جامعة المستقبل
كلية التقنيات والعلوم الصحية
قسم تقنيات البصريات

المرحلة الثانية ٢٠٢٣-٢٠٢٤

LASER in Ophthalology

Lecture 1st : Laser definition Characteristics and applications in eye

A **laser**, short for "**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation," is a device that produces a concentrated beam of **coherent** light through a process called stimulated emission. It operates based on the principles of **quantum mechanics**.

Core Components:

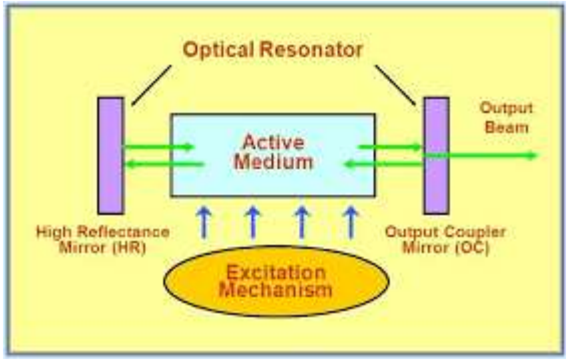
- Active Medium: Material (e.g., crystal, gas, semiconductor) capable of emitting light.
- Pumping Mechanism: Energizes the active medium.
- Optical Cavity: Reflects and amplifies light.

Excitation:

- External energy source excites the active medium (electrical discharge or optical pumping).
- Excited atoms or molecules reach higher energy states.

Photon Emission:

- Excited particles return to lower energy states, emitting photons (packets of light energy).



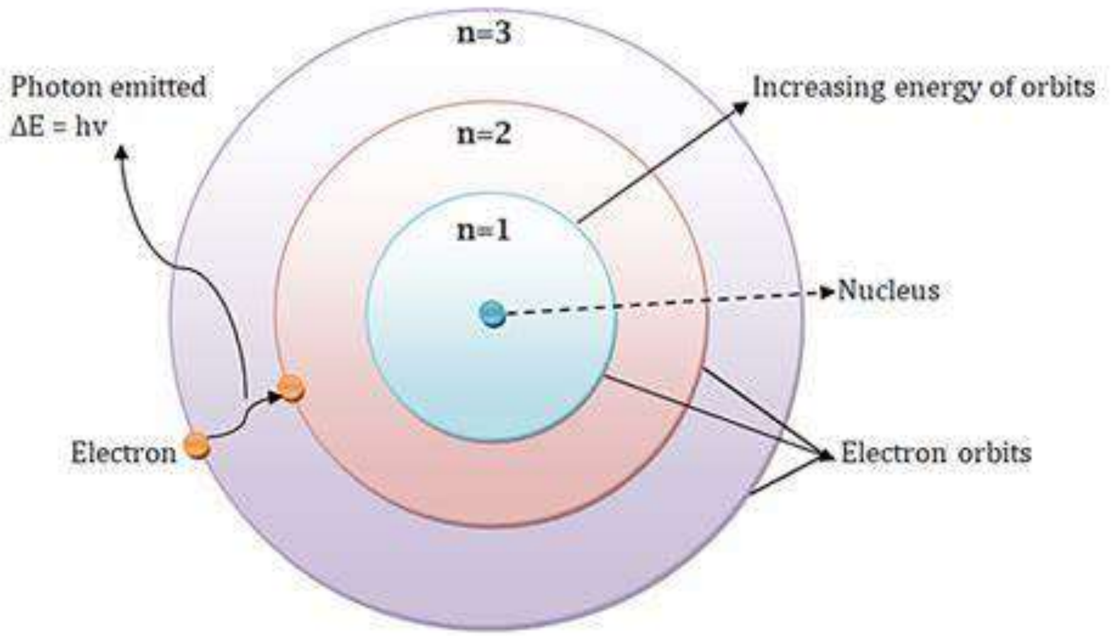
Stimulated Emission:

- Emission is stimulated by photons of the same wavelength.

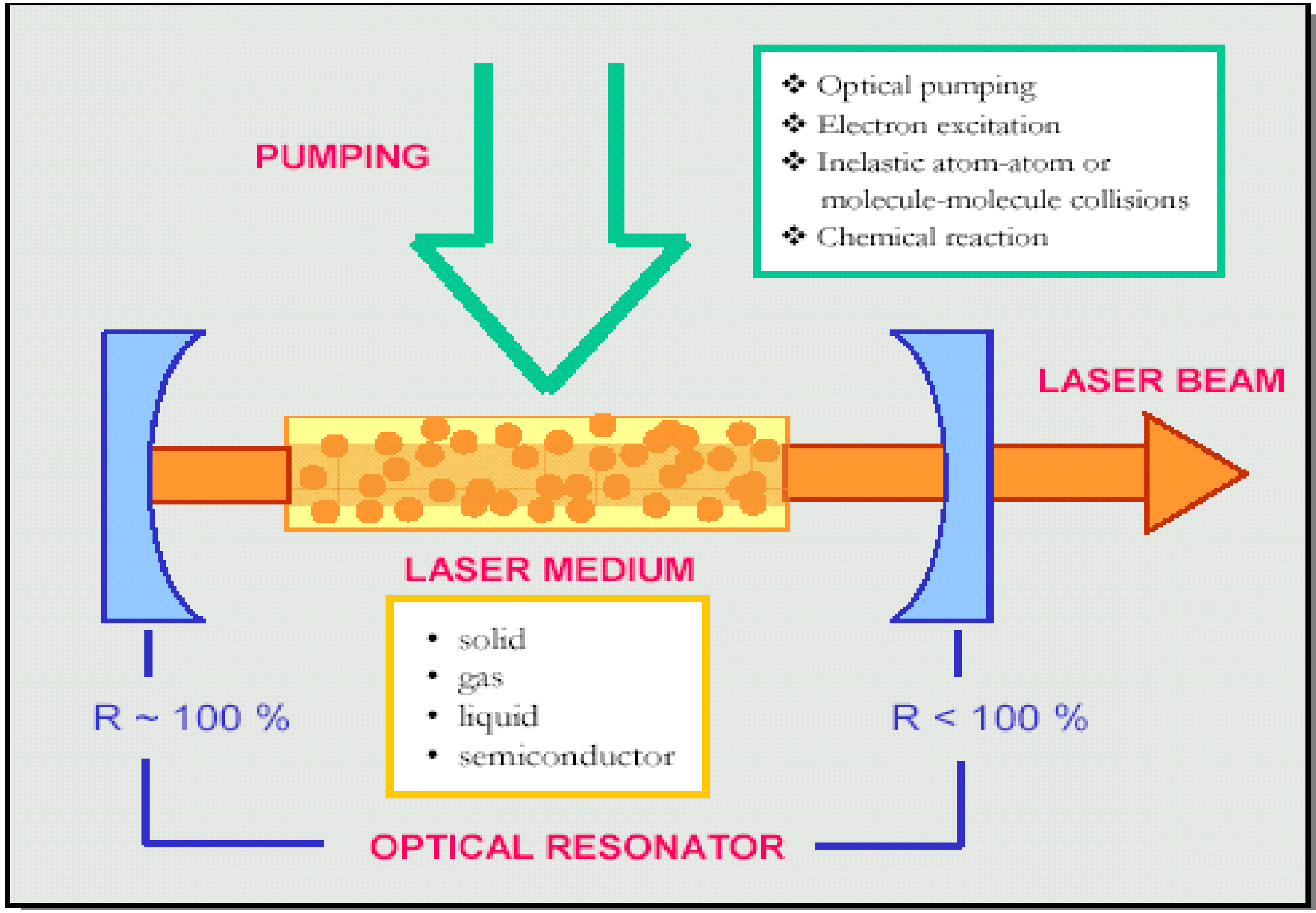
- Mirrors in the optical cavity reflect emitted photons, stimulating further emissions.

The atom, or system, is said to undergo a **transition** between *two* energy levels when it emits or absorbs energy.

The **lowest** energy level of a system is called its **ground state;**
higher energy levels are called excited states.



Bohr's atomic model hydrogen emission spectra



How lasers utilize this process to generate coherent light:

1.Stimulated Emission of Radiation:

1. The term "laser" stands for "Light Amplification by Stimulated Emission of Radiation."
2. In a laser, a gain medium (such as a gas, liquid, or solid-state material) is excited, producing a population inversion where more atoms are in higher energy states than lower ones.

2.Stimulated Emission:

Photons, emitted spontaneously or by external stimulation (stimulated emission), trigger other excited atoms to release photons of the same frequency, phase, and direction.

3-Amplification:

This process leads to the amplification of light, as more and more photons are produced with the same characteristics.

4-Coherence:

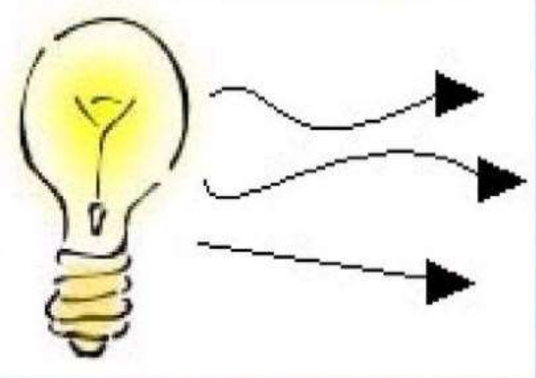
The emitted light is coherent, meaning the waves have a consistent phase relationship.
This coherence distinguishes laser light from ordinary light sources.

5-Mirrors:

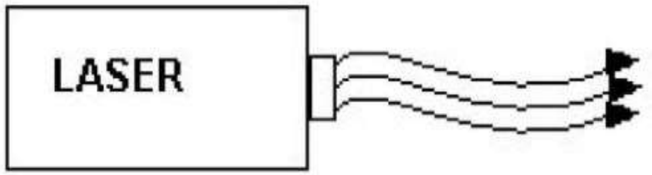
The laser medium is placed between two mirrors. One mirror is highly reflective,
while the other is partially transparent.
This arrangement allows light to build up through multiple passes through the gain medium.

6-Emission of a Laser Beam:

The result is a highly collimated and coherent laser beam that exits through the partially transparent mirror.

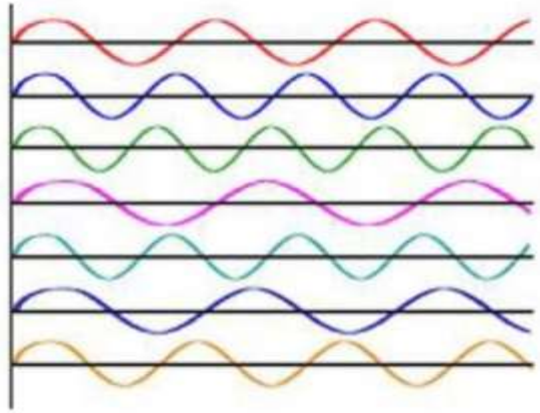


1. Many wavelengths
2. Multidirectional
3. Incoherent

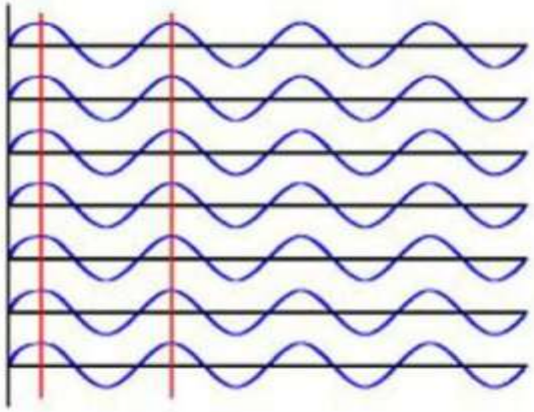


1. Monochromatic
2. Directional
3. Coherent

Coherence:



Incoherent light waves



Coherent light waves

key characteristics of laser light:

Coherence: Laser light is highly coherent, meaning that the waves of light emitted by a laser are in phase with each other. This coherence allows laser light to maintain a tight beam and propagate over long distances without significant spreading or divergence.

Monochromaticity: Laser light is typically very close to a single wavelength or color. Unlike other light sources that emit a broad spectrum of wavelengths, lasers produce light that is highly pure and concentrated at a specific wavelength. This property is advantageous for applications that require precise control of light properties.

Directionality: Laser light is highly directional, meaning it propagates in a well-defined, narrow beam. The use of mirrors and an optical cavity in a laser system helps to direct and focus the emitted light into a concentrated beam. This directionality allows laser light to be easily focused and targeted to specific areas.

High Intensity: Laser light is characterized by its high intensity or brightness. The coherent and focused nature of laser light allows it to be concentrated into a small spot or area, resulting in a high power density. This high intensity makes lasers useful for cutting, welding, and other applications requiring a concentrated energy source.

Low Divergence: Laser beams have low divergence, meaning that the beam spreads out minimally as it propagates through space. This property enables laser light to travel long distances while maintaining its focused and collimated nature. Low divergence is crucial for applications such as laser communication and long-range laser measurements.

Long Coherence Length: Laser light has a long coherence length, meaning that it can maintain its coherence over large distances. This property is beneficial for applications such as **interferometry**, **holography**, and **optical** coherence tomography, where the interference of light waves is essential for precise measurements and imaging.

- Highly adaptable and versatile (Real) properties of laser light.
- Applicable across various fields due to its unique characteristics.

uses of lasers in eye-related treatments:

LASIK (Laser-Assisted in Situ Keratomileusis): LASIK is a popular laser eye surgery used to correct refractive errors such as nearsightedness (myopia), farsightedness (hyperopia), and astigmatism.

During LASIK, a laser is used to

reshape the cornea, improving its focusing ability and reducing the need for glasses or contact lenses.

Photorefractive Keratectomy (PRK): **PRK** is another laser eye surgery used to correct refractive errors.

In PRK, the laser is used to

remove a thin layer of the cornea's surface (epithelium) before reshaping the underlying corneal tissue to correct the refractive error.

Laser-Assisted Cataract Surgery: In cataract surgery, a clouded natural **lens** is replaced with an artificial intraocular lens **(IOL).**

Laser-assisted cataract surgery incorporates lasers in various steps, including creating

precise incisions in the cornea,
opening the lens capsule, and
fragmenting the cataract for easier removal.

Retinal Laser Surgery: Laser technology is used in the treatment of various retinal conditions, such as diabetic retinopathy and retinal tears.

In these procedures, lasers are used to

- **seal** leaky blood vessels,
- **reduce** abnormal vessel growth,
- **repair** retinal tears, or create
- **scar** tissue to stabilize the retina.

Glaucoma Laser Surgery: Laser therapy can be used as a treatment option for glaucoma. Different laser techniques, such as selective laser trabeculoplasty (SLT) or laser peripheral iridotomy (LPI), are employed to

- **improve** the drainage of fluid from the eye,
- **reducing** intraocular pressure.

Laser Refractive Surgery Enhancements: In some cases, individuals who have previously undergone LASIK or other refractive surgeries may require additional adjustments. Laser enhancements can be performed to fine-tune the visual outcome and address any residual refractive errors.

It's important to note that specific laser procedures and their suitability for individual patients are determined by eye care professionals based on a thorough evaluation and diagnosis. The use of lasers in eye treatments has provided effective and precise solutions for various eye conditions, offering improved vision and quality of life for many individuals.

THANKS SEE YOU IN NEXT LECTURE