A primary advantage of pulsing is improved heat management. Essentially the "off" period during pulsing allows the laser to cool, and compared to continuous laser, generates less heat at a given level of intensity.

The symbols and units of pulse parameters

- The peak power and the average power

Let's start with output power. For every laser you can define two different output powers.



Period and repetition rate are reciprocal

$$\Delta t = 1/f_{rep.}$$

Pulse energy calculated from average power

$$E = \frac{P_{ave.}}{f_{rep.}} = P_{ave.}.\Delta t$$

Laser average power

Average power calculated from pulse energy

$$P_{ave.} = \frac{E}{\Delta t} = E.P_{ave.}$$

Peak pulse power estimated from pulse energy

$$P_{peak.} = \frac{E}{t}$$

Peak power and average power calculated from each other

$$P_{peak.} = \frac{P_{ave.}}{f_{rep.}.t} = \frac{P_{ave.}.\Delta t}{t}$$

Laser intensity

Intensity of radiant energy is the power transferred per unit area, it can express as:

$$I = \frac{P_{ave.}}{Aera}$$

Medical Laser

Ch . 2

The penetration of incident light into the Skin

The wavelength penetration depends on the depth of penetration of incident light into the skin layer. Laser irradiation typically exceeds the critical values in terms of wavelength, as shown in the figure.

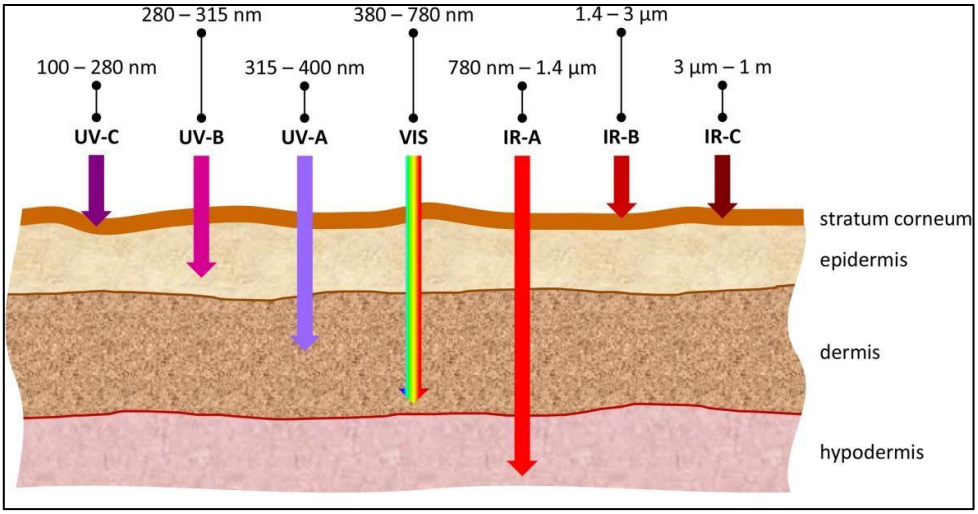


Figure 1: Demonstrate how different wavelengths penetrate various depths into skin tissue.

- Far-ultraviolet (UV-C) and IR irradiation are absorbed within the outermost layer of human skin.
- UV-B laser irradiation can penetrate the epidermis.
- UV-A visible laser irradiation shows a higher penetration depth through the skin and passes through the epidermis.
- Near-infrared (IR-A) light penetrates and crosses the dermal layer, reaching the subcutaneous tissue, the hypodermis.
- IR-B and IR-C wavelength ranges are absorbed within the outermost layer of the human skin

Thermal Conditions Which Cause Skin Burns

A burn is a type of injury to the skin or other tissues caused by heat, cold, electricity, chemicals, friction, hot water, etc. At temperatures greater than 44 °C, proteins begin losing their three-dimensional shape and breaking down. There is a significant inflammatory response in large burns (over 30% of the total body surface area). This results in increased leakage of fluid from the capillaries, and subsequent tissue edema. This causes overall blood volume loss, with the remaining blood suffering significant plasma loss, making the blood more concentrated.

Alexandrite laser

Alexandrite laser is a semiconductor solid laser that emits laser light near-infrared.

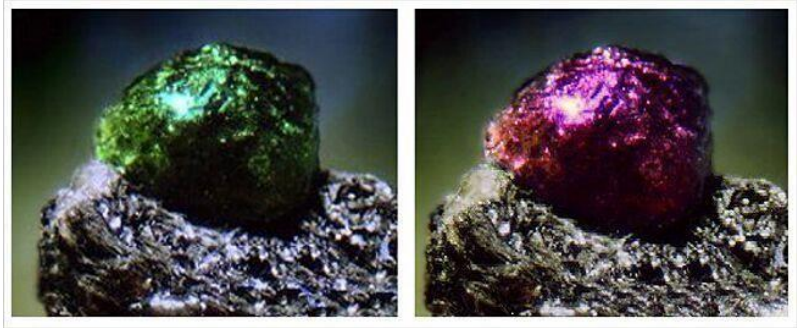


Figure 2: Alexandrite gem appears green in daylight and red in artificial light.

- Chemical formula of the crystal is (Cr^{3+}:$BeAl_2O_4$) and Alexandrite lasers are chromium-doped solid-state lasers based on the crystalline gain medium Alexandrite.
- Laser-active Cr^{3+} ions substitute Aluminum ions in the host crystal.
- Emission wavelengths are typically between (0.7 -0.8) μm and in many cases around 0.75 μm.
- Pumping method of Alexandrite laser with 1 or 2 Xenon flash lamps.

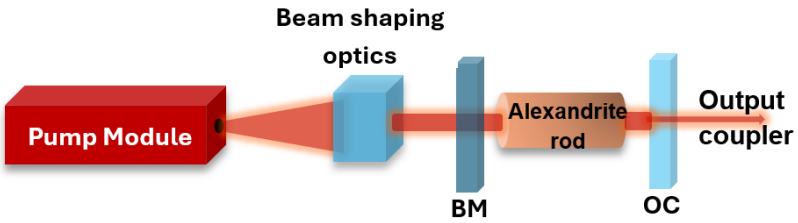


Figure 3: The Resonator system of Alexandrite laser

The energy level diagram of (Cr^{3+}:$BeAl_2O_4$) Alexandrite laser crystal shown in Figure 4 are not four-level lasers but are run in a quasi-four-level regime:

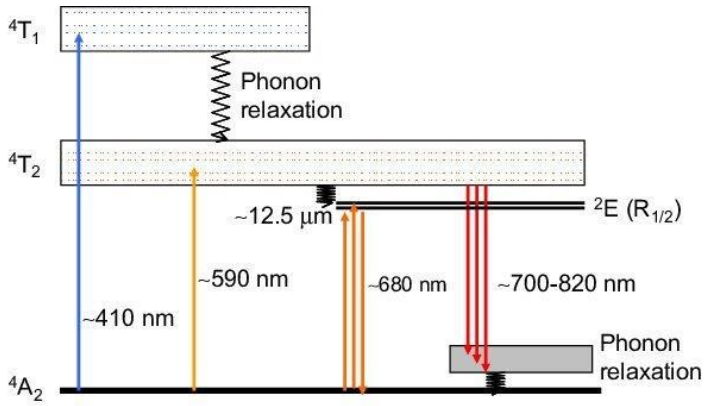


Figure 4: Energy level diagram

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The uses of Alexandrite lasers:

1. Hair Removal

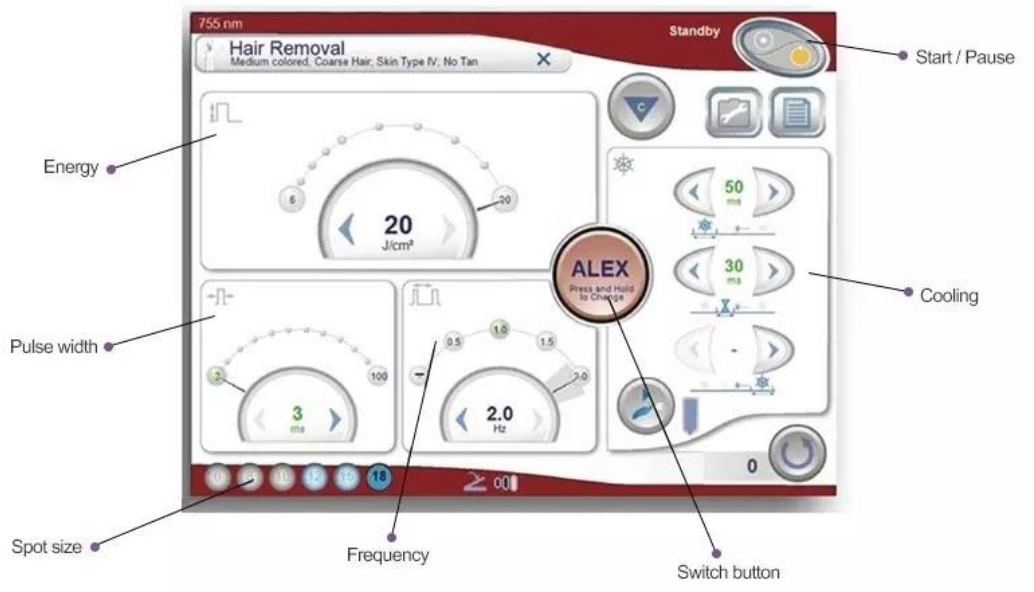


Figure 5: The operation interface

- The primary principle behind laser hair removal is **selective photo thermolysis** (SPTL), the matching of a specific wavelength of light and pulse duration to obtain optimal effect on a targeted tissue with minimal effect on surrounding tissue.
- Lasers selectively can cause damage by heating the cells in the follicle which causes hair growth, hair follicle, while not heating the rest of the skin.
- Light is absorbed by dark objects but reflected by light objects and water, so laser energy can be absorbed by dark hair or skin, with much more speed and intensity than from light skin.
- Because of the selective absorption of photons of laser light, only hair with colors such as black, brown, or reddish-brown hair or dirty blonde can be removed. White hair, light blonde, and strawberry blonde hair do not respond well. The laser works best with dark hair.
- Light skin and dark hair are an ideal combination, being the most effective and producing the best results.

- Vascular lesions may require multiple treatments. The treatment time depends on the form, size, and location of the lesions and skin type.
- Small red vessels can usually be removed only 1 to 3 times and are generally invisible directly after the treatment.

3. Tattoo removal

- Alexandrite lasers can lighten or remove many tattoo inks and are especially effective for removing green and black inks. Tattoo ink is removed by using a specific wavelength, which passes through the skin but is absorbed by the ink.
- The color of the tattoo and the depth of the pigment influence Multiple times of laser treatment for tattoo removal (5 to 20 sessions) spaced at least 7 weeks apart may be required to reach positive results.

Specifications:

- Wavelength: 755nm
- Pulse width: 2-20 ns
- Spot size: 5-10 mm
- Repetition rate: 1-5hz
- Pulsed or continuous wave (CW) operation is possible.
- First commercially available tunable laser.
- High pulse energy possible (up to 3 J).

Disadvantages

- Hair removal is short-term.
- Occurrence of side effects in 2% of dark-colored patients.

Laser eye treatments

Excimer lasers (Gas laser)

Excimer lasers are an interesting and important class of molecular lasers involving transitions between different electronic states of special molecules referred to as excimers.

The excimer gain medium is a noble gas (e.g. argon, krypton, or xenon) or mixture with a halogen (e.g. fluorine or chlorine, e.g. as F, Cl).

An excimer gain medium is pumped with high-current discharge required to produce the excimer molecule (or sometimes with an electron beam), which creates so-called *excimers* (excited dimers), and the term *exciplex laser* is used (for excited complex).

When a fast, high-current discharge passes through the noble gas or mixture gas with a halogen in the tube, they can form temporarily bound molecules with themselves (dimers) or with halogens. Then, atoms become extremely excited (ions) and excimer molecules form.

Excimer laser processing:

1. if A and B are two atoms of a noble gas then: $A+B\longrightarrow No\ reaction$
2. By using high current discharge : $A^{+}+B^{-}\rightarrow AB^{*}$
3. In picosecond timescale, the molecule will dissociate : $AB^{*}\rightarrow A+B+laser$

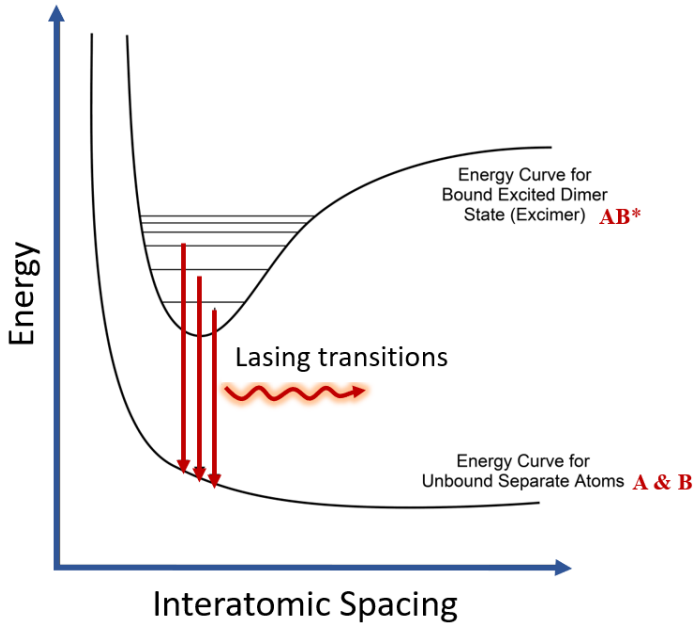


Figure 6. Shows the Lower energy level in an excimer system.

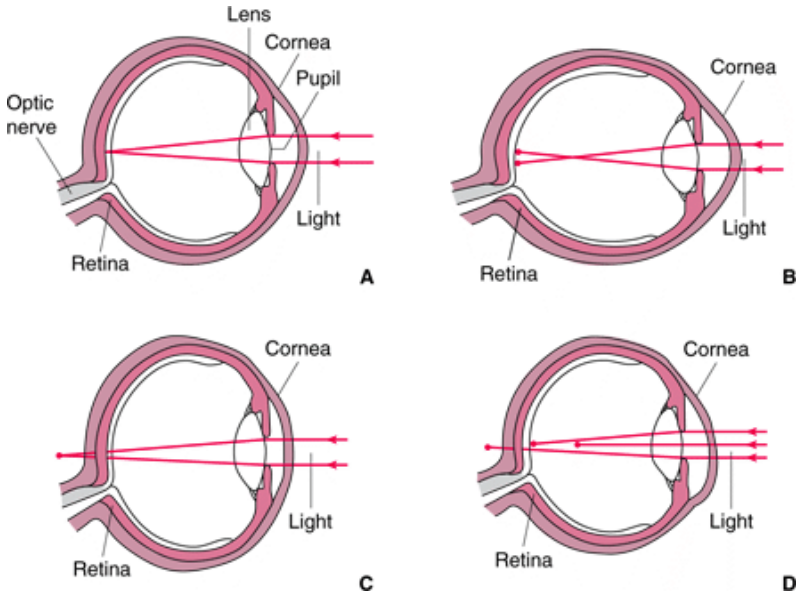
When the separated atoms A and B move closer to each other, the energy of the system rises. This is shown by the lower curve in Figure. So, we can consider the lower energy level as the ground state. The upper energy state is formed when the two atoms (ions) A^{+} and B^{-} form an excited dimer.

This is a temporary state that forms only for an instant in time when the excited atoms combine to form a molecule so that the upper energy level for AB^{*} is considered as an exciting state.

Resulting in a strongly repulsive of the two atoms *A* and *B* which very quickly (on the order of a picosecond) dissociates back into two unbound atoms. At the same time, the electron relaxes to the ground state and this forms a population inversion (lasing process). The wavelength of an excimer laser depends on the molecules used and is usually in the ultraviolet.

Errors of Refraction

(A) Emmetropia; (B) Myopia; (C) Hyperopia; (D) Astigmatism.



A. Emmetropia (normally refracted): When light rays entering are focused on the retina by the cornea and the lens, creating a sharp image that is transmitted to the brain. This ideal condition describes an eye that has no refractive error or visual defects (describe a person with perfect vision).

B. Myopia (nearsightedness): The point of focus is in front of the retina because the cornea is too sharply curved, the axial length of the eye is too long, or both. To correct myopia, a concave (minus) lens is used.

C. Hyperopia (farsightedness): The point of focus is behind the retina because the cornea is too flatly curved, the axial length is too short, or both. To correct hyperopia, a convex (plus) lens is used.

D. Astigmatism: Nonspherical (variable) curvature of the cornea or lens causes light rays of different orientations (e.g., vertical, oblique, horizontal) to focus on different points. To correct astigmatism, a cylindrical lens (a segment cut from a cylinder) is used.

E. Presbyopia: It is a loss of the lens' ability to change shape to focus on near objects due to aging. Typically, presbyopia becomes noticeable by the time a person reaches the early or mid-40 years. A convex (plus) lens is used for correction when viewing near objects.

LASIK (Laser-Assisted in Situ Keratomileusis)

LASIK is currently the most advanced, safest, and most accurate form of laser eye surgery for correcting nearsightedness (Myopia), farsightedness (Hyperopia), and astigmatism. During LASIK surgery, a specialized cutting laser is used to reshape the dome-shaped clear tissue at the front of the eye (the cornea) to enhance vision.

How does LASIK surgery work

- Heavy numbing drops are placed on the operative eyes to reduce discomfort and the need to blink.
- A flap of cornea tissue to make the excimer laser enter the eye.
- Peeled and reshaped the Conal tissue by an excimer laser (an ultraviolet), the amount of tissue removed by the laser is calculated before.
- The LASIK makes the cornea thinner when the reshaping is done, and the surgeon closes the cornea.

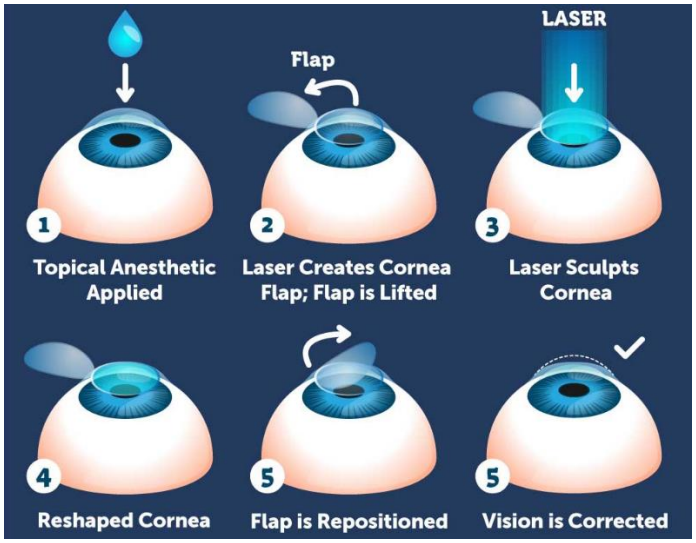


Figure 7: Shows LASIK works in five steps

Neodymium-Yag (Nd: YAG) laser

The laser system operates on four levels and uses a crystal that is a neodymium-doped yttrium aluminum garnet (Nd:$Y_3Al_5O_{12}$), which is a solid-state laser. While it is technically correct to refer to it as a neodymium laser since the active lasing ion is the rare-earth metal Nd^{3+}, this type of laser is commonly named after its host material. Therefore, it is often called a YAG laser or a glass laser. Table 1.1 lists the common Nd^{3+} hosts and their corresponding wavelengths.

Table 1.1 shows the common Nd^{3+} Hosts and Wavelengths

Common Name	Chemical Formula and Name	Wavelength (nm)
YAG	$Y_3Al_5O_{12}$ (yttrium aluminum garnet)	1064
Vanadate	YVO_4 (yttrium *o*-vanadate)	1064
Glass	Various phosphate and silicate glasses	1060/1054
YLF	YLF (yttrium lithium fluoride)	1053
LSB	$LaSc_3(BO_3)_4$ (Lanthanum Scandium Boron)	1062

The Nd:YAG laser has a lower pumping threshold and can operate in continuous wave (CW) mode. It is optically pumped using either a flashlamp or a diode laser. The energy levels are illustrated in Figure 10.

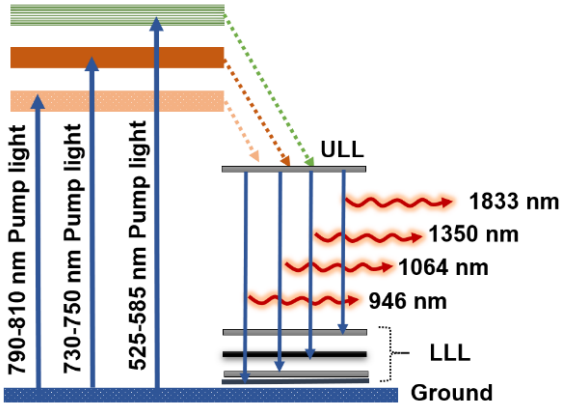


Figure 8: Energy levels in the YAG laser

Nd:YAG lasers are utilized in various medical applications, including the removal of skin cancers, endoscopy, urology, neurosurgery, otolaryngology, gynecology, dermatology, dental surgery, and general surgery.

CO_2 Laser

It is a mixture of **Carbon** dioxide, **Nitrogen,** and **Helium** for cooling the laser system in the approximate ratio 1: 2: 8. CO_2 is a gas laser also a four-level system like He-Ne laser system. Figure 1.12 shows energy levels in Co_2 laser.

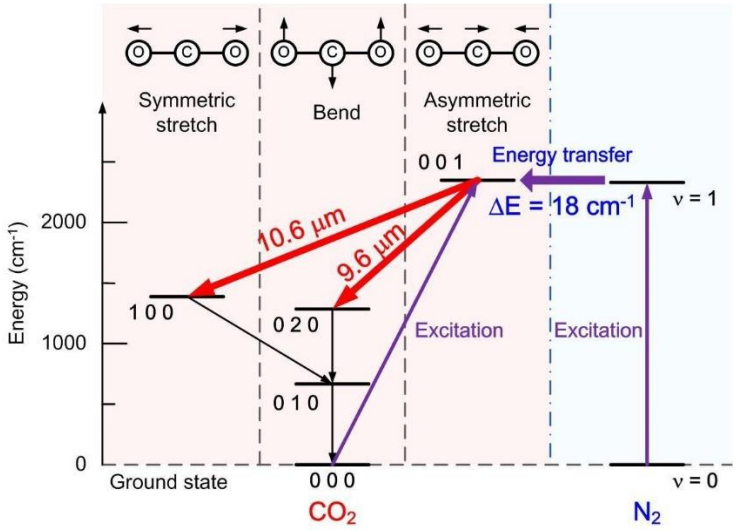


Figure 9. shows energy levels in Co_2 laser

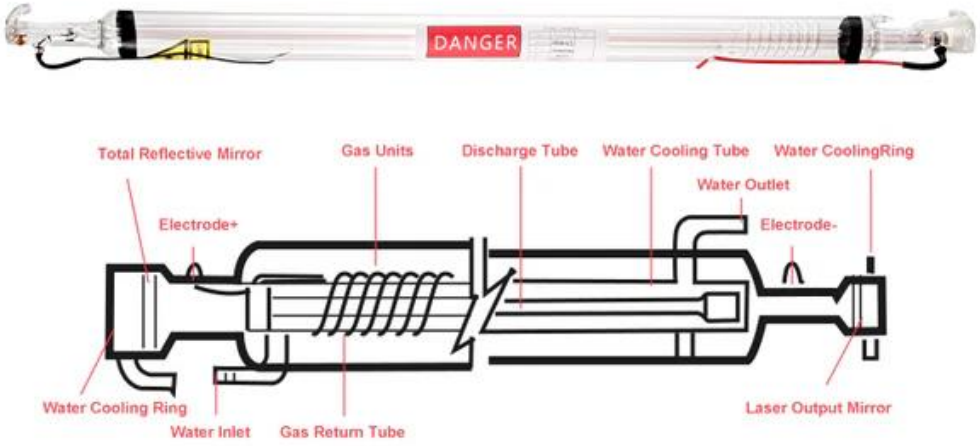


Figure 10. CO_2 laser tube structure and working principle

CO_2 lasers are highly effective in medical treatments, capable of removing the outer layer of skin, effectively treating skin cancer, and addressing various cosmetic skin concerns, including fine lines, deep wrinkles, and acne scars.

Appendix (A)



Alexandrite laser parts

The headpiece features a precise laser spot size adjustable between 8 and 16 mm, complemented by continuous cooling to ensure comfort and efficiency during treatment. With an adjustable pulse width of 5 to 100 ms, it effectively targets the skin and delivers rapid results as it glides over the skin.

Table 2-2-1 Product technical parameters

Technical Parameters	Data
Power Supply Voltage	100V~130V/50-60Hz
Power	500W
Wavelength	1064nm/532nm/1320nm
Max. Energy	1200mj
Laser bar size	Φ5mm
Light source	Xenon Lamp
Air volume	9L/min
Cooling Power	15W
Cooling Temperature	5℃
Frequency	1~10Hz
Spot size	2~5mm
Screen	13.3inch OGS Android screen
Dimension	30cm*48cm*50cm (L*W*H)
Net weight	20Kg



Nd-YAG laser system for tattoo removal-pigmented-lesions- wrinkles-and-skin-treatment-etc.

Laser type	Sealed off CO_2 laser
Wavelength	10.6 µm
Mode structure	TEM 00
Max output power	30W
Spot Size	0.2mm
Lens Focal Distance	100 mm / 50mm
Power Fluctuation	<= 10%
Aiming Beam	630nm Red Laser (adjustable brightness)
Delivery System	Articulated Arm With Scanner
Operation Mode	Continuous Wave , Single Pulse , Repetition Pulse , Super Pulse , Scanning
Scanning Pattern	Circle , Triangle, Rectangle, Line
Scanning Size (max)	20 mm x 20 mm
Pulse Width	Single Pulse (0.01-1s) Repetition Pulse (0.001-1s) Super Pulse (0.01-1s) Scanning (100µs-10 ms)
Cooling System	Internal Closed –loop Water Cooling Circulation
Power Supply	100~120VAC ,50/60Hz or 200~240 VAC , 50/60 Hz
Input Power	500 VA
Environment Temperature	5-40° C
Relative Humidity	≤ 80%
Dimension (W*L*H)	260mm X 360mm x 960mm
Weight	46 kg



CO_2 fractional system 10600nm.

Presented by: *Dr. Ruba Al-Obaidi & Dr. Oday M. Abdulmunem*