AL- Mustaqpal University
Science College
Dep. Medical physics

Medical physics
Third Stage

Lec 2
Properties 0f Laser

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Laser can be defined as follows :

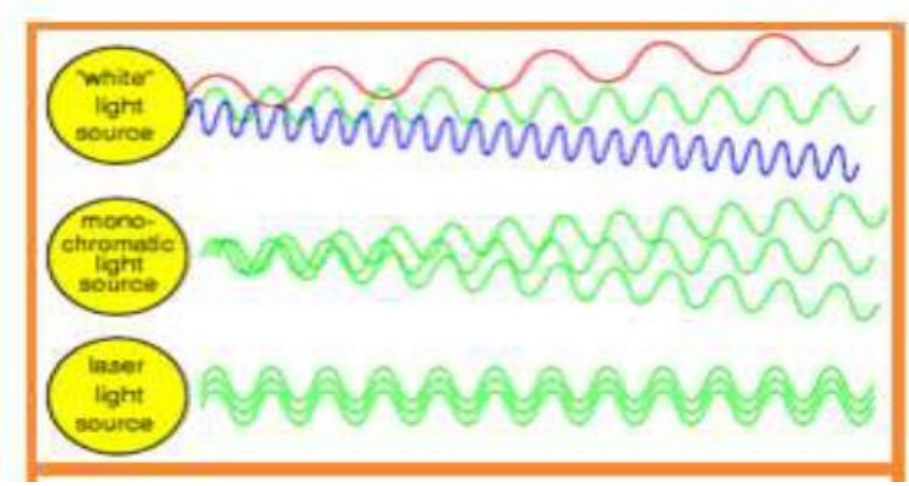
" Light Amplification by Stimulated Emission of Radiation ".

The laser light exhibits some peculiar properties compared with the conventional light which make it unique. The broad applications of lasers are made possible by their unique properties which distinguishes them from all other light sources.
A laser emits a beam of electromagnetic radiation that is always monochromatic, collimated and coherent in natur . Lasers consist of three main components:
a lasing medium (solid, liquid or gas), a stimulating energy source (pump) and an optical resonator.

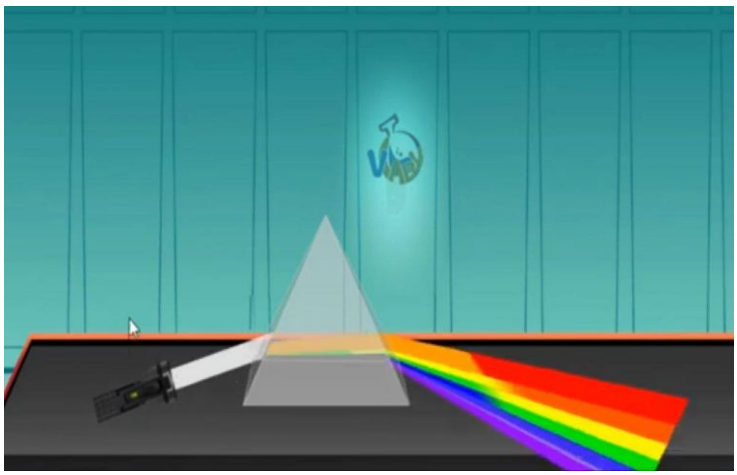
There are many uses for lasers, some of them beneficial to humanity and some dangerous, This depends on the type of laser and its intensity. It is imperative to be aware of the risks associated with laser use in terms of tissue damage (burns and eye injuries) and fire hazards. Therefore, a person must be fully familiar with the laser before working with it.

Properties 0f Laser :

1 - **Monochromatic :** Monochromatic light is a light containing a single colour or wavelength. The light emitted from a laser is monochromatic, it is of one wavelength (one color). The light emitted from ordinary light sources have different energies, frequencies, wavelengths, or colors.

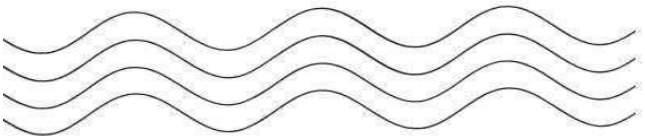


Like white light is a combination of many different wavelengths (different colors). Therefore, when white light passes through a prism, it decomposes into seven colors. But laser light has a single wavelength or colour.

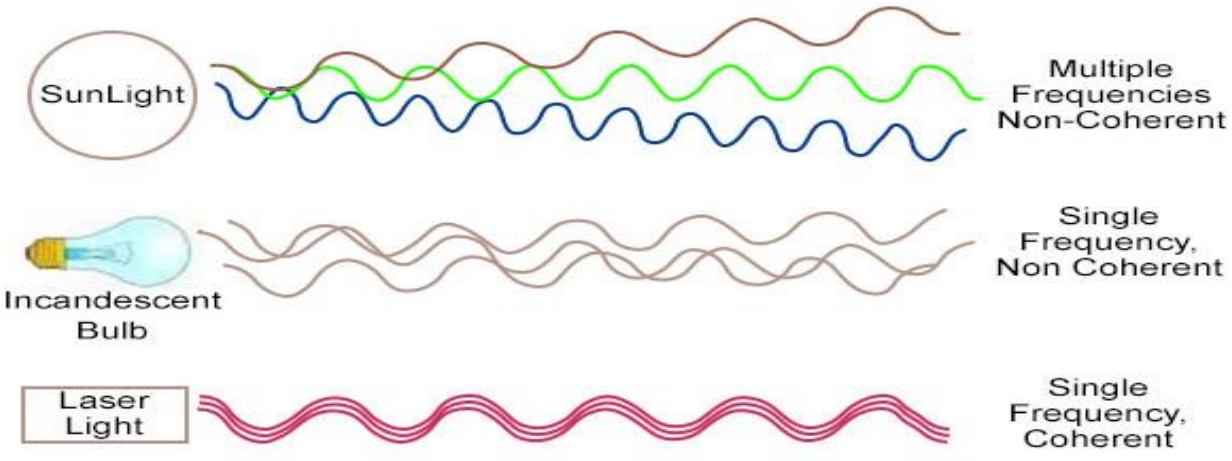


Laser light covers a very narrow range of frequencies or wavelengths. This can be due to the stimulated characteristics of laser light. The bandwidth of the conventional monochromatic light source is **100 nm**. But the bandwidth of an ordinary light source is **1 nm** . For a highly sensitive laser source it is **10^{-9} nm** .

2 - **Coherence :** A predictable correlation of the amplitude and phase at any one point with another point is called coherence . That means if two or more waves of same frequency and in the same phase or have constant phase difference then these waves are said to be coherent in nature. In the case of conventional light, the property of coherence exhibits between a source and its virtual source whereas in the case of laser the property coherence exists between any two or more light waves. So, when two or more LASER radiations can make regular interference each other, therefor LASER radiation has a coherency.



Coherent Light Waves



3 - Directionality : The light beam coming from an ordinary light source travels in all directions, but laser light travels in a single direction. 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. Laser light is emitted as a relatively narrow beam in a specific direction For example, the light emitted from torchlight spreads 1km distance it spreads 1 km distance. But the laser light spreads a few centimeters distance even it travels lacks kilometer distance. The directivity depends on the angle of divergence.

The directionality of the laser beam is expressed in terms of divergence

$$\Delta\theta = \frac{r_2 - r_1}{D_2 - D_1}$$

Where r_1 and r_2 are the radius of laser beam spots at distances of D_1 and D_2 respectively from the laser source.

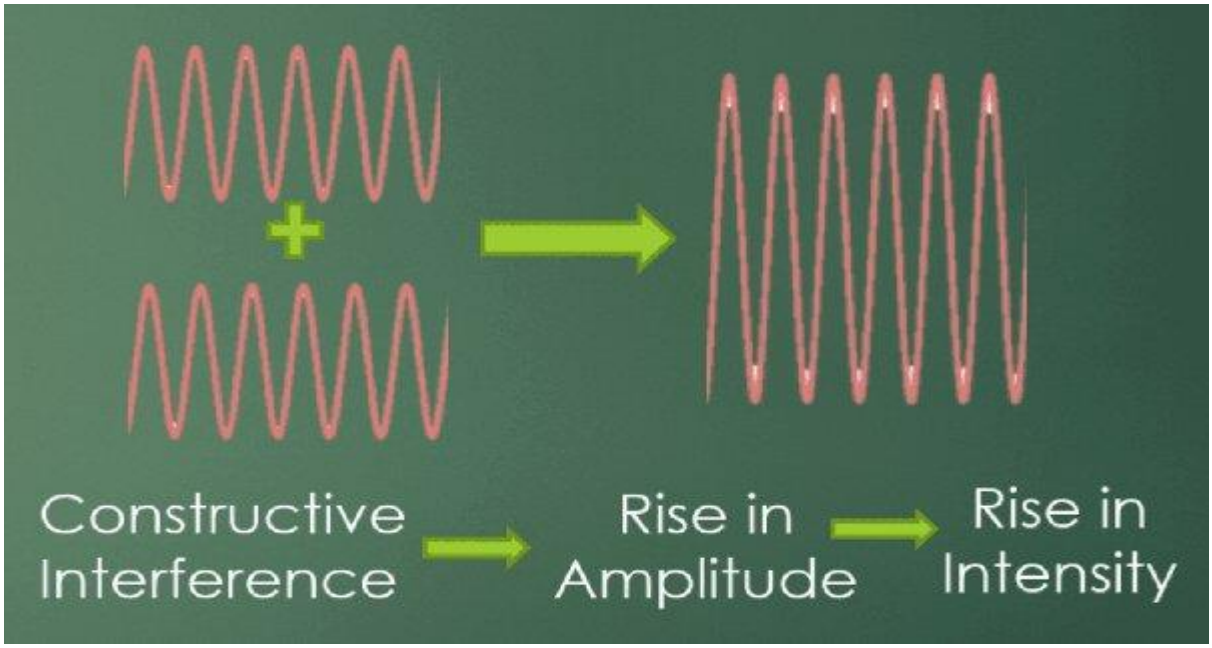
4. Highly Intense or Brightness

Laser light is highly intense than conventional light. We know that the intensity of a wave is the energy per unit time flowing through a specific area. Because laser light is: Monochromatic - It contains only one specific wavelength and hence one color. Coherent - The motion of all photons is coordinated. Directional - The laser beam is very narrow, concentrated and therefore, it is a

high intensity source. A one mill watt He-Ne laser is more intense than the sun intensity. This is because of the coherence and directionality of the laser.

Suppose when two photons each of amplitude **a** are in phase with another, then young's principle of superposition, the resultant amplitude of two photons is **2a** and the intensity is $\mathbf{4a^2}$. Since in laser many numbers of photons are in phase with each other, the amplitude of the resulting wave becomes **na** and hence the intensity of the laser is proportional to $\mathbf{n^2a^2}$. So the 1mW He-Ne laser is more intense than the sun.

The intensity of light falling on a surface, depends on the intensity of the source and on how far the light spreads after leaving the source.



Discussion

1**. What** is the characteristic of monochromatic light ?
a) Having multiple wavelengths
b) Having a single wavelength or color
c) Having a narrow range of frequencies
d) Having a high intensity
E) None of the above

2. **What** is the typical bandwidth of an ordinary light source ?
a) 1 nm
b) 10 nm
c) 100 nm
d) 1 μm
E) None of the above

3. **What** is coherence in relation to light waves ?
a) A predictable correlation of amplitude and phase
b) A random correlation of amplitude and phase
c) A constant phase difference between waves
d) A changing frequency between waves
E) None of the above

4. **Why** is a 1 milliwatt He-Ne laser more intense than the sun ?
a) Due to its high frequency
b) Due to its coherence and directionality
c) Due to its high wavelength
d) Due to its low intensity
E) None of the above

5. **What** happens when two or more LASER radiations interact with each other ?
a) They cancel each other out
b) They make regular interference with each other
c) They change color
d) They change frequency
E) None of the above

6. **What** is a characteristic of laser light ?
a) It has a wide range of frequencies
b) It has a narrow range of frequencies
c) It has multiple wavelengths
d) It has a low intensity
E) None of the above

7. **What** determines the intensity of light falling on a surface ?
a) Only the intensity of the source
b) Only how far the light spreads after leaving the source
c) Both the intensity of the source and how far the light spreads
d) Neither the intensity of the source nor how far the light spreads
E) None of the above

8. **What** is the result of superposition of two photons in phase with each other ?
a) The amplitude of the resulting wave becomes a/2
b) The amplitude of the resulting wave becomes 2a
c) The amplitude of the resulting wave becomes na
d) The amplitude of the resulting wave becomes 0
E) None of the above

9. **Why** does laser light have a high intensity ?
a) Because it has a high frequency
b) Because it has a high wavelength
c) Because many photons are in phase with each other
d) Because it has a low intensity
E) None of the above

10. **What** is the characteristic of ordinary light sources?
a) They have a single wavelength or color
b) They have a narrow range of frequencies
c) They have different energies, frequencies, wavelengths, or colors
d) They have a high intensity
E) None of the above