

# Laser

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To Dr. M. Jayasimhadri

- **INTRODUCTION**
- **CHARACTERISTICS OF LASER RADIATION**
- **SPONTANEOUS & STIMULATED EMISSION.**
- **APPLICATION OF LASER.**

# Laser

## Introduction

### ■ INTRODUCTION

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation.

Laser are optical phenomena which find major application in various fields such as medicine, engineering, fiber optic communication, industries etc.

Einstein proposed idea to amplify light and microwaves by utilizing the energy which is released by atoms or molecules during energy level transitions.

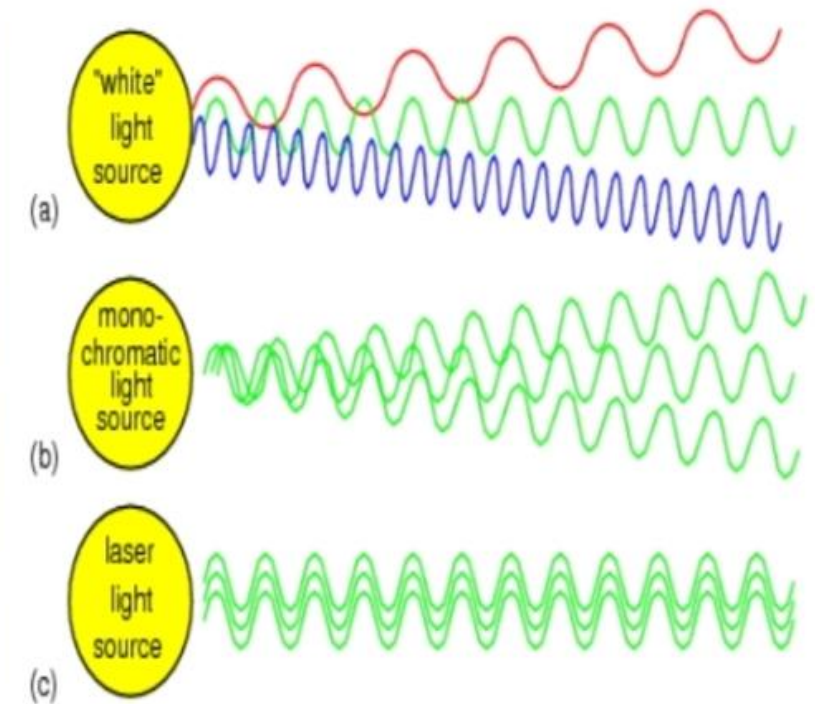
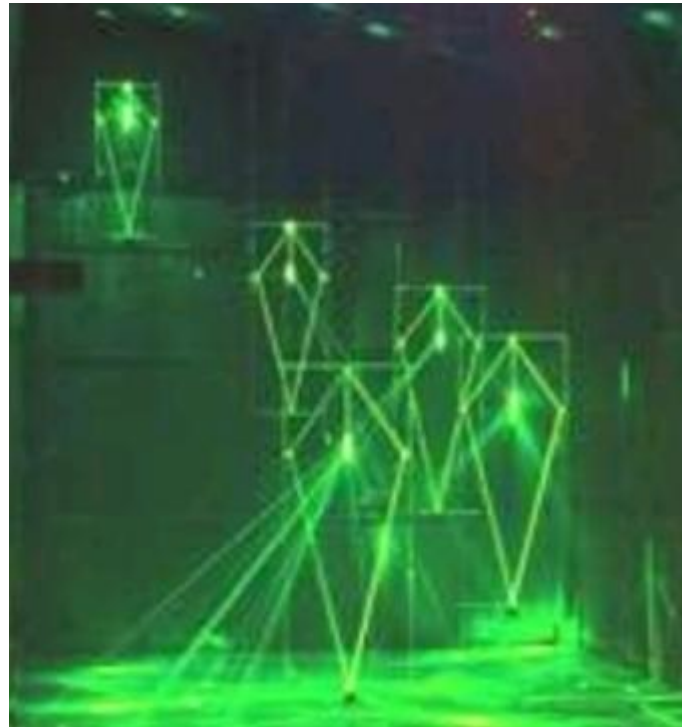
- Outline an application of the use of a laser; medical applications, communications, bar-code scanners, laser disks, surveying, welding and machining metals, drilling tiny holes in metals, production of CDs, reading and writing CDs,

## Monochromatic light

► Monochromatic light has a very narrow range of frequencies (i.e. it is only made of light of one colour)

# Laser

Laser light



# Laser

Characteristics of laser light

## ■ Characteristics of Laser Light

- The following characteristics, distinguishes a laserbeam from an ordinary light.
- Highly Monochromaticity.
- Highly Directionality.
- Coherence.
- Intensity.

# Laser

## Characteristics

### ■ (1) **High Monochromatic** :

\*Mono means single and chrome means colour, therefore monochromaticity is a source with single colour.

- It is important to note that energy radiation for all atoms corresponds to their respective energy level.

So that frequency of laser light is constant ( $E = h\nu$ ).

LASER radiates light having single frequency wavelengths known as “Monochromaticity”

This characteristic is very useful in medical treatment because the biological effect is strongly related to the wavelength of light and also used as source in many laboratory experiments

# Laser

## Characteristics

- (2) **High Directionality :**

Laser is almost perfectly parallel.

This means that it has good directionality.

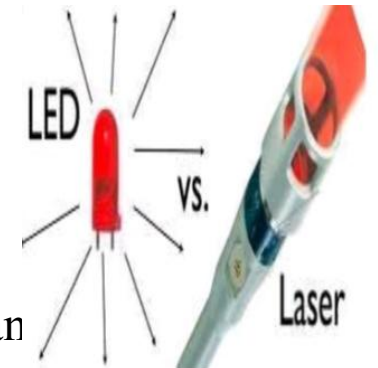
For the same power, normal light can travel very small distance before it is diverted but laser could travel very large distance almost without diversic“

$$\Delta\theta=\lambda/D$$

\*Theta =angle of divergence.

D –diameter of source aperture.

- Used as ranging device and also used to study plan distance.



# Laser

## Characteristics

- (3) **High Intensity :**

Due to the coherent nature of laser, it has the ability to focus over a small area of  $10^{-6} \text{ cm}^2$ , i.e. extremely high concentration of its over a small area.

- (4) **Coherence :**

The wave trains which are identical in phase and direction are called coherent waves.

Since all the constituent photons of laser beam possess the same energy, momentum and propagate in same direction, the laser beam is said to be highly coherent.



# Laser

Einstein's theory

- **Einstein's theory**

- In 1916, according to Einstein, the interaction of radiation with matter could be explained in terms of three basic processes:

- 1) Absorption

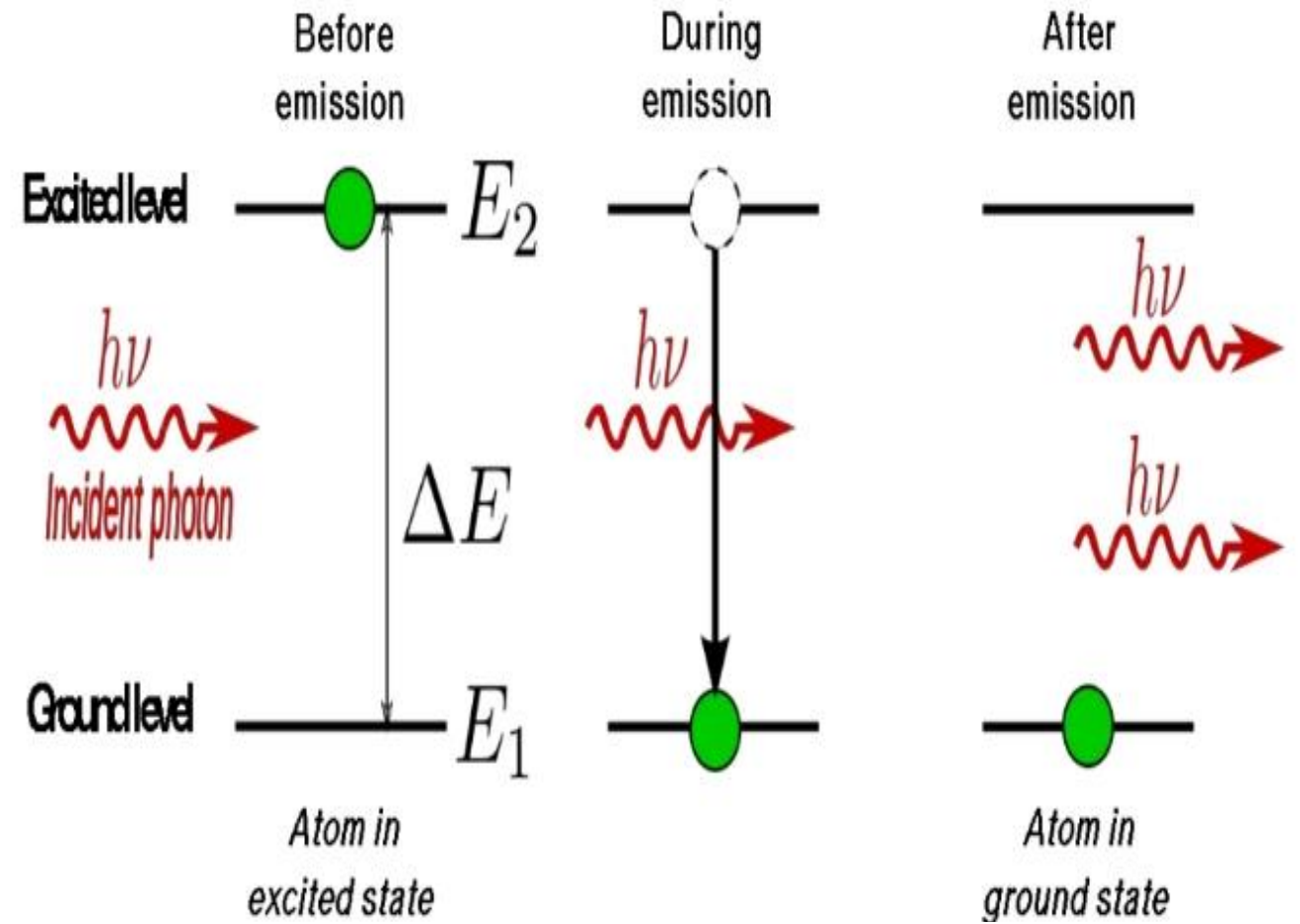
- 2) Spontaneous Emission

- 3) Stimulated Emission.

- The three processes are illustrated and discussed in the following:

# Laser

Pictorial representation of its working



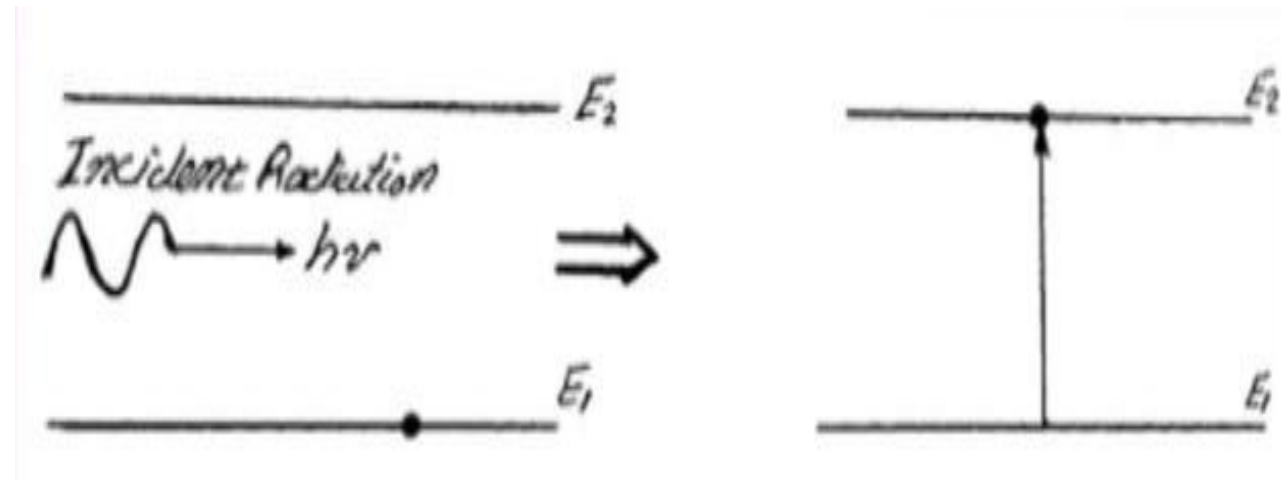
$$E_2 - E_1 = \Delta E = h\nu$$

# Laser

Induced Absorption

## 1. Induced Absorption

Let the atom be initially in the lower state  $E_1$ . If a photon of  $h\nu$  is incident on the atom in the lower state, the atom absorbs the incident photon and gets excited to the higher energy state  $E_2$ . This process is called induced absorption as shown fig. 1.



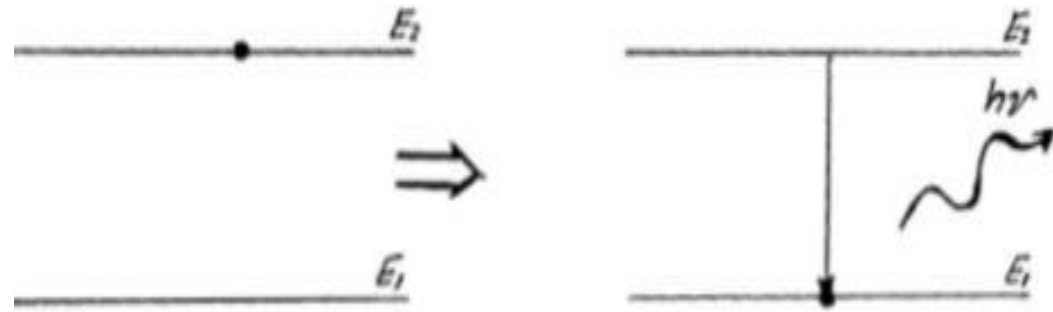
# Laser

Spontaneous emission

## ■ 2. Spontaneous emission

It is a process in which there is an emission of a photon whenever an atom transits from a higher energy state to a lower energy state without the aid of any external agency.

For this process to take place, the atom has to be in the excited state. Since, the higher energy level is an unstable one, the excited atom in the higher energy level  $E_2$  spontaneously returns to the lower energy level  $E_1$  with the emission of a photon of energy  $h\nu = E_2 - E_1$  as shown in fig.



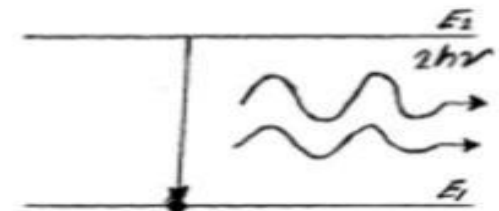
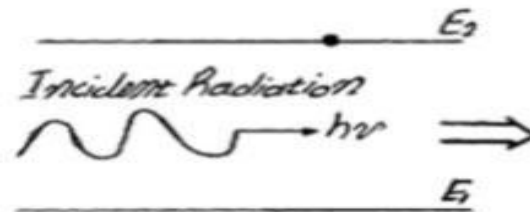
# Laser

Stimulated emission

## ■ 3. Stimulated emission

Quite by contrast stimulated emission” requires the presence of external radiation when an incident photon of energy  $h\nu = E_2 - E_1$  passes by an atom in an excited state  $E_2$ , it stimulates the atom to drop or decay to the lower state  $E_1$ .

In this process, the atom releases a photon of the same energy, direction, phase and polarization as that of the photon passing by, the net effect is two identical photons ( $2h\nu$ ) in the place of one, or an increase in the intensity of the incident beam. It is precisely this process of stimulated emission that makes possible the amplification of light in Laser.



# Laser

Some related concepts

- **Basic concepts in laser physics**

- Population Inversion :**

- It is a state of achieving more number of atoms in the excited state compared to the ground state.

- It can be achieved by a process called pumping.

- Pumping :**

- It is the mechanism of exciting atoms from the lower energy state to a higher energy state by supplying energy from an external source.

- Lasing :**

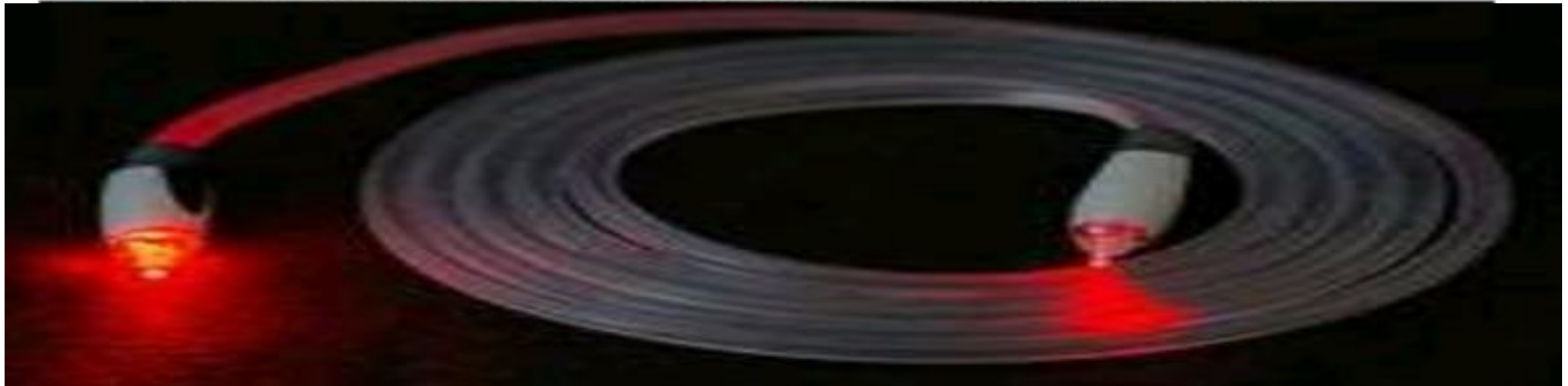
- The process which leads to emission of stimulated photons after establishing the population inversion is referred to as lasing

# Applications of lasers

## Lasers in communication:

In optical fiber communication laser bandwidth is very high compared to the radio and microwave communications.

- As it has large bandwidth, more amount of data can be sent.
- More channels can be simultaneously transmitted.
- lasers are also used in other communication





## Lasers in industry:

- Lasers can be used to blast holes in diamonds and hard steel.
- Lasers can cut, drill, weld, remove metal from surfaces and perform these operations even at surfaces inaccessible by mechanical methods.
- Lasers range finder is used to measure distance to making maps by surveyors.





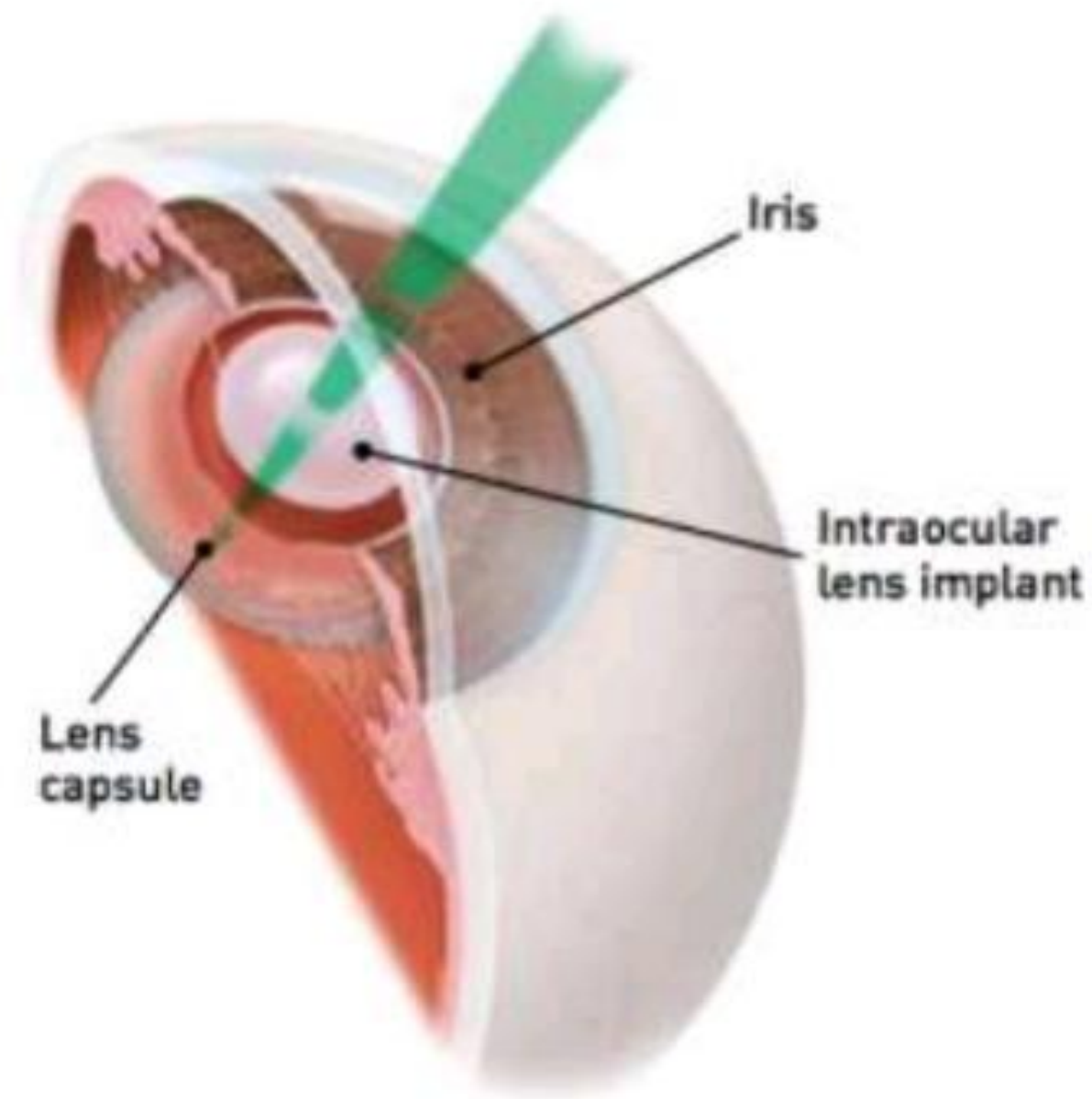


- Argon and Co2 lasers are used in treatment of liver and lungs .
- New kind of laser surgery that uses molecules to stitch together wounds .
- Co2 laser is particularly used in spinal and brain tumour excision and kidney stone extrusion.
- Lasers are used in the treatment of Glaucoma.

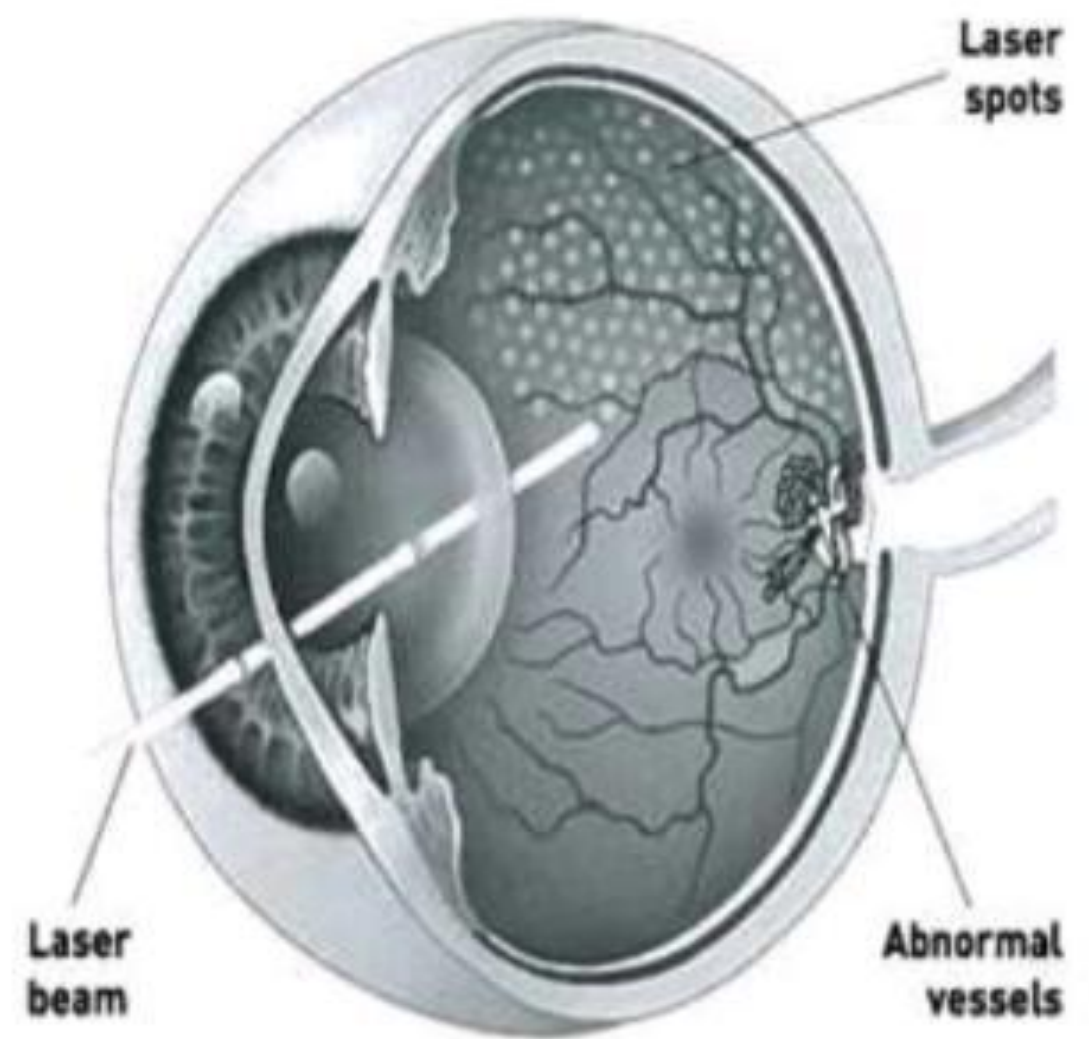
# Laser used in eye treatment

- The laser can also repair a detached retina—one that has broken loose from the rear part of the eyeball
- The laser is very useful in removing extraneous blood vessels that can form on the retina—the thin, light-sensitive membrane at the back of the eyeball





**A laser can make an opening in a cloudy lens capsule to restore normal sight.**



**LASER SURGERY CAN SLOW OR STOP THE GROWTH OF ABNORMAL BLOOD VESSELS IN THE RETINA CAUSED BY DIABETIC RETINOPATHY.**




## **Lasers in military:**

- A laser beam can be bounced off a target such as enemy air plane or ship, to determine its distance and speed.
- Laser can serve as a war weapon.
- High energy lasers are being employed to destroy enemy air crafts and missiles.



## CONCLUSION

- Finally I conclude that laser plays a crucial role in the modern world.
- Therefore laser play an pivotal role in the present technical world.

A close-up photograph of a pair of human hands, palms up, holding a small, rectangular piece of white paper. The paper has a torn, deckled edge on its right side. The words "Thank You" are written on the paper in a black, elegant cursive script. The hands are positioned symmetrically, with the fingers slightly curled around the edges of the paper. The background is dark and out of focus, making the hands and the paper the central focus of the image.

*Thank You*