Laser And Its Applications

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What does the word laser stand for?

L -Light
A -Amplification by
S - Stimulated
E -Emission
R –Radiation

Light Amplification by Stimulated Emission of Radiation

Basic Concepts:

- Laser is a highly monochromatic, coherent narrow beam of light

- Laser apparatus is a device which emits highly coherent, monochromatic light with high power density and directionality.

The first laser device was built by Maiman in 1960.

COHERENCE :

Coherence is a measure of the correlation between the phases measured at different points or at different times on a wave. It is very essential for lasing action

There are two types of coherence:

i. Temporal coherence
ii. Spatial coherence.

TEMPORAL COHERENCE

The correlation of the wave fields at different instant of time at one location is Temporal coherence.

If at any fixed point, the amplitude of the wave remains constant and phase varies linearly with time, then the wave field is said to be temporally coherent.

The longest time period for which the phase and amplitude of an wave remains constant at a space point is called coherence time.

So coherence time, $\Delta t = \tau_c$

Therefore the coherence length

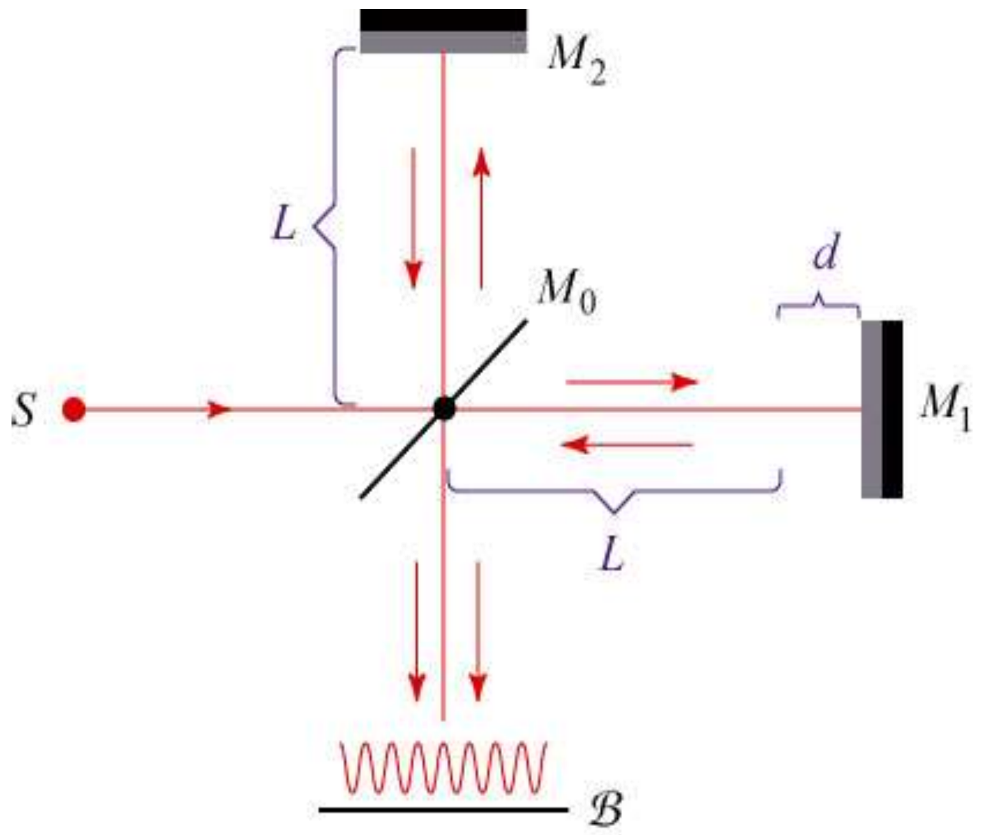
$$L_c = \text{speed of the wave} \times \tau_c$$

In interference phenomenon,

if the path difference >coherence length L_c

then no interference pattern is observed.

Temporal coherence can be explained nicely by Michelson Morley experiment



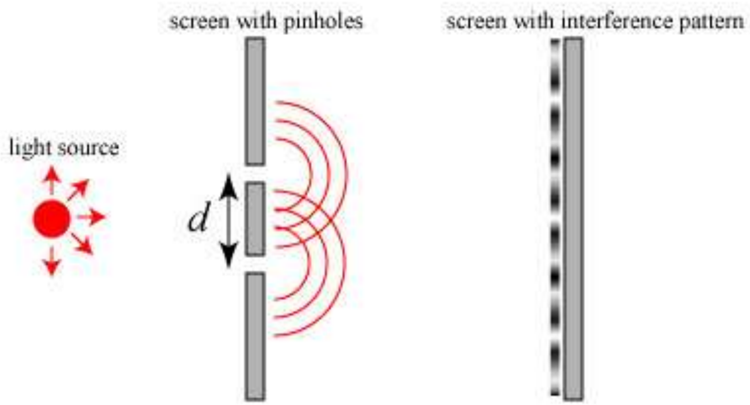
Temporal coherence in Michelson interferometer

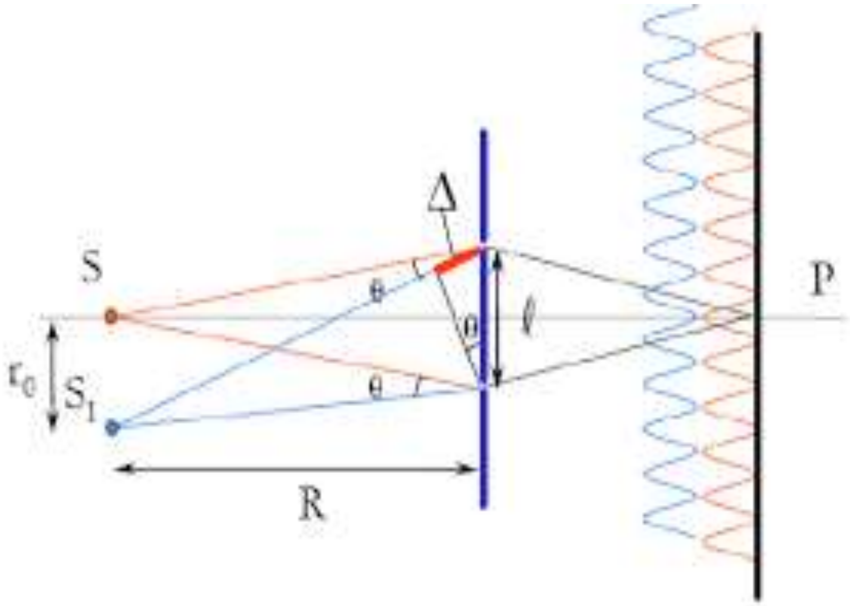
Spatial coherence:

Spatial coherence is the phase relationship between two space points in a particular instant of time. If the wave has only one value of amplitude over an infinite length then the wave is perfectly spatially coherent.

When the shape of a source is gradually increased then lateral dimension of the source over which the radiation remains coherent determines the spatial coherence.

Young's double slit experiment





Spatial coherence

In above figure S and S1 are two sources separated by a distance ro. The two light waves coming from S meets the central point with zero phase difference but light waves from S1 meets central point with a phase difference. If this phase difference is equal to λ/2, then there will be dark fringe for the source S1, so we get general illumination at point P.

Mathematically it can be shown that ro=λR/2 l. If we have an extended source of linear dimension λR/ l, then no interference pattern will be obtained. Good interference pattern will be obtained onl when

$$ro \ll \lambda R / l$$

$$l \ll \lambda R / ro$$

$$l \ll \lambda / \Theta \qquad \text{where } \Theta = R/ro$$

If the distance between the holes increases the interference fringes decreases. lw = λ/Ɵ is the lateral distance over which the beam is spatially coherent and is called as lateral coherence width.

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