* Describe Michelson Morley experiment and discuss its consequences. Discuss the significance of negative or null results.

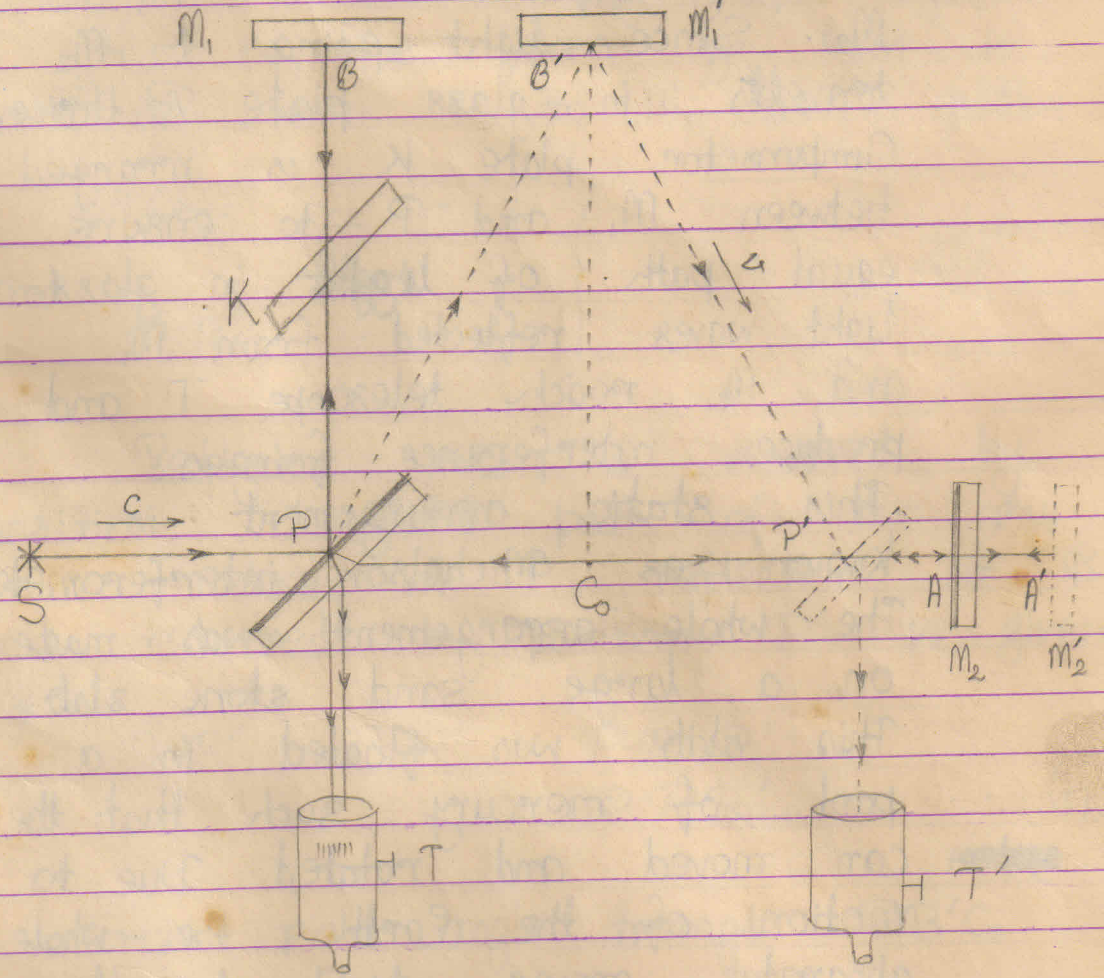

Figure-1 Schematic Michelson Morley Experiment

The schematic arrangement of instrument in the famous Michelson-Morley experiment is shown in figure 1. Glass plates P and K are plane and parallel. These are two halves of the same plate. P has it's upper face fifty persent silvered while K is unsilvered. Mirrors M_1 and M_2 are front silvered. Their reflecting faces are equidistant from silvered face of P such that light from source S ~~[illegible]~~ incident at P travels equal distance in reflecting from mirror M_1 and M_2. Since light going to M_2 travels in glass plate P thrice, Cumpunsetor plate K is arranged between M_1 and P to ensure equal path of ~~light~~ in glass. Light waves reflected from M_1 and M_2 reach telescope T and produce interference fringes. This static arrangement is known as Michelson interferometer. The whole arrangement was made on a large sand stone slab. This slab was floated in a pool of mercury, such that the system ~~system~~ can moved and rotated. Due to motion of the Earth, the whole apparatus moves. Light travelling from P to M_1 and back to T will have different time than that travelling from P to M_2 and back to T.

If v = velocity of the Earth, then, we can have a time difference. Symultaneously the system is ~~moved~~ moving with the Earth in static aether. Mirror M_1 goes to M_1', plate P goes to P', M_2 goes to M_2'. Similar reflection conditions are obeyed.

Calculation is as follows:—

In the experimental arrangement let path $PA = PB = d$

v = velocity of the Earth

c = velocity of light.

If t = time taken by light in travelling from P to M_1, then path

$$\left.\begin{array}{l} PB' = ct \\ \text{and} \\ BB' = vt \end{array}\right\} \quad \ldots\ldots\ldots\ldots \text{(i)}$$

Reflected ray is received by position P'. Total path of this ray from incidence at P, reflection at B' and returned to position P' is given by,

$$PB' + B'P' = PB'P'$$
$$= 2PB' \quad \ldots\ldots\ldots \text{(ii)}$$

From right angled triangle $PB'C_0$ we have,

$$(PB')^2 = (PC_0)^2 + (C_0B')^2$$

or, $$c^2t^2 = v^2t^2 + d^2 \quad \ldots\ldots\ldots \text{(iii)}$$

[Since $PB = C_0B' = d$]

This gives,

$$t = \frac{d}{\sqrt{c^2 - v^2}}$$

or,

$$t = \frac{d}{(c^2 - v^2)^{1/2}} \quad \ldots\ldots\ldots\ldots \text{(iiia)}$$

let total time t_1, taken by light to travel whole path $PB'P'$ is double of this and the result is,

$$t_1 = 2t$$
$$= \frac{2d}{c}\left\{1 - \frac{v^2}{c^2}\right\}^{-1/2}$$
$$\simeq \frac{2d}{c}\left\{1 + \frac{v^2}{2c^2}\right\} \quad \cdots\cdots\cdots (iv)$$

where higher powers of v^2/c^2 have been neglected.

In the direction of the motion of the Earth, ray PA has velocity relative to the static aether and is given by $(c - v)$, at the time of return from M_2 relative velocity becomes $(c + v)$.

Distance $PA = d$

Time t_2 is the sum, given by

$$t_2 = \frac{d}{c - v} + \frac{d}{c + v}$$

[(c-v) for going and (c+v) for coming]

This gives

$$t_2 = \frac{2cd}{c^2 - v^2}$$
$$= \frac{2cd}{c^2\left(1 - \frac{v^2}{c^2}\right)}$$
$$= \frac{2d}{c}\left(1 - \frac{v^2}{c^2}\right)^{-1}$$

Binomial expansion of R.H.S. gives

$$t_2 \simeq \frac{2d}{c}\left\{1 + \frac{v^2}{c^2}\right\} \quad \cdots\cdots\cdots (v)$$

At the expense of

Inspection shows that $t_2 \neq t_1$

The time difference between paths of longitudinal and transverse rays is given by,

$$t_2 - t_1 = \frac{2d}{c}\left(1+\frac{v^2}{c^2}\right) - \frac{2d}{c}\left(1+\frac{v^2}{2c^2}\right)$$

$$= \frac{2d}{c}\left(\frac{v^2}{2c^2}\right)$$

$$\text{or, } t_2 - t_1 = \frac{v^2 d}{c^3} \quad \ldots\ldots\ldots\ldots\ldots \text{(vi)}$$

The path difference between the two rays in terms of wavelength unit is given by,

$$\delta = \frac{c\cdot(t_2 - t_1)}{\lambda} \text{ wavelength} \ldots\ldots \text{(vii)}$$

Substituting in this the value of $t_2 - t_1$ from equation (vi) we obtain,

$$\delta = \frac{v^2 d}{c^2 \lambda} \text{ wavelength} \ldots\ldots\ldots \text{(viii)}$$

This is the fringe shift due to the motion of the earth through static aether. If now the whole apparatus is rotated through 90°, such that mirrors M_1 and M_2 interchange their positions then the ray travelling longer path in the previous case will travel shorter path and vice-versa. Due to this the affect will be doubled and this time total displacement of fringes is equal to

$$\Delta = 2\delta = \frac{2v^2 d}{c^2 \lambda} \text{ wavelength} \quad \cdots\cdots (ix)$$

This is theoritical.

In Michelson-Morley experiment the value of d was 11 meters, light used was sodium yellow whose wave length $\lambda = 5900$ Å, velocity of the Earth $v = 30$ km/s, velocity of light $c = 3 \times 10^8$ m/s
By calculation,

$$\boxed{\Delta = 0.37 \text{ of a fringewidth}} \quad \cdots\cdots (x)$$

This displacement can easily be measured by the apparatus used.

By experiment it was found to be less than even $\frac{1}{20}$th of the value ~~eccepted by equation (x)~~ expected by equation (x).
By repeatations of the experiment, season after season and Year after Year the result was on the average $\frac{1}{40}$th of that given by equation (x).

This is known as '*null result*' or '*negative result*'.

Even this, negative result is not useless. It leads to two very important conclusions:

i) The motion of the earth

through an aether at rest can not be determined and

ii) The motion through aether can not be detected even by optical experiments performed within the reference system.