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DETECTING AND CORRECTING THE ERRONEOUS CONCEPTS IN THE ANALYSIS OF MICHELSON-MORLEY EXPERIMENT

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ABSTRACT

After detecting errors in the presentations of the path of rays of the historical Michelson Morley Experiment by various international authors, the present author has explained the true cause of the oblique path of rays in the diagrams of the experiment; the true explanation is given, both conceptually and mathematically.

Keywords: Michelson Morley Experiment, Mechanics, Path of Rays, Ray Diagram.

INTRODUCTION

The usual text books on special theory of relativity do not treat the theory and the ray diagrams of the historical Michelson Morley Experiment properly. Though two articles published in American Journal of Physics (Feb 1988 and Dec. 1989) had explained the true path and its reason. Even the Indian authors writing textbooks on Mechanics follow the erroneous treatments given by eminent international authors in their books. So it becomes necessary to rectify them.

A) What is wrong with the usual many alternative analyses of M-M Experiment: About 2 decades ago, it was found by the present author (Soni, 1988) that the text books of optics and special Relativity aiming to obtain the expected fringe shift under the classical assumption of luminiferous ether, were using erroneous concepts to explain the oblique path of rays in the transverse arm of the M-M experiment.

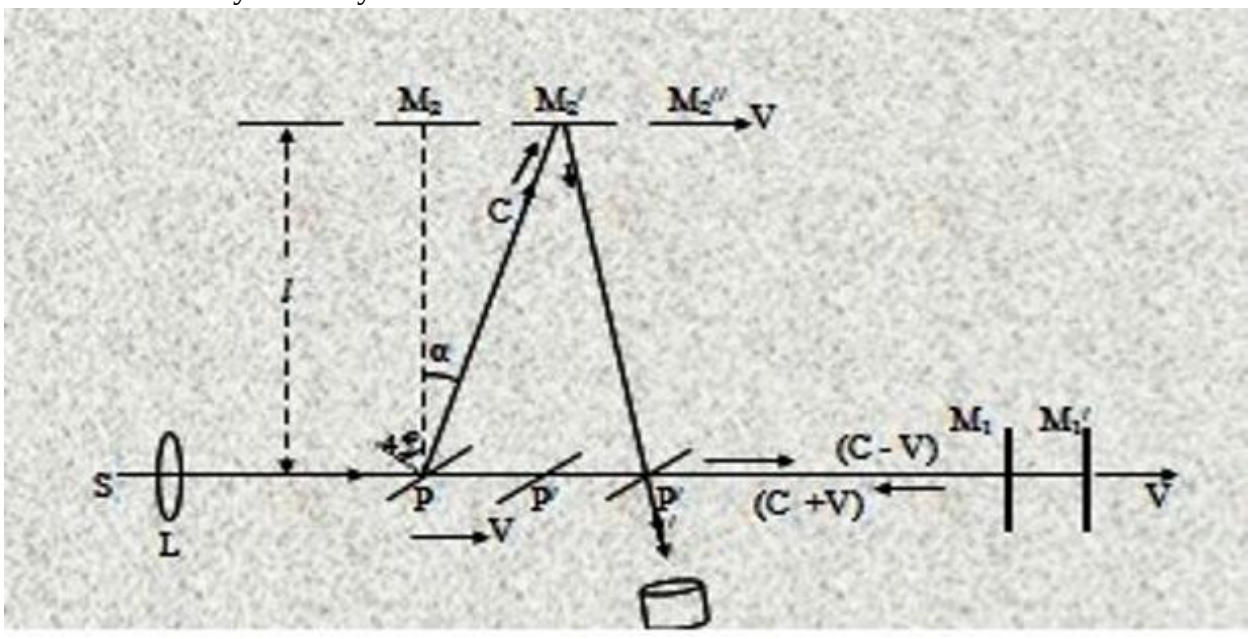

Figure 1. Conventional ray diagram of Michelson Morley Experiment

From the view point of the ether frame a diagram like figure 1 is drawn to obtain the transit time in the longitudinal arm as $l/(c-v) + l/(c+v) \sim 2l/c(1+v^2/c^2)$ and in the transverse arm simply as $2l/(c^2 - v^2)^{1/2} \sim 2l/c(1+v^2/2c^2)$ where l is the length of each interferometer arm, v the speed of earth & c is the speed of light through ether.

Then it is written that after 90^0rotation, the arms will interchange roles so that the change in transit time difference becomes $2lv^2/c^3$ resulting in an equivalent path difference of $2lv^2/c^2$, if earth were passing through ether.

Now, as is obvious from the ray diagram of Figure 1, one may ask a question that if the incident ray makes an angle of 45^0, why it is $(45^0+\alpha)$ for the reflected ray?

a) Some authors like Max Born(book-1924,1962) write "--In a direction perpendicular to earth's orbit, as light passes from P to M_2 , the earth moves a short distance forward so that the point M_2 arrives at the point M'_2 of ether. Thus the 'true path' of light in the ether is PM'_2 , and if it takes a time t to cover this distance, then $PM'_2 = ct$." Later on same or similar arguments were followed by many other authors like Bergman (1969), Robert Resnick (1968) and others. Here one may ask as to under which law of light in "ether" does this 'true path' appear?

b) Another argument to justify the cross stream path was forwarded by A.P.French (book 1972) where he takes the view point of the 'interferometer frame' and says, "The light traveling from P to M_2& back must be aimed into the ether wind at such an angle that the resultant velocity is along PM_2."

c)A.P. French and many other authors compare this situation with a boat crossing the river(like Figure 2) intending to reach a point directly opposite across the bank. While forgetting that boat is driven by a conscious being who knows in which direction to attack, they don't realize that a ray of light cannot know it beforehand that it should aim at an angle into the ether wind to reach the opposite end!

d) Authors like C. Moller (1974) who consider the point P to be a new isotropic source of secondary wavelets are also not correct as they are not doing justice to the parallel incident beam of light.

(e) Berkley Course Vol-1(1965), supposing that the oblique path of light is caused due to an aberration like effect (in line with the original Michelson-Morley 1887 analysis) is also incorrect (because here, unlike a star, the source of light is not fixed in ether). Though a few examples are given in the foregoing, actually all the text-books as well as the review articles written till this day had been giving many such unphysical arguments. The oblique transverse path is correct, but the reasons behind it usually written in line with Max Born, or others as said above, are incorrect!

B) True cause of the transverse oblique path: Totally at variance with what we had till now been reading in literature, before 90 rotation of the apparatus it is the reflection of a parallel beam of light from a moving half silvered mirror, which causes the transverse arm light to go oblique in ether. As shown in Figure 3 when the lower end of the parallel beam of light is incident on the moving half silvered mirror, it gets reflected. The upper end of the beam is reflected when the mirror has moved a bit ahead, and by using Huygens' principle it can be explained that the reflected light goes oblique (at an angle $\alpha=\sin^{-1} v/c$, shown mathematically in section C in the following).

After 90^0 Rotation of the Apparatus: After 90^0rotation of the apparatus, the arms do change their roles but not in the way as is generally written that they justinterchange roles. In this case, the oblique transverse path is caused by themotion of the collimator (convex lens) through ether. When this oblique parallel beam of light further meets the moving half silvered mirror then the use of Huygens ' Principle shows that this beam will now be reflected along the direction of motion of the earth

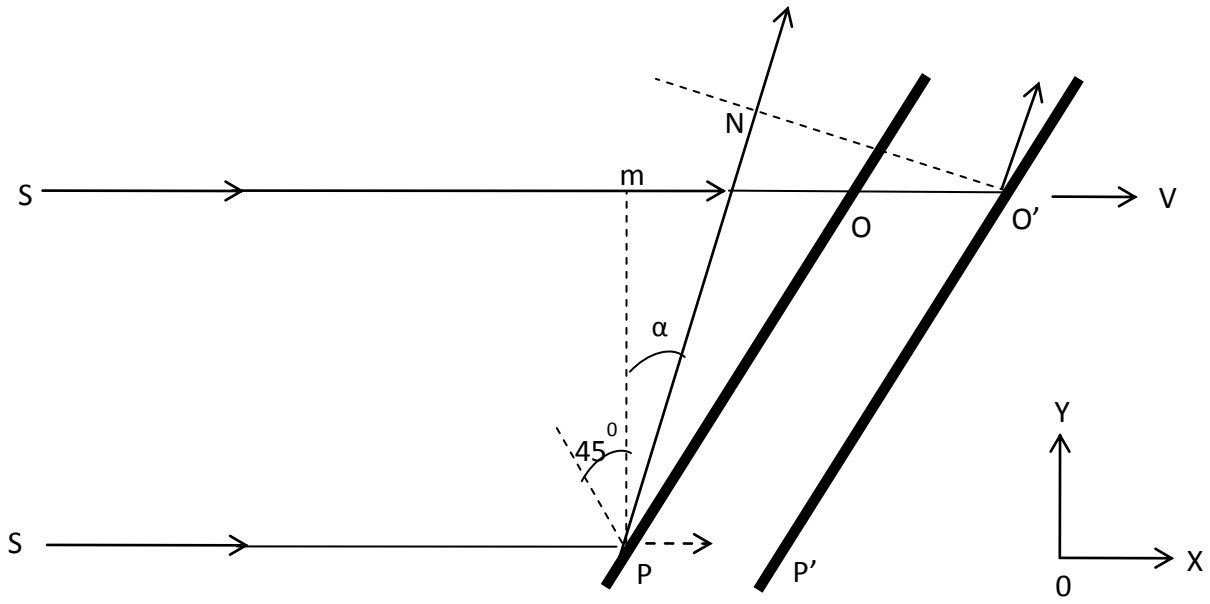

Figure 2. Before 90^0 Rotation of the Apparatus

Full picture After 90^o Rotation of the Apparatus

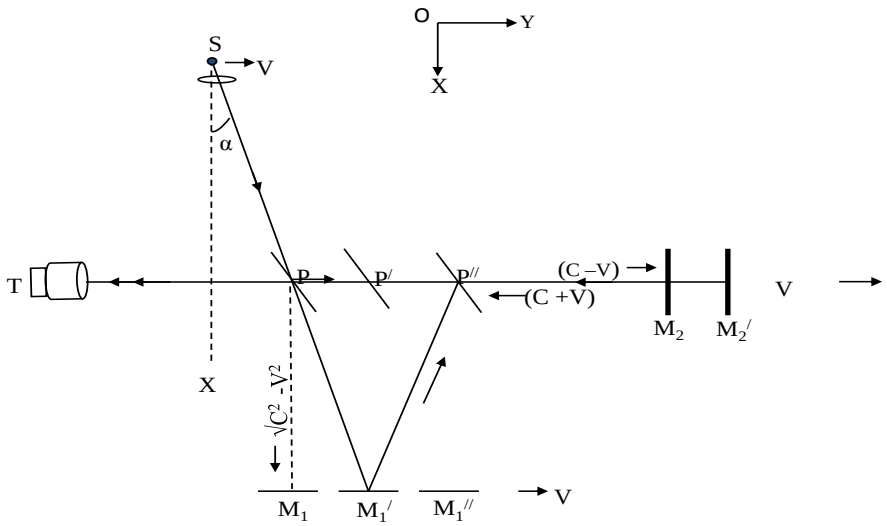

Figure 3. After 90^0 Rotation of the Apparatu

C) Finding mathematically, the angle of the oblique ray.

i) Before 90^0 rotation of the apparatus:

Using electromagnetic wave theory, the z-component of the electric vector of a plane wave propagating along the x-direction can be written as

$E_Z = Ae^{i k (x - ct)}$

……(1)

After reflection, let the plane wave proceed at an angle ɵ with the x-direction, then

$E_Z = Ae^{i k' (x \cos ɵ + y \sin ɵ - ct)}$

……(2)

So that under the boundary condition for reflection,

$k (x-ct) = k' (x \cos\theta + y \sin ɵ - ct)$

…….(3)

ii) After 90^0 rotation of the apparatus: The incident parallel beam of light is first rendered oblique by the motion of the collimating lens (fig.4). The beam splitter is moving along the (new) y direction while the parallel beam of light is incident upon it at an angle α with the x direction. According to electromagnetic wave theory, the plane incident wave is now represented by

$E = A e$

……(7)

Which gives from Equation (2)

$k (x \cos \alpha + y \sin \alpha - ct) = k' (x \cos\theta + y \sin\theta - ct)$.

……..(8)

The inclined mirror now lies on $y = (x + vt)$.

…….(9)

From Eqs. (8) & (9) we obtain $(\cos \alpha + \sin \alpha) [v/c \sin \theta - 1] = (\cos \theta + \sin \theta) [v/c \sin \alpha - 1]$

……..(10)

which has a solution $\theta = л/2$ for $\alpha << 1$. This result confirms the ray diagrams.

And since the half-silvered mirror is inclined at 45^0, and is moving along the x-direction, it can be represented by

$y = (x - vt)$

……(4)

Substituting eq.(4) in eq.(3) and comparing coefficients of x and t, one obtains

$(1 + v/c \sin\theta) = (\cos\theta + \sin \theta)$

…….(5)

If v = 0, eq. (5) has a solution $\theta = л/2$, which is justified if the mirror is at rest in ether. However for non-zero v but at $v << c$, eq. (5) has a solution

$\theta = (л /2 - \alpha)$,

…….(6)

where $\alpha \approx v/c \approx \sin^{-1} v/c$.

Solution (6) gives the direction of the reflected transverse ray as shown in figures 1 and 3.

Thus before 90^0 rotation of the apparatus, the motion of the beam splitter renders the path of rays in the transversearm oblique& after rotation, it is the motion of the collimator which does so and further, the motion of the beam splitter in the second orientation sends the reflected beam along the direction of motion of the earth through ether. This true model can be meticulously understood (as explained in the foregoing) geometrically by using Huygens'construction & theoretically by using electromagnetic wave theory.

All this is quite at variance with what we had been reading so long,right from the original analysis of M-M Experiment.

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