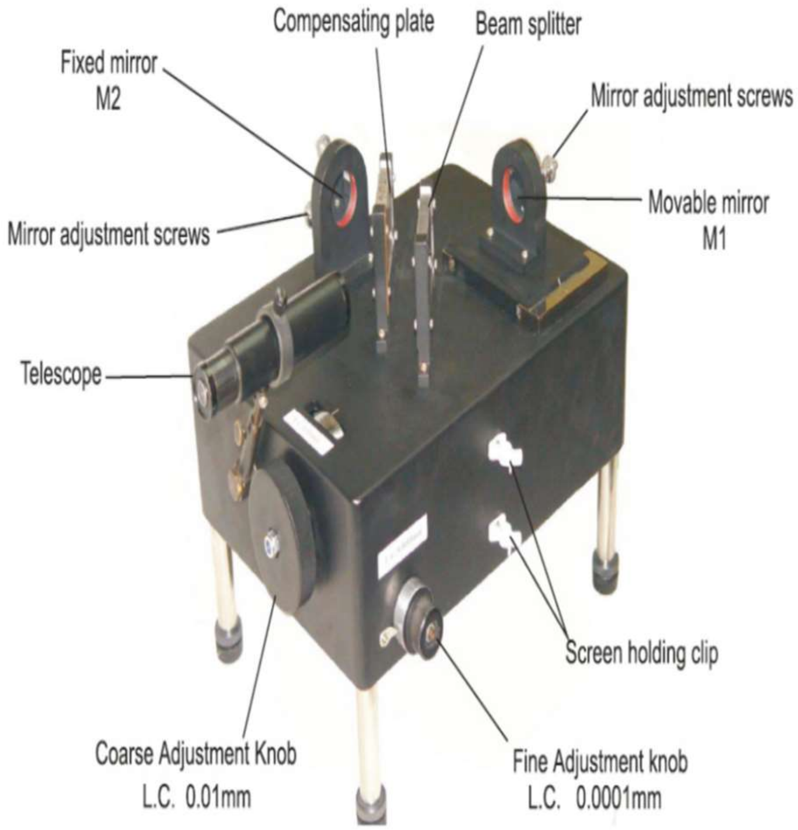
Michelson interferometer

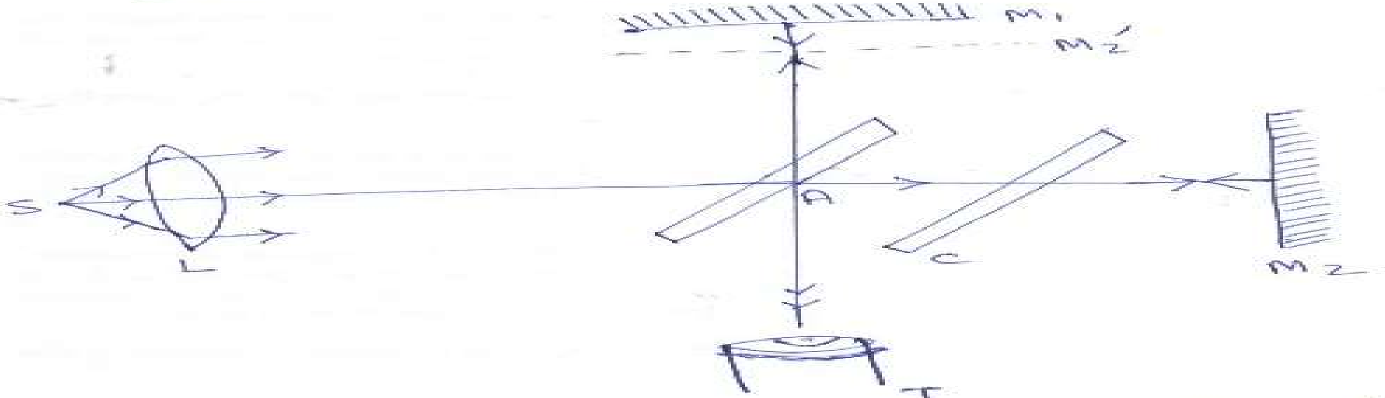
- The instruments based upon the principle of interference are called interferometers.
- These are basic optical tools used to precisely measure wavelength, distance, index of refraction, and temporal coherence of optical beams etc.
- It is an amplitude-splitting interferometers devised by Albert Michelson in 1890, the first American physicist to receive the Nobel Prize (1907 for work in optics).
- Michelson and Morley used this interferometer in their celebrated series of experiments designed to demonstrate the existence of the ether.



Michelson interferometer is an arrangement was designed to test ether-hypothesis of Michelson-Morley experiment.

It is used to find wavelength of light, fine structure of spectral lines and some other measurements based on the phenomenon of interference of light.

It uses two-beam interference.
Two beams in the Michelson interferometer travel along widely separated paths.



M_1 and M_2 are two optically plane mirrors highly silvered on front surface.
A and C are two plane parallel glass plates of equal thickness.
The rear side of A is half-silvered.

M_2 is fixed and M_1 can moved accurately by a calibrated screw.

S is a source of monochromatic light.

L acts as an extended source. This serves to increase the intensity of the fringe pattern.

A is a beam splitter tilted at an angle of 45° to incoming beam. The light is divided into two parts of equal amplitude.

The two beams emerging from the beam splitter travel perpendicular to each other.

Transmitted beams strikes a fully silvered mirror M_2 and retraces its path to the beam splitter A.

Reflected beams proceeds towards M_1 and retraces its path to the beam splitter.

As these two beams are coherent, they produce interference fringes.

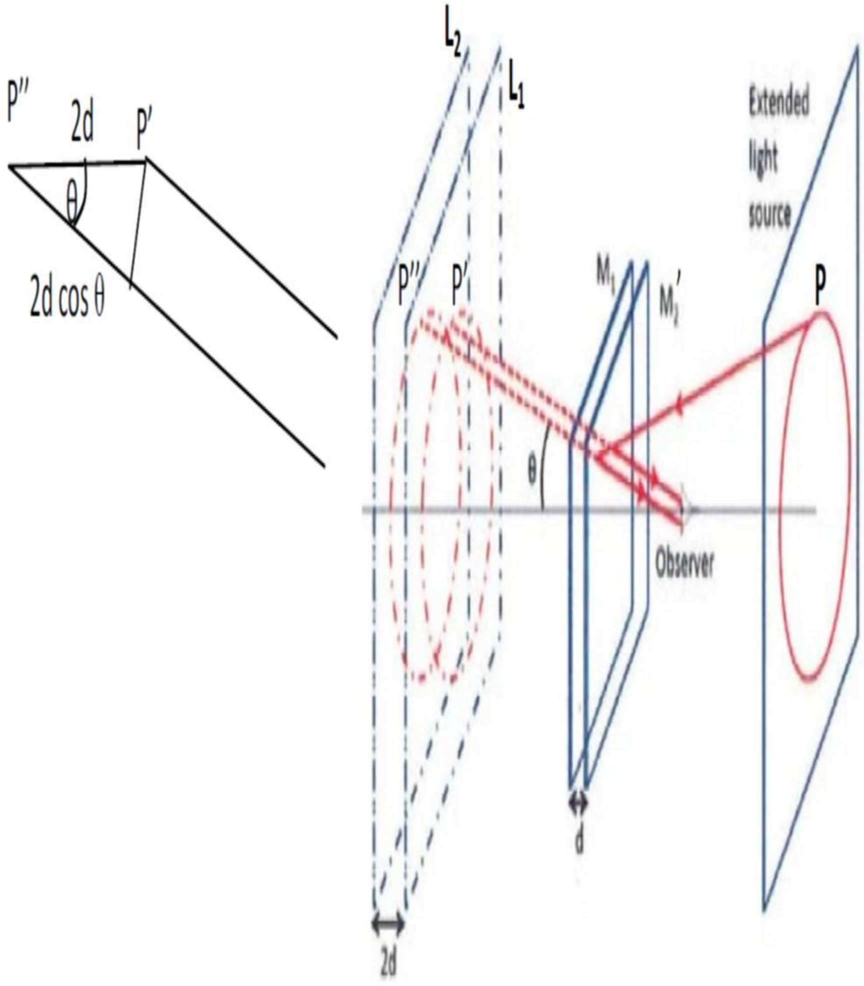
A telescope T is so arranged to see fringes.

If M_1 and M_2 are equidistant from the beam splitter, the two beams would not have travelled the same optical path, because the beam that strikes and return from M_1 travels an additional path length equal to twice the width of the beam splitter.

To compensate for this extra path, an unsilvered compensating plate C made of the same glass as the beam splitter is introduced in the path of the first beam.

Telescope focussed to infinity, a set of bright and dark rings would be seen in the field of view.

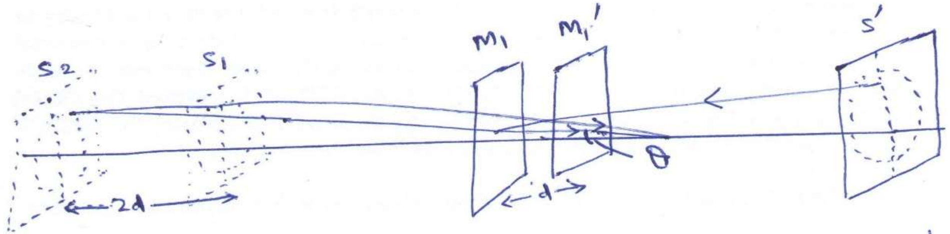
If one of the mirrors is moved towards or away from the beam splitter, rings emerge from or collapse at the centre of the field of view.



Concentric circular fringes are obtained when the air film is parallel as shown in Fig. 2. M_2' is the virtual image of M_2 and it is parallel to M_1. For simplicity, light source L is at the observer's position. L_1 and L_2 are the virtual images of L formed by M_1 and M_2', and are coherent. Let *d* be the distance between M_1 and M_2', therefore the distance between L_1 and L_2 is 2*d*. Let θ be the angle between the incident beam originated at P and the reflected beams from M_1 and M_2'. Then path difference between light beams from points P' and P'' is $2d\cos\theta$. A maximum (bright fringe) will be formed when $2d\cos\theta = n\lambda$. For a fixed value of n, λ and *d*, the value of θ is a constant, and the contour of the maximum point becomes a ring. The centre of the ring is in line with the observer and perpendicular to the mirror plane. Each circular ring corresponds to a particular value of θ. Hence the fringes are known as **fringes of equal inclination**.

If two mirrors M_1 and M_2 are perfectly vertical and exactly perpendicular to each other, beam splitter A is at an angle 45° with incident beam, image M_2' will be parallel to M_1.

Concentric circular fringes will be formed.



The total path difference between the two beams is $2d\cos\theta = n\lambda$

where θ is the angle of inclination of the reflected beam with normal. 2d is the distance between two effective source S_2 and S_1.

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- When the two mirrors are tilted, they are not exactly perpendicular to each other and therefore, virtual image M_2' is not parallel to M_1.
- Air path between them is wedge-shaped and the fringes appear to be straight.
- Instead of a monochromatic light source, if a white light is used, a few colored fringes with a central dark fringe can be observed. It can be used to determine the wave length of light from a monochromatic source.
- Among other interesting demonstrations that can be performed using the unit in the form of a Michelson Interferometer are:

1. Accurate measurement of small changes in length
2. Measurement of refractive indices of gases and transparent solids
3. Accurate comparison of wavelengths. Etc.