Al-Mustaqbal University
Department of Medical Physics
Laser Basics
Third Stage

كلية المستقبل الجامعة
قسم الفيزياء الطبية
اساسيات الليزر
المرحلة الثالثة

Laser Basics

المحاضرة الثانية

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Electromagnetic Waves

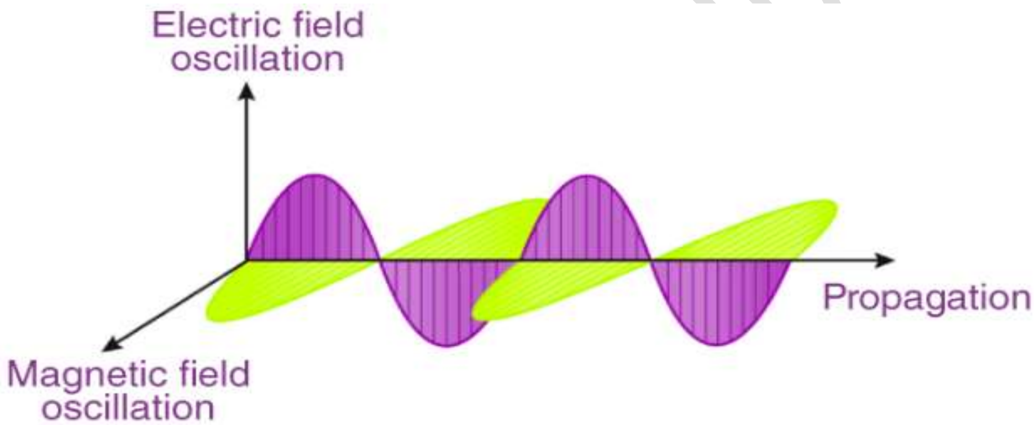
Electromagnetic waves or EM waves are waves that are created as a result of vibrations between an electric field and a magnetic field. In other words, EM waves are composed of oscillating magnetic.

Description

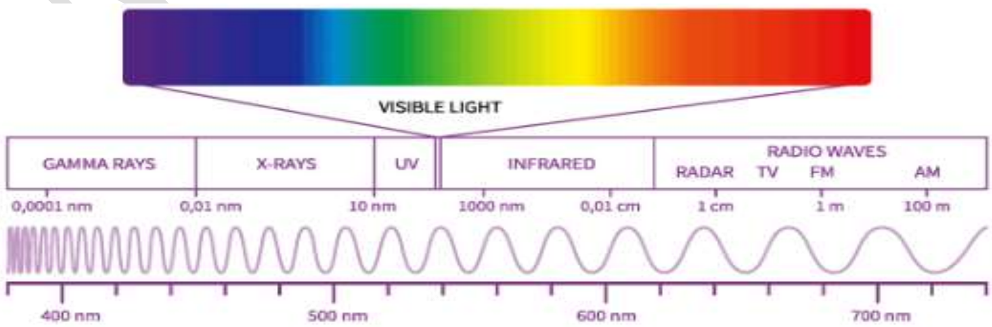
Electromagnetic waves are formed when an electric field comes in contact with a magnetic field. They are hence known as 'electromagnetic' waves. The electric field and magnetic field of an electromagnetic wave are perpendicular (at right angles) to each other. They are also perpendicular to the direction of the EM wave.

EM waves travel with a constant velocity of 3.00 x 10^8 ms^{-1} in vacuum. They are deflected neither by the electric field, nor by the magnetic field. However, they are capable of showing interference or diffraction. An electromagnetic wave can travel through anything - be it air, a solid material or vacuum. It does not need a medium to propagate or travel from one place to another. Mechanical waves (like sound waves or water waves), on the other hand, need a medium to travel. EM waves are 'transverse' waves. This means that they are measured by their amplitude (height) and wavelength (distance between the highest/lowest points of two consecutive waves).

the electromagnetic field is produced by an accelerating charged particle. Electromagnetic waves are nothing but electric and magnetic fields travelling through free space with the speed of light c. An accelerating charged particle is when the charged particle oscillates about an equilibrium position. If the frequency of oscillation of the charged particle is f, then it produces an electromagnetic wave with frequency f. The wavelength λ of this wave is given by $\lambda = c/f$. Electromagnetic waves transfer energy through space.



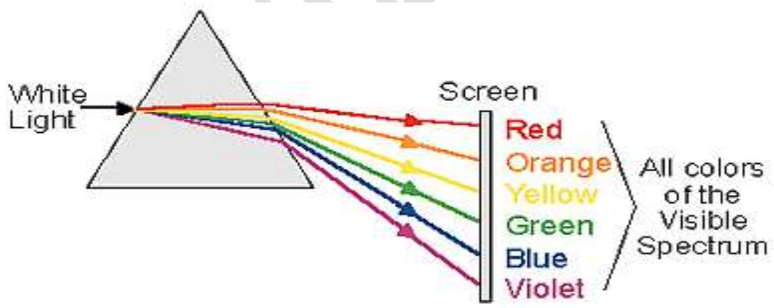
Electromagnetic Spectrum



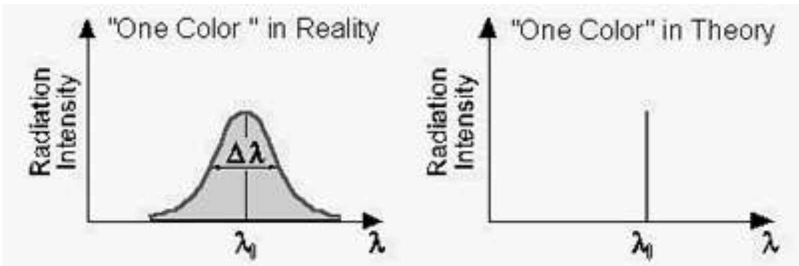
Properties of laser

Monochromatic:

The light emitted from a laser is monochromatic, that is, it is of one wavelength (color). In contrast, ordinary white light is a combination of many different wavelengths (colors).When "white light" is transmitted through a prism, it is divided into the different colors which are in it.(Figure1-a) and LASER radiation does not have all those color, because it has only one same wavelength and phase. And Mono-chromaticity also means that LASER has a high intensity of the light within the very small wavelength. So it can have a high energetic level in microscopic region. (Figure 1-b) Actually, the temperature of the Laser radiation is higher than Sun. (more than 6000K)



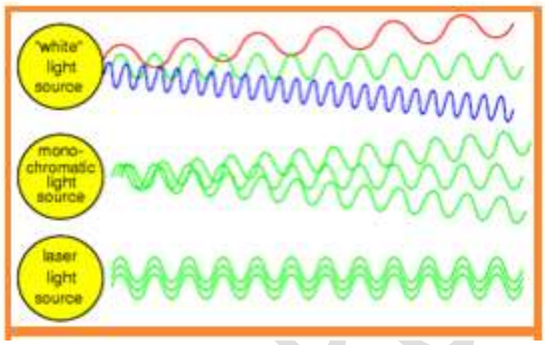
(Figure1-a)



(Figure 1-b)

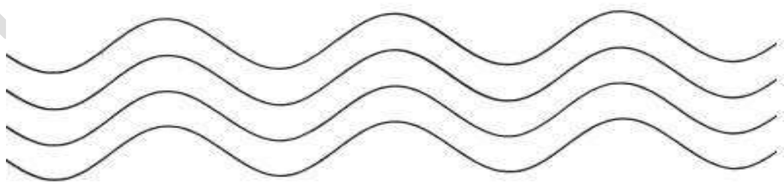
Directional:

Lasers emit light that is highly directional. Laser light is emitted as a relatively narrow beam in a specific direction , The directivity depends on the angle of divergence . Ordinary light, such as coming from the sun, a light bulb, or a candle, is emitted in many directions away from the source.



Coherent:

LASER radiation is composed of waves at the same wavelength, which start at the same time and keep their relative phase as they advance. So, when two or more LASER radiations can make regular interference each other, LASER radiation has a coherency.



Coherent Light Waves

There are two types of coherence:

1- spatial coherence: refers to whether there are irregularities in the optical phase in a cross-sectional of the laser.

2- temporal coherence: refers to the time duration over which the phase of the beam is well defined.

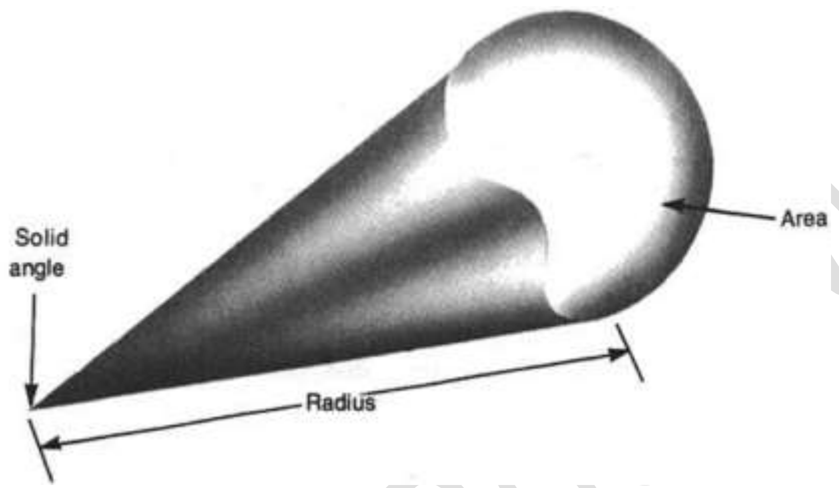
The temporal coherence time (τ_c) is given by the reciprocal of the spectral line width Δv, the coherence length (ζ_c) is given by

$$\zeta_c = c\ \tau_c = c\ 1/\Delta v$$

Ordinary light is not coherent because it comes from independent atoms which emit on time scales of about 10^{-8} seconds. There is a degree of coherence in sources like the mercury green line and some other useful spectral sources, but their coherence does not approach that of a laser.

Brightness:

When you say that one light source is brighter than another, you mean that the brighter source creates a greater intensity on the surface of your retina when you look at the source. The intensity on this surface depends on the intensity of the source and the extent to which the light spreads out after it leaves the source. The faster light spreads out, the less reaches your eye. This spreading out of the light is called the divergence of the source, and it can be measured in terms of the solid angle formed by the light leaving the source. the magnitude of a solid angle is measured in steradians.



The brightness of an optical source is defined as the source's intensity divided by the solid angle of its divergence

$$\mathbf{B = P/A\ \Omega}$$

in which

P is the power of the source

A is its cross-sectional area

Ω is solid angle steradians

Note that, because steradians are dimensionless, the dimensions of brightness are watts per square meter. the same dimensions as for intensity. But brightness is different from intensity because the intensity of a source doesn't depend on its divergence.

The combination of these properties gives the laser radiation many advantages, like achieving very high power densities, not available from other sources.