# *PHYSICS*

*Project-I Report*

*on*

# ***Laser***

Submitted towards the partial fulfillment of
the requirement for the award of the degree

***Bachelor of Technology***
*In*
***Information technology***

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# Laser

# Contents

# INTRODUCTION

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

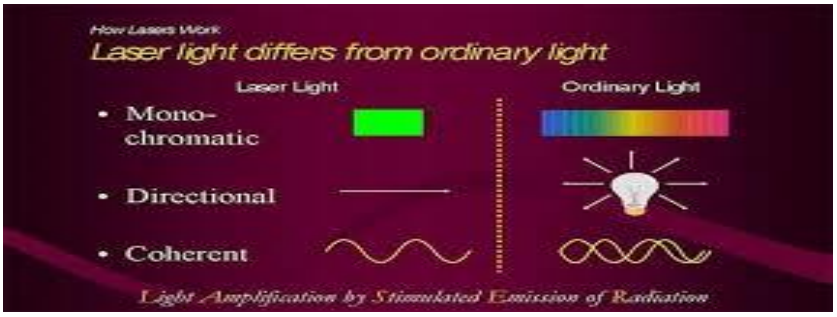
Laser are optical phenomena which find major application in various fields such as medicine, engineering, fiber optic communication, industries etc.

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

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




# Characteristics of Laser Light

The following characteristics, distinguishes a laser beam from an ordinary light.

1.Highly Monochromaticity.
2.Highly Directionality.
3.Coherence.
4.Intensity.

## 1.High Monochromatic :

*Mono means single and chrome means colour, therefore mono chromaticity is a source with single colour.

• It is important to note that energy radiation for all atoms is corresponds to their respective energy level. So that frequency of laser light is constant (E = hv).

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 thewavelength of light and also used as source in many laboratory experiments

## 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 diverting .

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

*Theta =angle of divergence.

D –diameter of source aperture.

Used as ranging device and also used to study planetary distance.

### 3.High Intensity :

Due to the coherent nature of laser, it has the ability to focus over a small area of 10-6 cm2, i.e.extremely high concentration of its over a small area.

### 4.Coherence :

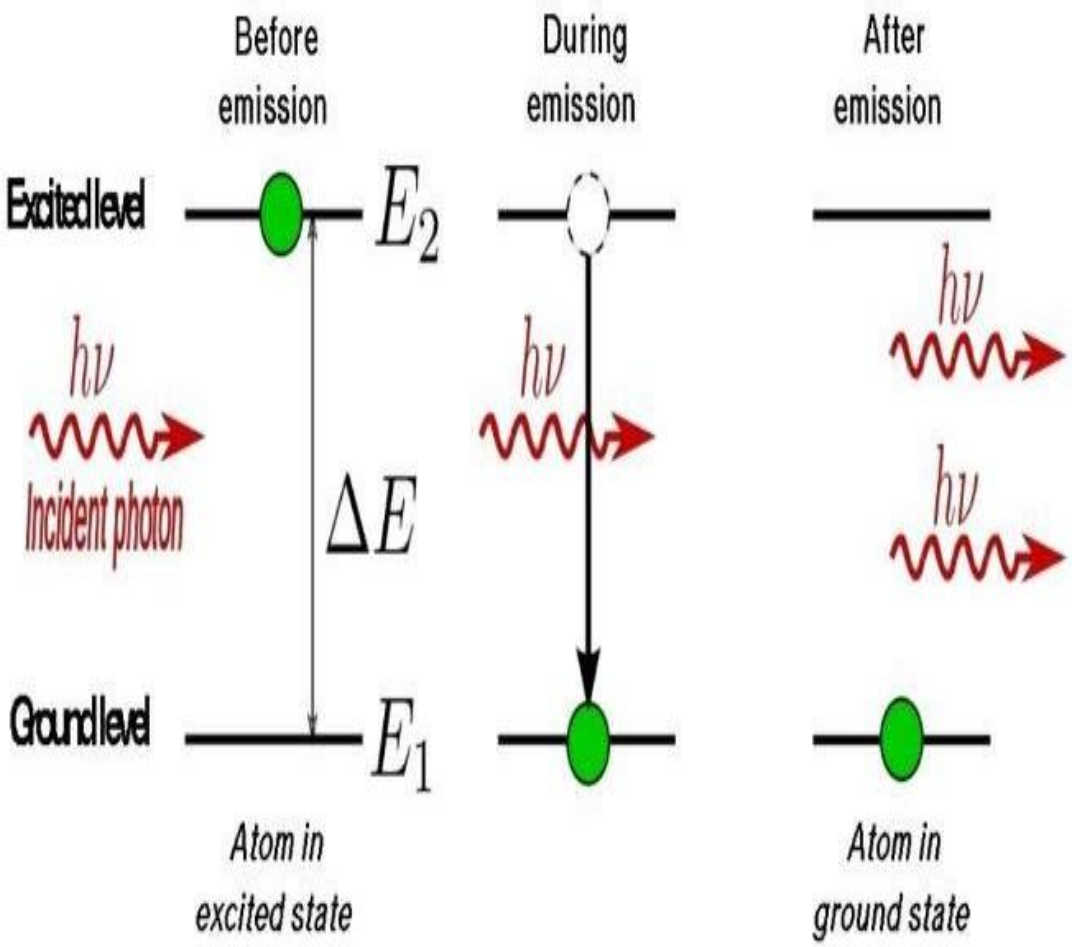
The wave trains which are identical in phase and direction are called coherent waves. Since all the constituent photons of laser beam possess the same energy, momentum and propagate in same direction, the laser beam is said to be highly coherent.

# Einstein's theory

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

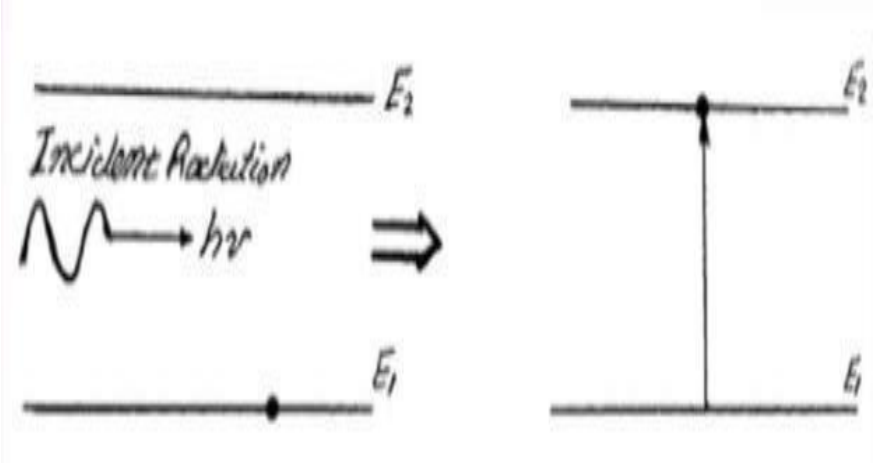
1) Absorption
2) Spontaneous Emission
3) Stimulated Emission.

The three processes are illustrated and discussed in the following:



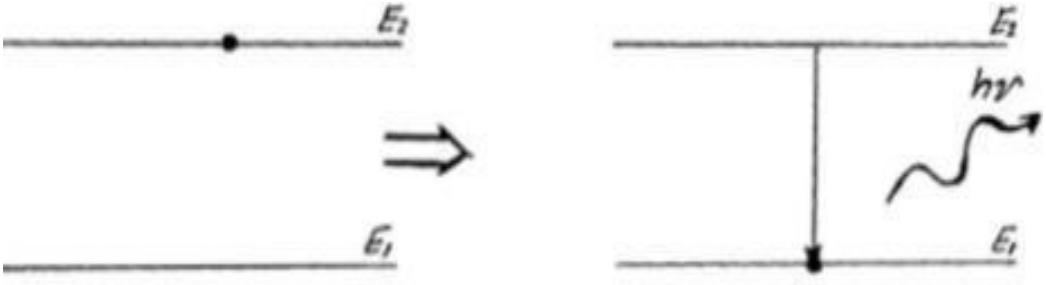
## 1.Induced Absorption

Let the atom be initially in the lower state E1. If a photon of hv is incident on the atom in the lower state,the atom absorbs the incident photon and gets excited to the higher energy state E2. This process is called induced absorption as shown fig. 1.




## 2.Spontaneous emission

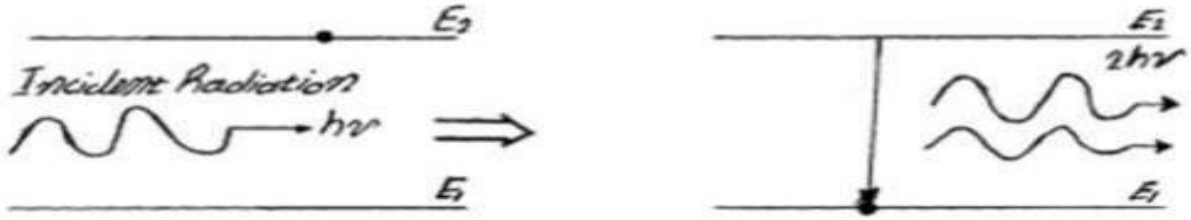
It is a process in which there is an emission of a photon whenever an atom transits from a higher energy state to a lower energy state without the aid of any external agency.
For this process to take place, the atom has to be in the excited state. Since, the higher energy level is
an unstable one, the excited atom in the higher energy level E2 spontaneously returns to the lower energy level El with the emission of a photon of energy hv =E2-E1 as shown in fig.



## 3. Stimulated emission

Quite by contrast stimulated emission'' requires the presence of external radiation when an incident photon of energy hv =E2-E1 passes by an atom in an excited state E2, it stimulates the atom to drop or decay to the lower state E1.

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 (2hv) in the place of one, or an increase in the intensity of the incident beam.

It is precisely this processes of stimulated emission that makes possible the amplification of light in Laser.

# 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 :

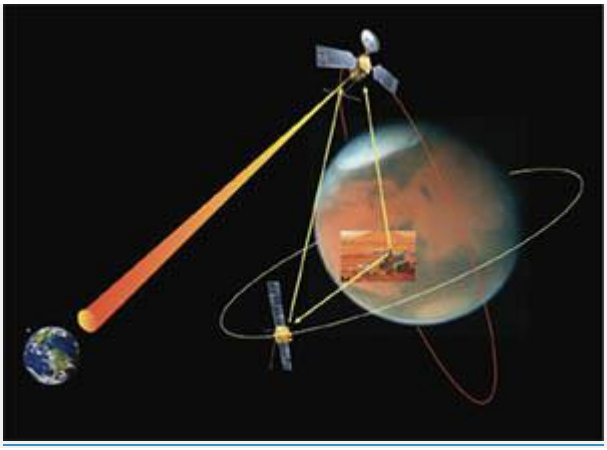
It is the mechanism of exciting atoms from the lower energy state to a higher energy state by supplying energy from an external source.

## Lasing :

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

# Application of laser

# Lasers in communication



***Communication in space***

Laser communications systems are wireless connections through the atmosphere, The light speed is the fastest speed than anything can travel, so laser communications and laser sensing are important in mortar defense and other crucial aerospace and defense applications.

Lasers are able to see through the dense foliage, and they can allow for space communication from distances measured in millions of miles, We use lasers everywhere such as in the military systems, the avionics and in submarines.

Laser communications are better than radio as light wavelengths are packed much more tightly than the sound waves and they transmit more information per second with a stronger signal, Lasers are used in communication with the optical fibers instead of telephone cables.

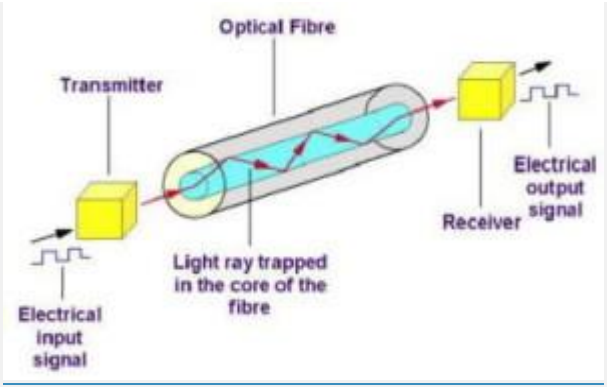
We send and receive the data, video and other information, using lasers to encode and transmit the data at rates 10 to 100 times faster than radio, Laser is a very intense, concentrated, highly parallel and monochromatic beam and coherence is a very important property of laser.

Lasers have been used in communications for years, and we can transfer information by lasers every day such as reading CDs and DVDs, and we can scan bar codes at checkout lines or tapping the fiber optic backbone of the phone or internet services.

Laser communications systems can be easily deployed because they are inexpensive and small, They have low power and they do not require any radio interference studies, Data exchange is relatively easy to combine with accurate range metering which is essential in many applications.

Lasers communications are solutions to satisfy increasing bandwidth needs, Laser communication systems can transmit speeds of up to a gigabit per second, Laser communications assure much faster data traffic at lower power consumption, smaller geometrical size and much higher immunity to eavesdropping.

# Advantages of fiber optics cables




***Optical fiber***

The optical fibers are thin strands of glass through which a laser beam can travel for several miles, and laser amplifiers are needed only every six or seven miles to strengthen the light signal.

One of the advantages of the laser fiber optics is that several fibers can be wrapped inside one cable, and each cable contains many laser beams, each carrying billions of bits of information.

Multiple signals can be sent with high quality and low loss by light propagating along the fibers and the lasers are more nearly monochromatic and this allows the pulse shape to be maintained better over long distances.

The optical signals are sent at infrared wavelengths of 1.3 to 1.6 micrometers, the glass fibers are most transparent.

# Lasers in industry

Lasers are one of the most widely used tools in manufacturing today, especially as additive manufacturing and Industry .It allow engineers to create more complex features and product designs that require tight tolerances. Laser machining can create fine features that are difficult or impossible to make using traditional machining equipment. Laser cuts are super-clean with no burrs or heat effects to the surrounding material, thereby eliminating the need for some secondary finishing steps. Laser processes are becoming go-to manufacturing technologies for medical device manufacturers as they design smaller and more advanced products.

Below are  applications for lasers in manufacturing.

## 1. Laser Marking

Lasers are increasingly used to imprint unique identification (UID) numbers on parts and products, which allow them to be easily traced in the event of a recall. Laser markings are highly durable and, for medical devices, can withstand many cycles of sterilization. Both human-readable and barcode information, including lot and batch codes and even design histories, can be laser-marked on products with flat or curved part geometries.

## 2. Surface Texturing

Lasers can create textures or patterned microstructures on the surfaces of components or products that improve physical performance, such as wear rates, grip, optical properties, and load capacity. Laser micro-texturing can create roughness on medical implants that make it easier for new tissue or bone to take hold and grow into the new implant. Patterns with features as small as 10 µm can be produced with very high depth resolution.

## 3. Laser Ablation

This subtractive machining method essentially vaporizes material with great precision using a laser beam. Pulse length, wavelength, and intensity are adjusted according to the material being processed. Ablation is especially useful for machining sensitive materials such as nanomaterials, or superconductive materials, because the noncontact method does not change the structure of the material or damage its surface with abrasion or heat.

## 4. Laser Drilling

Lasers are incredibly accurate at drilling micron-sized holes in a wide range of materials. Image: Laser Light

Lasers are incredibly accurate at drilling micron-sized holes in a wide range of materials, including metals, polymers, and ceramics. "Many of today's manufactured parts call for microscopic features that can only be created with laser drilling," said Matt Nipper, director of product development for Laser Light Technologies. "Very small, complex features can be produced in a variety of materials, with methods such as direct write, trepanning, and mask projection, with no heat effects or material damage."

## 5. Laser Cutting

Similar to laser drilling, laser cutting relies on a focused laser beam to ablate material, straight cut, or cut patterns, to very precise depths in the material or component. Ultrafast lasers are typically used for various types of metals and polymers because they cut clean edges and do not create heat-affected zones. Lasers can cut a wide variety of materials, including aluminum, titanium, and steel, with micron-level tolerances.

## 6. Laser Welding

This process is especially effective for products with complex geometries or dissimilar materials that are difficult to join together. Depending on product, laser welding can be the best joining process compared to gluing or soldering, especially for connecting metals and plastics. It also creates strong, high-precision welds that can be as small as 0.004 inches and provide repeatable quality.

### 7. Wire Stripping

Wire stripping removes sections of insulation or shielding from wires and cables to provide electrical contact points and make the wire ready for termination. "Laser wire stripping is a fast process that provides excellent precision and process control and eliminates contact with the wire, allowing for the processing of delicate wire gauges greater than 32 AWG," said Nipper. "Insulation can be removed to within a 0.005-inch tolerance. Stripping can be programmed to ablate insulation at any point along the wire, enabling high-precision mid-span removals."

# Lasers in Medicine

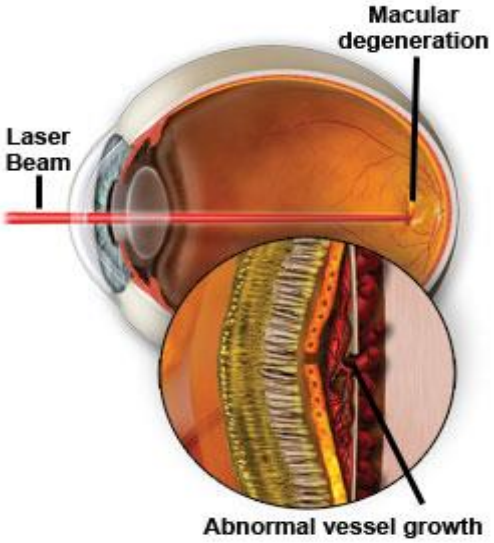
It has only been since the invention of the laser 50 years ago, that the potential of light in medicine has really been revealed.The special properties of lasers make them much better than sunlight or other light sources at targeting medical applications. Each laser operates within a very narrow wavelength range and the light emitted is coherent. They can also be very powerful. The beams can be focused to a very small point, giving them a high power density. These properties have led to lasers being used in many areas of medical diagnosis and treatment.

### Lasers repair skin and eyes

Lasers are now widely used in dermatology for things like tumor, tattoo, hair, and birthmark removal. The use of lasers for vision correction and a wide variety of ophthalmology applications grew after Charles J. Campbell in 1961 became the first physician to use a ruby laser to treat a human patient with a detached retina.

Later, ophthalmologists used argon lasers (which emit green-wavelength light) to treat detached retinas. This application uses the properties of the

eye itself—specifically the lens—to focus the laser beam onto the area where the retina has become detached. The highly-localized power from the laser causes the retina to reattach.



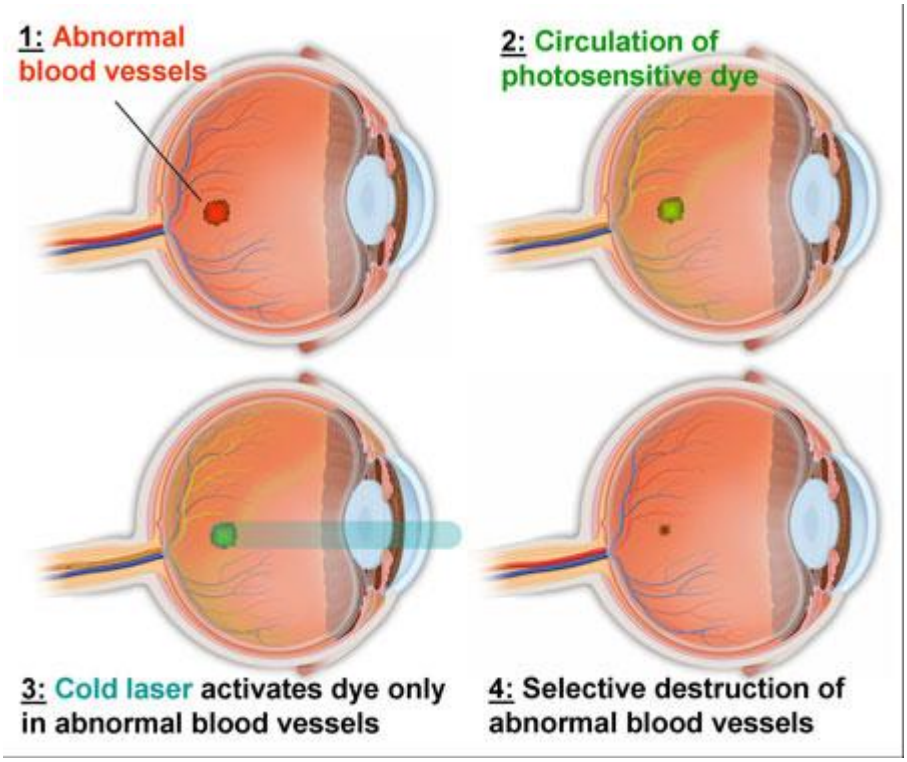

## Profitable cosmetic surgery

Such technology developments are inevitably popular with commercial investors due to the huge revenue potential. The analyst firm Medtech Insight estimated in 2008 that the market for energy-based aesthetic devices would be worth more than $1 billion by 2011.

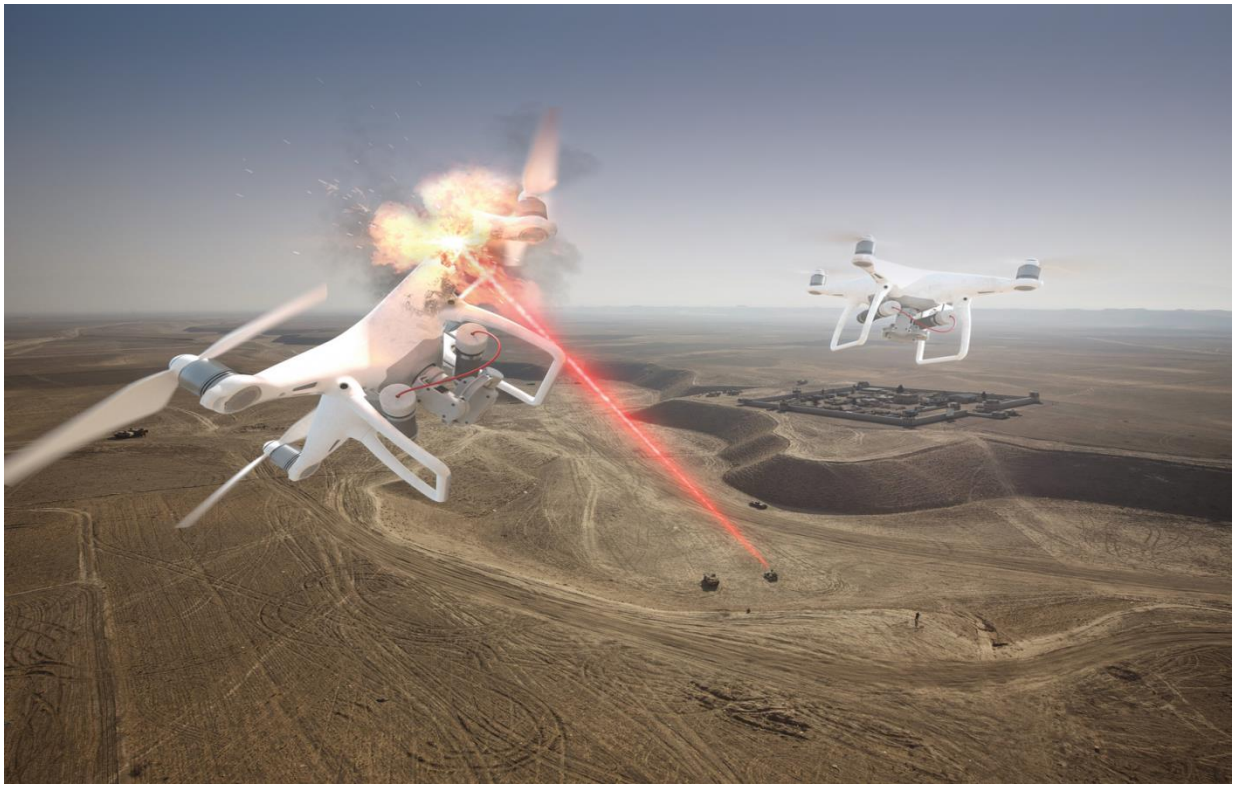
## Laser imaging and diagnosis

Lasers have a major role to play in the early detection of cancer as well as many other diseases. For example,a group is looking at infrared spectroscopy using IR lasers. This is interesting because cancer and healthy tissue may have different transmissions in the IR range. One promising application of the technique is to measure melanomas. With skin cancers, early detection is very important for the patients' survival rates. Currently melanoma detection is done by eye, so relies on the skill of the physician.

Laser-based systems are also starting to replace the x-rays traditionally used in mammography. Using x-rays poses a challenge: high intensities are needed to be able to detect cancers well, but as the intensity of the x-ray is raised, so is the risk of the x-ray itself causing cancer. The alternative being studied is to use very fast laser pulses to image breasts as well as other parts of the body such as the brain.



# Lasers in military



Since the first laser was demonstrated in 1960, there has been speculation about and growing interest in using the technology as a weapon,

With sufficient resources, the chemical lasers of the time could generate enough power to damage a target, but only could be carried by the largest available platforms and, needing replenishment of the chemicals used, could only be fired for a limited time before returning to base.

## Protecting ships

."The Navy in recent years has leveraged significant advancements in industrial and decades of research and development work on military lasers done by other parts to make substantial progress toward deploying on Navy surface ships. Navy surface ships would use s initially for jamming or confusing (i.e., "dazzling") intelligence, surveillance and reconnaissance sensors, for countering small boats and potentially in the future for countering enemy missiles, as well," the report said.

Navy ships would generally be short-range defensive weapons — they would generally counter targets at ranges of about one mile to perhaps eventually a few miles. In addition to a low marginal cost per shot and deep magazine, potential advantages of shipboard lasers include fast engagement times, an ability to counter radically maneuvering missiles, an ability to conduct precision engagements and an ability to use lasers for graduated responses ranging from detecting and monitoring targets to causing disabling damage."

# Battlefield lasers

“The fact that it’s a laser weapon allows you to put energy on target at the speed of light. It can be an instantaneous heating event.

The advantage of the laser is that we have the ability to have an unlimited magazine when it comes to unmanned aerial systems, as well as rockets, artillery, mortars. Special Operations also has a strong interest in laser weapons, as demonstrated by the Air Force.The goal is to provide an armed overwatch capability using directed energy.The testing of that and the integration work that is ongoing is all proceeding at pace. We haven’t seen anything up to this point that would lead us to believe that is not all achievable in the near-term time horizon that we’re working against.

Fielding a fully operational laser weapon would require advances across a complex range of technologies, many of which are ready — or nearly so — for deployment. But the first generation of such weapons will go to the warfighter with demands for greater and greater capability.

# 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.