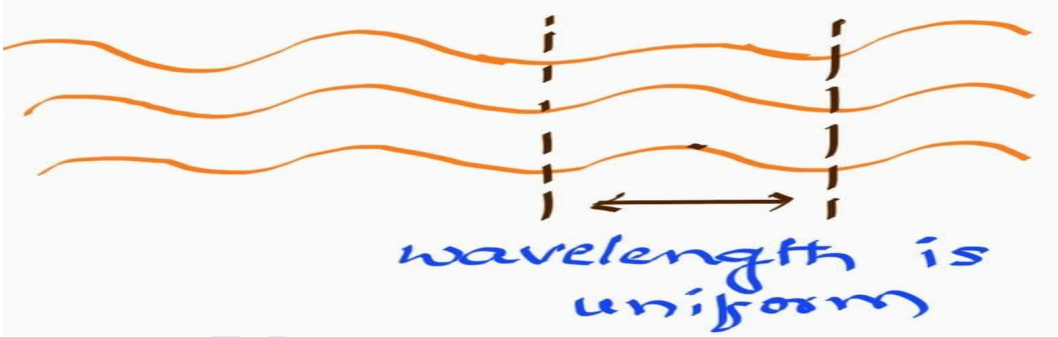
LASER BEAM CHARACTERISTICS

- The important characteristics of laser beams are:
    1. High monochromaticity
    2. High directionality
    3. High intensity
    4. High coherence
    5. Negligible divergence

1. High monochromaticity:

- A monochromaticity is a property of light containing a single wavelength(s)/frequency/colour of light, unlike white light which contains multiple wavelengths.



- The laser light is more monochromatic than that of a conventional light source. This may be due to stimulated characteristics of the laser.
- The bandwidth of the conventional monochromatic light source is 1000 Å. But the bandwidth of an ordinary light source is 10^4 Å.
- The light source from a laser is highly monochromatic and contains a very narrow range i.e., less than 10 Å.

2. High directionality:

- A conventional light source emits light in all directions. On the other hand, lasers emit light only in one direction.

- The width of the laser beam is extremely narrow and hence a laser beam can travel to long distances without spreading.
- Illustration with label: directionality without spreading
- A cylindrical resonant cavity is used in lasers for producing light in one direction.

3. High Intensity:

- We know that the intensity of a wave is the energy per unit time flowing through a specific area.
- The laser light is more intense than conventional light because laser light is concentrated into a small, focused beam, it can deliver a lot of energy over a small area.This is why lasers can cut, burn, or be used in surgery

  Example: 1 milliwatt He-Ne Laser is more intense than the sun intensity.
- In a laser, many no. of photons are in phase with each other, the amplitude of resulting wave becomes "nA"

- Intensity of Laser $\propto n^2A^2$

  Where:

  A → amplitude

  n → no. of photons

4. High Coherence:

- A predictable correlation of the amplitude and phase at any point with another point is called coherence. That means, if two or more waves of the same frequency are in the same phase (constant phase difference), then these waves are said to be coherent in nature.
- In case of conventional light, the property of coherence exists between a source and its virtual source. Whereas, in the case of lasers, the property of coherence exists between

any two sources of the same phase.

- There are two types of coherence. They are:

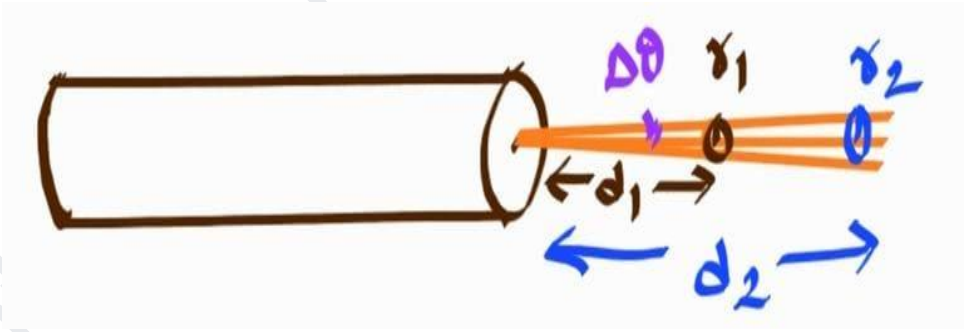
(i) **Temporal coherence** → exists between one point and another on the same wave train.

(ii) **Spatial coherence** → exists between one point and another on different wave trains.

5. Negligible Divergence:

- Light from a laser propagates in the form of plane waves instead of spherical waves and the light beam remains essentially as a bundle of parallel rays, hence negligible divergence. The directionality of laser beam is expressed in terms of divergence, i.e.

$$\Delta\theta=(r_2- r_1) / (d_2 - d_1)$$



Where: r_1, r_2 are radii of laser beam spots at distances of d_1, d_2 respectively from laser source.

Example: A typical value of divergence of a He-Ne laser is 10^{-3} radians.