SPECIAL RELATIVITY IS NOT NECESSARY FOR MICHELSON AND MORLEY EXPERIMENT

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Abstract:
In this paper we show that: (A) The design of Michelson and Morley (MM) experimental hardware was inadequate and therefore it could not create a nonzero phase shift to measure the speed of earth. We explain using linear transformations on reference frames, why fiber optic gyroscope (FOG) hardware can detect earth's motion but MM hardware cannot. (B) The analytical theory that MM derived was also incorrect and that is why it predicted a nonzero phase shift; that is, the theory did not match the hardware. We create a correct theory, based on the computation of the phase angles of the beams, which matches the results of the MM hardware. (C) The MM experiment validates that the speed of light is dependent on the speed of the light source and that the light velocity should be treated using vector algebra. The Newtonian theory of vector additions can perfectly justify the null result of the MM experiment and therefore Einstein's special theory of relativity (STR) is not required. We have replaced the STR's contraction formula by the phase calculations to explain the null result. (D) The MM experiment demonstrates that light cannot bend if we consider that the light speed is isotropic. Vector algebra is necessary for bending of light in its path. The analysis in this paper is based on the observation from a stationary reference frame located outside the earth.

Keywords: Michelson Morley, special relativity, speed of light, reference frame, linear transformation, optical gyroscope

1. INTRODUCTION

In 1887 Michelson and Morley (MM) presented their design and analysis of an experiment to determine the speed of earth around the sun; but it produced a null result. In their paper [1] on page 340 they write – "It seems fair to conclude from the figure that if there is any displacement due to the relative motion of the earth and the luminiferous ether this cannot be much greater than 0.01of the distance between the fringes". On next page 341, the say – "…the displacement to be expected was 0.4 fringe. The actual displacement was certainly less than the twentieth part of this, and probably less than the fortieth part". Thus on page 15-5 Feynman [2] declared – "The result of the experiment was null". Einstein also said the result was null.

In this paper we show that the mechanical hardware of the MM-experiment was not designed correctly to detect the velocity of earth. MM did not do their theoretical calculations with proper care. A correct theoretical analysis using Newton's method shows that the MM-hardware was supposed to give only null result. Any small variations experienced were only due to secondary effects. Thus it was not necessary to create the special theory of relativity (STR) to justify the null result, Newtonian theory was adequate.

Later in the history, the MM experiment was considered as a validation of the special theory of relativity (STR) created by Einstein. In 1907 Michelson received the Nobel Prize in Physics. Contrary to many publications, for example [3, p.63] and [4, p.1251], which say Einstein did not know or vaguely knew about the MM experiment and created the STR independently, but Einstein himself said in 1922 [5] – "While I was thinking about this problem in my student years, I came to know the strange results of Michelson's experiment. Soon I came to the conclusion that our idea about the motion of the earth with respect to the ether is incorrect, if we admit Michelson's null result as a fact. This was the first path which led me to the special theory of relativity. Since then I have come to believe that the motion of the earth cannot be detected by any optical experiment though the earth is revolving around the sun."

Therefore we can realize that the MM experiment was the basis for the development of STR; it changed the history of physics. So we explore again, with a new light, what was really wrong in the MM experiment. Our research shows that MM experiment actually validates Newton's theory and not STR as popularly claimed. The MM hardware provided zero phase difference; but the formula predicted nonzero phase difference. Einstein however, assumed that MM were correct, thought that no optical method can measure the velocity of earth, and then created a theory of relativity to explain the MM results. Apparently Einstein did not check the theoretical calculations of MM.

Most important difference, in the context of the MM experiment, between Einstein's theory and the Newtonian theory is the following: Einstein says - that the light velocity is constant and is independent of the velocity of the source of light. Newton says - that is not correct, light velocity is a vector and can be added to any other velocity vector to produce different values for the velocity of light. This paper shows that Newton's notion can explain the MM results correctly and therefore STR is not necessary. The paper also show that STR cannot explain why light will bend if its velocity is considered as constant. Only Newtonian theory can explain that phenomenon.

A careful examination of the experimental setup, based on Newtonian theory, will reveal that the light velocities are different in different paths; the effective path lengths are also different. If we assume energy is constant, then the

light frequency will also remain constant. Thus the wavelengths must change, like in refraction theory [6], to account for the velocity changes. This difference in wavelengths will cause phase changes. This phase change depends on both velocity and distance. Thus Newton's approach for MM derivation must consider phase changes [6], which MM did not do. Calculations by MM show a non-zero value in path length differences. Then they assumed: a non-zero path length difference will produce a non-zero phase difference. This was a fatal assumption; their experimental hardware provided zero phase difference.

During the last twenty years many researchers have tried in many different ways to justify the null results of the MM experiment using both STR and Newtonian based calculation methods. Unfortunately, all Newtonian approaches, like in [2] and [4, pp.1248-1250] etc., used the same erroneous calculations and created controversies [6]. Most of them used time of flight for both beams as the measure and used wrong calculation for distances. In his [7] analysis, although time results were correct, he did not compute the phases of the two beams. A brief summary of MM history mentions about Hedrick's report at 1927 conference on MM experiment which was later refuted on 1935 by Kennedy and can be found in [8].

Our paper has two major sections on calculations for MM experiments, one on Newton's approach and another on Einstein's approach. In Newton's approach, we show why the phase calculation is important. In the second approach we show that STR cannot explain why the vertical beam travels at an angle. We also mention about an experiment where the small phase shift, created due to gas filled chamber, of MM has been used to find earth's absolute speed [9]. A section on fundamentals is included to cover many basic ideas related to the MM experiment. In particular we explain there, why a fiber optic gyro can detect the motion of earth but MM cannot. The core contribution is in section four on Newton's method. We start with the original experiment as designed by MM.

2. MICHELSON & MORLEY (MM) EXPERIMENT

In the following subsections we briefly describe the plans [1] of this famous history making experiment that produced null result and also motivated Einstein to create his special theory of relativity (STR).

2.1 The MM Setup

We copy the figures from the original paper below, almost exactly, to avoid all possible confusions and to provide a quick reference. Figure-1 and Figure-2, slightly modified from the original paper [1, p.335], describe the MM experimental setup. We also use the same symbols that MM have used in their paper. The modifications are in the graphics for light source, addition of earth velocity arrow, and a simpler shape of the telescope. We do not describe the original hardware here, mainly because it is not necessary, and their paper is readily available on the internet library. We only describe the relevant concept behind the experiment.

In Figure-1, b and c are mirrors, called here as vertical or y-axis and horizontal or x-axis mirrors respectively. The 45 degrees line a, represents a beam splitter. A portion of the light from source s gets reflected to b by a, and another portion gets transmitted to c through a. Both beams then return back to a, and then to the telescope d, where it forms the interference fringes due to phase differences between the two paths of the light. The arrow marked as v indicates the velocity of earth in the horizontal or x-axis direction as stated in [1].

The interference fringes were recorded in the above position and then the entire apparatus was rotated 90 degrees around the z-axis (not shown in the figures) and the interference was recorded. MM observed a fringe shift of 0.01 and they expected, according to their calculations, about 0.4 [1, p.341]. Thus MM declared the experiment as giving a null result.

2.2 Formulas Derived by MM

We also copy the derivation exactly, from MM's paper [1, p.336], as a reference for comparison with our results.

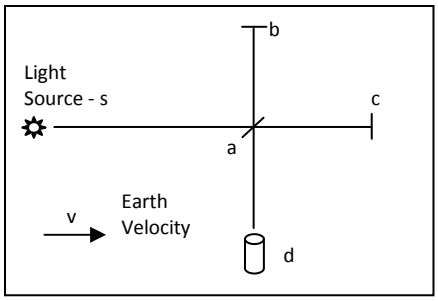

Fig.1: MM calculations x-axis

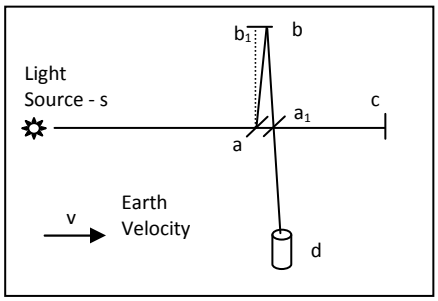

Fig.2: MM calculations y-axis

We use their notations also. They have defined the variables in the following way:

V = velocity of light.
v = velocity of the earth in its orbit.
D = distance ab or ac in figure 1.
T = time light occupies to pass from a to c.
T_1 = time light occupies to return from c to a_1 (Fig.2). Then

$$T = \frac{D}{V-v} \tag{1}$$

$$T_1 = \frac{D}{V+v} \tag{2}$$

$$T + T_1 = 2D\ \frac{V}{V^2-v^2} \tag{3}$$

The horizontal distance travelled by light during this total time is then given by, neglecting the terms of the fourth order:

$$2D\ \frac{V^2}{V^2-v^2} \approx 2D\left(1+\frac{v^2}{V^2}\right) \tag{4}$$

The length of the other path is evidently, to the same degree of accuracy:

$$2D\sqrt{1+\frac{v^2}{V^2}} \approx 2D\left(1+\frac{v^2}{2V^2}\right) \tag{5}$$

We show later how these results were derived. The difference in distance between two paths is therefore:

$$\frac{Dv^2}{V^2} \tag{6}$$

If now the whole apparatus is turned through 90^0, the difference will be in the opposite direction, hence the displacement of the interference fringes should be:

$$2D\frac{v^2}{V^2} \tag{7}$$

MM then make the declaration [1, p.336]: "If, as was the case in the first experiment, $D=2x10^5$ waves of yellow light, the displacement to be expected would be 0.04 of the distance between the interference fringes". We show that this was an important erroneous assumption.

2.3 What was Wrong?

At high level the problem is very clear and has been described by MM themselves. MM created an experimental setup to measure the velocity of earth around the sun. They also derived a mathematical formula that is supposed to match the results of the experiment. But they found that the experimental result did not match the mathematical predictions. The hardware did not detect any motion. So they declared that the experiment gave null result.

We claim that the mathematical formula that MM derived was not correct. MM made many errors and did not derive the theory rigorously. We show that a correct derivation will match the experimental result. Thus the experimental setup was not correctly designed to detect the velocity of earth. The correct theory proves that the MM hardware cannot measure the velocity of earth.

What was wrong in their mathematical formulas? The experimental setup shows that the light speed will be different in different paths, the effective distances travelled by light are different in different paths. Therefore the phase angles of light must be explicitly computed for each path and then compared. MM did not compute the phase angles. Assumptions should not be made; same distances or same times do not necessarily mean same phases. Things can be very complex as we show.

To give specific examples, consider the expressions in (1). Here MM used constant velocity of light indicating Einstein's method. On the other hand in formula (5) they have used parallelogram law using Newton's method. Thus

the MM calculations are inconsistent and not correct. These calculations show confusions in maintain correct reference frames in all derivations. In the following sections we provide the details.

MM assumed that if the difference in distances is non-zero, as they derived in (6), then the difference in phases will be non-zero also. This was an erroneous hidden assumption for them. A thorough and detailed calculations show that phase difference will be zero for the MM experimental setup.

Notice also that in Figure 2 they moved the mirror a to new position a_1 due to the velocity of earth, which is correct, but they did not similarly move the mirror c to its new position for the same reason, in Figure 1. These discrepancies in MM calculations changed the history of physics as we see now.

What else was wrong? It appears that Einstein did not check the MM calculations and assumed that the results were correct. Then he went on to derive his own STR, based on this null result. Verifying the calculations would have revealed to him that MM hardware was not designed correctly, and STR was not necessary to explain the MM results.

Based on this null result Einstein also claimed, as mentioned in his quotation above, no optical experiment can measure the velocity of earth. Which we now know is false. Fiber optic gyroscopes and ring laser gyroscopes are widely used in US military for navigation of spacecrafts. Civilian airplanes also use them. They use circular and piecewise straight line optical paths, respectively, of light in two opposite directions, very much like MM experiment, in principle.

We also point out later that the same MM setup has been used, within a gas filled chamber, to detect the absolute speed of earth.

3. FUNDAMENTALS

This section will help to clarify some basic ideas about the MM experiment. We discuss linear transformations and show that the properties of one experiment cannot change under such transformations. This idea will then explain why the design of MM experimental hardware cannot measure the velocity of earth while a fiber optic gyroscope (FOG) can.

3.1 Notations

In software engineering there is an interesting way of using symbols or notations that eliminates proliferation of symbols and associated confusions. They have a notion of scope of a variable. The compiler automatically distinguishes two variables with same symbol based on the scope of definition. Concept of scope is very similar to the context of a subject. In this paper we will use such a philosophy for using our variables and hopefully the readers will be able to distinguish them from their contexts.

For example c is normally used to represent the speed of light. But MM has used it to denote an object in their figures, and we will use that. Since we are using Newtonian method where velocity of light is a vector and therefore can change its value, we will use c with various subscripts to represent various velocities of light present in the MM experiment. In this paper we will use special care to identify the context properly to avoid all variable related confusions.

No attempt has been made to use standard notations, if any, from physics, mathematics, or engineering. Similarly it is not intended to create new notations for the community of physicists. Thus all variables and notations used here are scoped specifically for this paper only.

3.2 Newton Vs Einstein

Einstein created the two postulates [4, p.1251] for his special theory of relativity (STR):

(A) The laws of physics must be the same in all inertial reference frames.

(B) The speed of light is same in all inertial frames regardless of the velocity of the observer or the velocity of the source emitting the light.

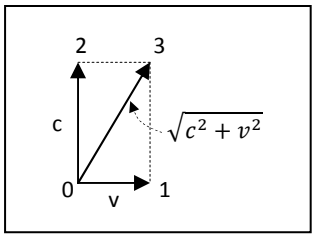

Fig. 3: Newton's method

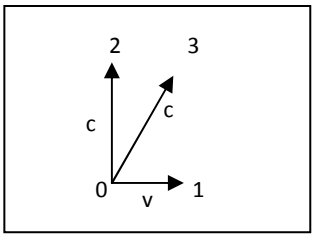

Fig. 4: Einstein's method

If you take a flashlight, hold forward, and run forward at speed v, then Newton says that the speed of light will be c+v, where c is the speed of light in vacuum. But Einstein says that the speed will be c, and will not depend on v. Similarly, if you turn the flashlight backward and still run forward the velocity will not be c-v, but only c according to Einstein.

More generally Newton says that light can be treated as a vector and the principles of vector additions will remain valid. Thus we can draw the two Figures 3 and 4 representing Newton and Einstein respectively. In Figure 3 we have used the classical method for vector addition using parallelogram law. Thus if the flash light is projected along the direction 0-2, and the flashlight moves at velocity v along the direction 0-1, then the light will travel along 0-3 at the velocity given by the parallelogram law: $\sqrt{c^2 + v^2}$. But Einstein says light will follow the direction 0-3 but with velocity c as shown in Figure 4.

However, Einstein fails to explain why the light will change the direction from going towards 2 and goes instead to 3. We will explore this question again, once we examine all the details of the MM experiment in the main body of the paper and learn that the light indeed bends and travels towards the point 3. Thus Einstein's postulate (B) fails to explain the change in direction of light due to the motion of source, which is so obvious according to Newton. However, it is clear that light cannot change direction if it does not get affected by another velocity or force vector. All of these results will be visible only when the observer is located at the origin of a stationary frame located outside earth as explained below.

3.3 Vector Space

In general we will use U or V to denote arbitrary finite dimensional vector spaces, and R^n to denote real n-dimensional vector space. We will not use complex vector spaces. We will also assume that the underlying space is always R^n for both U and V. In most cases n will be equal to 3, that is, we will assume 3-dimensional real vector space. For example U could be stationary and V could be a moving 3-dimensional real vector space.

Two vector spaces are identical or isomorphic [10] if there exists an one-to-one and onto linear transformation between them. In this case they are algebraically the same and we are free to choose the one that is convenient for our algebraic operations. Isomorphic vector spaces have same dimensions. Operations performed in any one of them will provide identical results. Therefore if U and V are isomorphic to R^n space, V is moving with a constant linear or angular velocity, and U is stationary, then both U and V are algebraically same. We can choose U to perform our operations. The above theory is same as the first postulate (A) of the principle of relativity. Thus if an experiment fails in a stationary frame, it will also fail in a moving frame, under any linear transformation or vice versa.

Some experiments on U can be considered as a linear transformation T on U, $T: U \to U$. Thus if we know T then we can find another similar experiment S on V, $S: V \to V$ which will provide same result as T. T and S are related by the similarity transformation:

$$T = P^{-1}SP \;\; and \;\; S = PTP^{-1}$$

Here P is a nonsingular transformation from U to V, P: $U \to V$.

In many applications, like robotics or inertial navigation, U can be a 3-dimensional stationary vector space and V can be a rotating space. These two spaces are connected by a rotation matrix, usually called the direction cosine matrix [11, p.24]. This matrix is always non-singular and can be used for P. Although we will never use the P matrix explicitly, but the fact of its existence must be under stood, to know the reference frame transformation mechanism and the reason behind STR postulate (A).

3.4 Reference Frames

Reference frame is the coordinate system of a linear vector space. The coordinate system can be Cartesian, Spherical, or cylindrical, East-North-Down, Lat-Lon-Height etc. However, the underlying vector space is always the 3-dimensional real linear vector space. Therefore all these reference frames represent isomorphic spaces. Note that the reference frame is related to the entire vector space and not to each coordinate axis. In MM experiment both directions, horizontal (x-axis) and vertical (y-axis), belong to the same 3-dimensional vector space with one specific coordinate system or reference frame. The x, y directions are integrated, tightly coupled, and move together.

In our calculations all we will need is the parallelogram law for vector additions. Therefore we really do not need to introduce the concept of reference frame and make the subject complicated. A clear and careful intuition will always give correct calculations. It seems in the original MM paper [1] the idea of reference frame was also not used. Reference frame is widely used in inertial navigation systems [11], mainly because it is necessary to transform the data from one frame to another frame for various reasons. Certain formulas are defined in certain frame; some instruments like gyroscopes and accelerometers record data in some other frames; the space vehicle needs to be

located in some other frame etc; all these frame management require definition of many types of reference frames in the same algorithm. In this paper we do not have such a complicated situation.

Inertial Frames

The physics textbook [4, pp. 114-115] defines the inertial frame in the following way: "If an object does not interact with other objects, it is possible to identify a reference frame in which the object has zero acceleration. Such a frame is called an inertial frame of reference".

A reference frame that is stationary in space will therefore be an inertial frame, because it has zero acceleration and zero velocity also. Similarly a frame that is fixed with earth, and in particular fixed with the MM hardware, is also an inertial frame, because we can assume that the earth is moving in a straight line with a constant velocity, during our experiment time. Constant velocity means zero acceleration.

There is no place on this universe where an object is isolated or not interacting with any other object. Everywhere there is always a gravitational force due to all heavenly objects in the universe. Since there is a force, there is acceleration also. Since all objects are moving, this force is time varying, and therefore the acceleration is also time varying. Thus the inertial frame, in its true sense, is non-existent in nature.

Stationary Frame

Stationary frame is a frame that is not moving and is fixed in space. For the purpose of the MM experiment and as an example we may assume a frame fixed with a distant star as a stationary frame.

The author of the paper [7] uses the concept of: "the observer in the absolute space is selected as the static system person" as reference frame and calls it the "ether man". The idea of a static hypothetical object in space is quite meaningful in theoretical sense. We consider this hypothetical eye is placed at the origin of a stationary reference frame. From this frame we will see that the earth is moving. All our calculations are based on this stationary reference frame, unless otherwise stated. At every step of our all calculations we will remind the reader about this stationary reference frame.

Einstein also has mentioned about static reference frame [12] "Recapitulating: we may say that according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, ether exists. According to the general theory of relativity, space without ether is unthinkable; for in such space not only would there be no propagation of light, but also no possibility for the existence of standards of measuring rods and clocks, nor therefore any space-time intervals in the physical sense."

Moving Frame

Since earth is moving, all frames defined and fixed on earth will always be moving and will be called as moving frames. The motion can be linear, like earth's motion along the orbit around sun, and similarly rotational, like the earth's rotation around its spin axis. Similarly a frame that is fixed with the MM hardware is also a moving frame, because the MM hardware is moving along with the earth. A frame that is fixed with the FOG platform is a moving frame, because the platform is rotating.

In our MM analysis we will use mainly the above two kinds of reference frames, moving and stationary. The observer will be at the origin of the stationary frame and the moving frame will be attached to MM hardware. These two frames, stationary and moving, may cause confusions in understanding our equations. In fact we show that this confusion has led to wrong derivation by MM in their theory. So we will remind the frame issues every time we perform a new calculation.

In any calculation, if we use the velocity of earth v, then we automatically mean our calculation is based on the stationary frame located outside earth. That is because only from an outside stationary frame we can observe that the earth is moving with the velocity v. Sitting on earth however, we never experience any motion of earth. This is a very important notion in all our concepts. If we sit on a moving frame, we will never see the motion, everything will be static. Just like in an airplane, we cannot feel its motion while sitting inside and do not look outside. Thus any frame defined with respect to the body of the airplane will not show the motion of the airplane. Therefore all equations on a moving frame, which is fixed with the moving object, cannot have the velocity of the moving object. The two terminologies, stationary and moving are confusing, stationary frame shows motion v, moving frame shows static conditions. In summary, for the MM experiment, we record:

(a) Stationary frame is located outside earth. The observer is at the origin of this stationary frame.
(b) Moving frame is attached with the MM experimental hardware.
(c) All our equations are based on the stationary frame, because they embed earth's velocity v.

Example:

The following example will help us to understand the core issues involved in the MM experiment, reference frame, fiber optic gyroscope, and linear transformations. In Figure 5, X and Y represent moving reference frame, fixed on earth, which is moving with earth. For example, it may be on the local level ground plane. Two objects A and B are moving with speed and directions given by A1 and B2 respectively. The problem is to find the relative velocity of B with respect to A.

To do that we make A stationary with respect to the reference frame, by adding an equal and opposite velocity A3 to A as shown. The important requirement of the linear transformation is that this A3 must be applied to all moving objects, in particular, to B also. This is done by adding B4 to B, where B4 and A3 are identical. Now using parallelogram law, we see that the resultant velocity of B will be along B5. Since A is stationary now, A will see B moving along B5. By linear transformation property, B5 will be the relative velocity of B with respect to A, even when A is not stationary and moving along A1.

The essential idea we want from this example is that if A is a large body, like the MM experimental setup, then all moving and stationary objects of A will acquire the same velocity v as a vector. With respect to an external stationary frame all objects of MM hardware, including light rays, will acquire velocity v. Similarly with respect to the moving frame attached to MM hardware everything will have v = 0. We have used this concept for the analysis of MM theory. We also use this same concept in optical gyroscopes described below.

We have mentioned, under linear transformation or according to postulate (A), if an experiment fails in the moving frame, then it will also fail in the stationary frame or vice versa. We can easily see that under a moving frame MM hardware cannot give any phase difference because the hardware design is perfectly symmetrical and there is no external velocity. Therefore the MM hardware will also show null result with respect to the stationary reference frame. MM did not recognize this basic concept about the linear transformation theory or the postulate (A). It appears that Einstein understood this basic concept, created the postulate (A), but made the fatal error by creating postulate (B) and by stating that no optical experiment can be designed to measure earth's velocity. But the ingenuity of people is overwhelming; Sagnac discovered a concept that helped to manufacture the optical gyroscope capable of measuring earth's velocity v, where light travelled in two opposite directions. We explain the details below.

3.5 Optical Gyroscopes

We consider only fiber optic gyroscopes (FOG) here to demonstrate the concept behind the inability of MM hardware. A FOG senses the rotational rate of the platform on which it is mounted. Thus if the gyro is mounted on earth it will sense the combined rotation rate around sun and around its spin axis. A FOG is described briefly using Figure 6.

A schematic of a FOG consists of optical fiber of about 100 or 1000 meter long coiled on a small spool of approximately 2 inches in diameter. The coil rotates at platform rate Ω. B is a multifunction integrated electro-optic device. For our context we may consider it as beam splitter and combiner. It splits the light from the source A and sends the light to both ends of the fiber. It also combines the returning beams from the coil ends and sends to the phase detector C.

The principle of operation of a FOG is that two beams travel in two directions in the same fiber loop. When the coil rotates, the distance a light beam travels becomes longer in one direction and shorter in other direction. As a result the two counter rotating beams create a phase difference between them which is detected by C. This phase difference is proportional to the rotation rate Ω of the platform. As mentioned before, the FOGs are widely used as commercial and military product, mainly for inertial navigation systems.

The FOG actually proves that the light speed is not constant and is opposed to STR theory, because this gives a phase difference as its experimental output. According to linear transformation theory or postulate (A), all

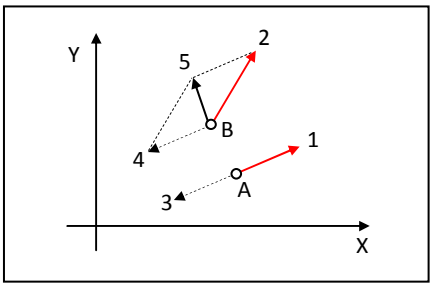

Fig. 5: Computing relative velocity

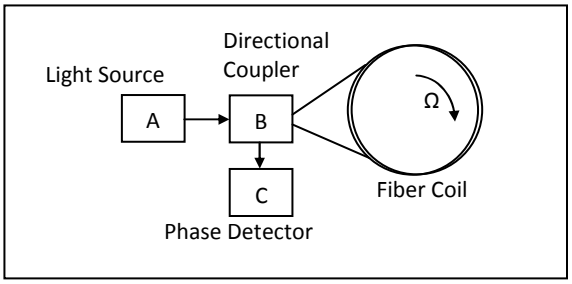

Fig. 6: Fiber Optic Gyroscope (FOG)

experimental results will remain same under such transformation. Thus if you analyze sitting on the rotating frame attached to the platform of the FOG, you will see that both light beams travel the same distance but the FOG will still be giving same phase difference. This indicates that the light speed has changed in two directions. In [15] the authors have designed a fiber optic linear motion system and observed a travel time difference between the two beams travelling in opposite directions, thus proving the light velocity is not constant even in linear motions

This analysis shows that the postulate (B) is not correct. Thus assuming light speed is constant is not meaningful for the analysis of MM experiment. We show that MM experiment proves, just like a FOG, the anisotropy of light velocity.

3.6 MM vs. FOG

In this subsection, we show why MM hardware cannot detect the velocity of earth whereas a fiber optic gyro (FOG) can. If you stop the earth by applying a translational velocity equal and opposite to earth's velocity, then MM hardware will represent a stationary experiment in a stationary frame located outside earth. In this mode earth velocity v can be ignored from all our calculations. In this stationary mode, it is easy to see that the MM hardware will not detect any phase difference, because it is perfectly symmetric in both x and y directions and there are no motions anywhere. Therefore according to the linear transformation law or Einstein's postulate (A), the MM hardware will also not create any phase difference when the earth moves in the normal way. Thus MM failed to recognize a very fundamental limitation of the MM hardware. This analysis is similar to an experiment performed when the airplane is on ground and when flying, which as is well known, will give same result.

If you think in terms of the moving frame attached to the MM hardware you will also see the null result using the linear transformation theory. On the moving frame you do not see any velocity for any object of MM experiment, just like you do not see any velocity on the airplane. Under this scheme, the MM hardware will not show any phase difference, because it is symmetrical. Now if you move to the stationary frame, which will give a linear transformation, due to addition of earth's velocity, you will also see the null result. This is because experimental outcome or the laws of nature is independent of linear transformation on vector spaces.

Similar analysis can be used for FOG also. A fiber optic gyroscope operates under rotational motion. Assume that the FOG platform is mounted on earth and you are looking from the external stationary frame. If you apply a rotational transformation to stop the earth's rotation and also therefore the platform on which the gyro is mounted, then the FOG will not sense the platform rotation. However, as illustrated by the example, this rotational transformation must be applied to the two counter rotating optical beams also in the same way, effectively still creating a phase difference at the detector. This will happen because one beam will stop but the other beam will speed up. Thus under this transformation the FOG will still detect the rate observed from the stationary frame. This same effect does not happen in the MM hardware. This analysis shows that the MM hardware design was not correct for measuring the speed of earth.

3.6 Speed of light

In [13], the author of the book Zhang has analyzed several laboratory experiments on the validity of one-way velocity of light. Zhang says - the one-way velocity of light has been proved to be independent of the motion of the source. Where he explains in the next sentence that independence does not mean the one-way velocity of light is isotropic. In [14] Gift quotes the above same book [13] and confirms that one-way light speed constancy has not been proven experimentally. It should be clear that if one-way is not proven then two-way cannot be proven also.

The postulate (B) has not been accepted yet as valid by most researchers. An optical gyroscope proves that velocity of light is dependent on the velocity of the source as explained before. In [15] an experiment demonstrates a phase difference in a fiber optic linear motion system. We have also explained that the light cannot change direction if you assume that the light velocity is independent of the source. In this paper our analysis will show that the MM experiment confirms that the light velocity depends on the velocity of the source emitting the light.

In [16] Paul says – "This apparent constant velocity of light with respect to a moving frame is the most fascinating illusion in science". Thus postulate (B) still remains an assumption only. Therefore the foundation of our analysis, light velocity should be treated as a vector and Newton's method is applicable, remains justified. Our analysis is theoretically correct and verifies with the experimental result.

3.7 Assumptions in Physics

Many have commented that such and such technology would not work if STR was wrong or as an example the GPS proves that relativity is correct because GPS uses STR. Many of our physicists believe in a philosophy like – whatever happens in mathematics will happen in nature also. These are very naive statements, and come from complete misunderstandings of modern engineering systems. They also reflect human ego, audacity, and ignorance

about human inability to understand the laws of nature. Nature created humans and creation can never understand the creator. It is just like - our computers can never understand humans who designed and manufactured them. Nature does not know our mathematics and physics, therefore nature cannot obey them. Using them we are only trying to estimate the behaviors nature. These estimates will never become unique universal truth of nature.

Real time embedded engineering is part of nature. Because it is made of components and materials taken from nature, it also interacts with nature, via analog to digital (ADC) and digital to analog convertors (DAC). If you look carefully inside any embedded hardware and software you will find it is a complete patch work and full of kludges. Engineers know that theories do not work in engineering and they know how to make things work. Let us give some examples to illustrate how math and physics can be completely wrong. Therefore application of any theory in embedded engineering, no way means validity of that theory. More details can be found in [17].

Every theory in mathematics and physics make assumptions about nature. But nature and embedded engineering can never accept any assumption. Engineering will automatically reject all the assumptions and therefore invalidate all theories and their applications; hence the need for patches and kludges. Since nature cannot make any assumptions, all theories of physics that are based on assumptions on nature, cannot be valid. In particular they are not just approximate theories, they can be outright wrong. Consider the Newton's first law, which states [4, p.115]: "(a) In the absence of external forces, when viewed from an inertial reference frame, (b) An object at rest will remain at rest and (c) An object in motion continues in motion with a constant velocity, that is, with a constant speed in a straight line".

In above the item (a) is an assumption, which cannot be valid in nature. There is no place in the universe where there is no external force. If you leave a ball in the deep space, it will immediately start moving in a curved path. The path will be curved because the objects in our universe are constantly moving. The total force on the ball will be changing all the time, both in magnitude and in direction; therefore the ball cannot remain stationary or go in a straight line. Thus we see that the conclusions of the law, (b) and (c), cannot be true. The conclusions are false because the assumption is wrong.

The following statements can be found in the textbook [18, p.8] about the Newton's first law: "We could hardly sustain that this principle (First law) is a strict experimental result. On the one hand it is not evident how to recognize whether a body is free of forces or not. Even if a unique body in the universe were thought, it is undoubted that its movement could not be rectilinear and uniform in every reference system".

Many math theories such as Fourier or Laplace transforms are based on infinite time assumptions. Since infinity does not exist in engineering, all physics theories that use them, like uncertainty principle, can never be tested by any engineering experiments [19]. It should be noted that replacing infinity with a finite large number, will not make them approximate, instead will dramatically change the theories of Laplace and Fourier transforms [17]. Thus implementations of engineering are patchworks. The theories of physics can work only on paper and pencils and cannot work in nature. In [17], it analyzes various mathematical and physical theories and their assumptions to show that science cannot describe nature's laws. The complexities of embedded engineering are beyond comprehension of mathematics and physics, yet engineering is far simpler than nature.

We are hoping that our theoretical analysis of MM experiments is not based on any assumptions on nature, and there are no errors in our formulations and derivations. It also corrects many previous publications on the subject and borrows ideas from their approaches. Therefore the qualitative conclusion of the paper, velocity of light depends on velocity of the source, should be valid.

4. NEWTON'S METHOD

According Newtonian method the light velocity is dependent on the velocity of the source. That is, the light should be considered as vector [7] and parallelogram method should be used to find the resultant velocity of light. We cannot use postulate (B) which says light has constant speed, independent of the velocity of the source of light, because that theory is for STR created by Einstein. Using Newton's method we show that MM hardware cannot measure the speed of earth. Our derivation will show that there will be no phase difference between the two light beams.

We repeat from the fundamental section. In this approach we may think of a hypothetical stationary frame, fixed in space outside earth, and we place our observing eyes there. From there we see that the earth, with its moving frame attached to the MM hardware, is moving at a constant linear velocity. We also assume that the earth is not rotating around its spin axis, during the period of experimental observation. We will be careful not to mix or confuse with stationary and moving frames. As mentioned before, according to Einstein's postulate (A), all laws of physics will hold in our moving frame. The distance metrics will remain same in both frames, although the distances will not. Momentum and energies will be conserved in both frames because they are laws of nature and postulate (A) confirms that.

There are three distinct light paths in the MM experiment. Light travels along the direction of earth's motion, against that direction, and perpendicular to that direction. Thus we have three quantities of everything. We employ the following steps to determine the phase difference between two beams, at the detector, using Newton's method:

(a) Find light velocities $\{c_1, c_2, c_3\}$ in terms of c_0 and v
(b) Express distances $\{d_1, d_2, d_3\}$ in terms of v and unknown time values
(c) Use steps a and b to solve for time values $\{t_1, t_2, t_3\}$
(d) Substitute known time values into step b to find actual distances
(e) Compute phases from known distances and known velocities.

4.1 Velocity Calculation

In this subsection we compute the velocities of light beams travelling in various directions. In different directions beams will have different velocities due to vector addition methods and as seen from the stationary frame in space. All velocities of light and of other objects, such as mirrors, will depend on v, the velocity of earth along its orbit around the sun, and on c_0, the speed of light in vacuum.

The light travelled in MM experiment at three different velocities in three different paths as shown by two parts of Figures-7 and by Figure-8. For horizontal beams the velocity computations are too obvious and are shown inside the two parts of Figure-7. For y-directions, light started vertically in Figure-8 after reflecting from the mirror a, along the direction ab_0. During the time light traveled, the mirror b moved to position b_1. Thus the light actually traveled along ab_1. This happens because, light has two velocity components as shown in Figure-8, one in vertical direction with value c_0 and another in horizontal direction with value v. The combined velocity of light, according to Newtonian method, should be their vector addition as shown inside Figure-8.

Very few authors have considered the resultant Newtonian velocity as $\sqrt{c_0^2 + v^2}$. Thus there was a persistent error all throughout the literature and all over past times. Summarizing, the light velocities according to Newton, are given in (8-10).

$$c_1 = c_0 + v \tag{8}$$
$$c_2 = c_0 - v \tag{9}$$
$$c_3 = \sqrt{c_0^2 + v^2} \tag{10}$$

One must recognize that (8-10) are measured with respect to the stationary frame located outside earth. The observer is at the origin of that stationary reference frame. From that location only one can see that the earth is moving with velocity v. Thus whenever there is v in an expression, like in any one of (8-10), the expression must be from stationary frame. Sitting on earth which is a moving frame, you do not see any motion and v must be zero. As an example, sitting on a moving frame, you will not see that the light is going along the diagonal as in Figure 8. All calculations in this paper, unless specifically mentioned, are done with respect to the stationary frame located outside earth.

Observe that it is necessary to use the vector addition using the parallelogram law to justify the diagonal light path shown in Figures-8. The STR method cannot explain why light will follow such a diagonal path; for Newton's method it is obvious. The postulate (B) will not allow a diagonal path.

MM used light velocity as constant for the x-axis formulas and therefore unknowingly used the STR approach, as shown later in Einstein's method section. We do not want to present that approach in this section to avoid confusions. However for y-axis direction MM used parallelogram law. Thus MM was not consistent in their methodology, they confused with reference frames in their calculations.

All authors who wanted to correct the formulas of MM have considered changes in light velocity, and used the

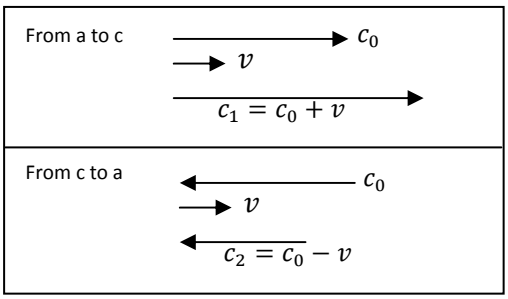

Fig.7: Velocity vectors in horizontal paths

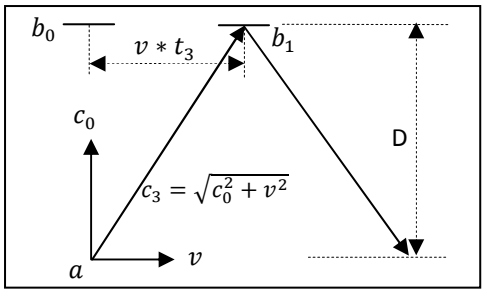

Fig.8: Velocity vectors in the vertical path

addition of light velocity vectors correctly for horizontal or x-axis directions as shown in Figure-7. For vertical or y-axis direction very few authors like, MM [1] and [7] have used the correct velocity vector diagram as shown in Figure-8. All other publications, including textbooks [2, 4] used wrong y-direction vectors for Newton's method. It has been derived [20] that light velocity changes in the Michelson Gale experiment for rotational cases.

4.2 Distance Calculations

Here we will express the distances travelled by each light beam in all three directions. We know the velocities from previous subsection, so we will express the distances using corresponding unknown travel time variables. We have to consider the motion of the entire experimental setup as a single unit with respect to the stationary frame. Thus the stationary frame distances will not be same as the moving frame or static distances.

We show that in most literature, including textbooks, the distance calculations for light path in the MM experiment are wrong. It has been discussed by many authors [6]; however, it is correctly presented in [7]. The Figures 9 and 10 show the correct distances and use the basic concepts that we have used in many other applications including Sagnac [21, p.619] effects.

In Figure-9, light travels from left to right, from beam splitter a to mirror c. The initial positions of the mirrors, when light starts from a, are shown in upper part of the figure. The final positions, when the light hits the mirror c, are shown in the bottom part of the figure. During this time interval t_1 the mirror c has moved to position c_1. Thus the effective distance traveled by light is given in (11):

$$d_1 = D + v * t_1 \tag{11}$$

This distance calculation is quite obvious, because the earth has moved right during the flight time. Note that (11-13) derived here are distances as measured by the eye of the observer located at the origin of the stationary frame outside the earth. This is so, because v appears in the equations.

Similarly from Figure-10 we can see that the distance is given by expression (12). In Figure-10 the light is travelling from right to left after reflecting from the mirror c. During the flight time t_2 the beam splitter has moved right to position a_1. Thus the effective distance is smaller here than the forward path as in (12).

$$d_2 = D - v * t_2 \tag{12}$$

Distance calculation along the vertical direction is shown in the Figure-8. The time taken to travel half the distance from a to b_1 is indicated as t_3. During this time the vertical mirror b travels from initial position b_0 to the final position b_1. Thus half the distance is given by (13):

$$d_3^2 = D^2 + (v * t_3)^2 \qquad or$$

$$d_3 = \sqrt{D^2 + (v * t_3)^2} \tag{13}$$

4.3 Time Calculation

We know the exact velocities of all beams. But we know the distances only as a function of unknown time variables. The following equation will solve time variables:

$$velocity_i * time_i = distance_i\,(time_i)$$

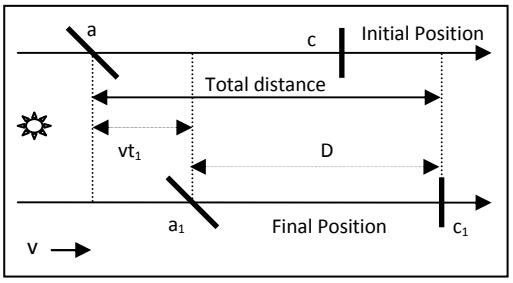

Fig.9: Distance calculation from a to c

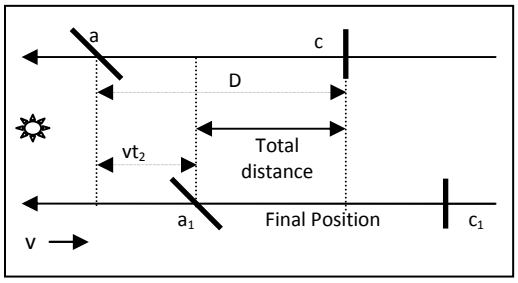

Fig.10: Distance calculation from c to a

All the computed distances, d_1, d_2, and d_3, are the distances traveled by the light beams at the corresponding velocities c_1, c_2, and c_3 respectively. All of those expressions are with respect to the stationary frame located outside earth. Again, this is so because they have the velocity term v in them and from this stationary frame only we can see that the earth is moving with velocity v. Sitting on earth, which has the moving frame, we will not observe v. The time is an experimental outcome; it is not a characteristic of the underlying vector space. Therefore according to linear transformation theory, Newton's theory, or postulate (A), time output is independent of reference frames. Therefore we collect:

$$d_1 = c_1 * t_1 \quad and$$

$$d_1 = D + v * t_1$$

Equating the above two expressions, we can do so because they are based on same stationary frame, we can find the time as:

$$t_1 = \frac{D}{c_1 - v} = \frac{D}{c_0 + v - v} = \frac{D}{c_0} \tag{14}$$

In (33) we derive the expression for t_1 using Einstein's principle of constant velocity of light and get a different result. MM have also used the derivation (33) thus unknowingly and making an error in the expression for t_1. Collecting equations from stationary frame we write:

$$d_2 = c_2 * t_2 \quad and$$

$$d_2 = D - v * t_2$$

Combining the above two stationary frame equations we can derive time t_2 as in (15).

$$t_2 = \frac{D}{c_2 + v} = \frac{D}{c_0 - v + v} = \frac{D}{c_0} \tag{15}$$

We can see that in (8) velocity has increased, and so the distance also has increased in (11), to keep the flight time same as the static flight time (14). The exact opposite has happened in case of (15) to maintain the static time. The static time is the time required on the moving frame attached to MM hardware. This expressions (14-15) show that the time is independent of reference frames as per Newtonian theory.

This interpretation is same as we often use in mechanics. We add a velocity, opposite to the direction of v, to make the earth stop and then calculate the static values for times. This is also equivalent to linear transformation discussed in the fundamental section. This moving frame approach will give the same results for times as in (14) and (15). In this sense (14-15) prove the linear transformation theory or the postulate (A). Total horizontal time can be written as in (16)

$$t_H = t_1 + t_2 = \frac{2D}{c_0} \tag{16}$$

We compare now that our derivations (14-16) are different from what MM derived in their expressions (1-3).

Similarly we can compute the vertical time, based on stationary frame results, as follows:

$$d_3^2 = D^2 + (v * t_3)^2 \quad or$$

$$(c_3 t_3)^2 = D^2 + (v * t_3)^2 \quad or$$

$$t_3^2 * (c_0^2 + v^2) = D^2 + (v * t_3)^2 \quad or$$

$$t_3 = \frac{D}{c_0} \tag{17}$$

We notice that here again we got the static frame time, even though we used stationary frame calculations. This confirms our theory that linear transformations do not affect experiments. Thus the total vertical time is same as the total horizontal time in (16) and is given by (18):

$$t_V = 2 * t_3 = \frac{2D}{c_0} \tag{18}$$

As we have mentioned, however, we should not conclude that the phases will be same also, because the light travelled different distances and with different velocities during this time period. Therefore we must compute the phase difference to establish the null result of MM experiment. The paper [7] stops here to justify the null result, which is not correct. We must proceed to compute the phases.

Now that we know the time values we can finalize the distances in each path by eliminating time. Note that we are still using stationary frame located outside earth, because velocity is still there in our expressions. Thus we write:

$$d_1 = D + v * t_1 = D + v * \frac{D}{c_0} = D\left[1 + \frac{v}{c_0}\right] \tag{19}$$

In a similar way we can write

$$d_2 = D - v * t_2 = D - v * \frac{D}{c_0} = D\left[1 - \frac{v}{c_0}\right] \tag{20}$$

The total horizontal distance $d_H = d_1 + d_2 = 2D$ and is not same as found by MM in their expression (4). The vertical distance can be written as in (21):

$$d_3 = \sqrt{D^2 + (v * t_3)^2} = \sqrt{D^2 + \left(v * \frac{D}{c_0}\right)^2} = D\sqrt{1 + \left(\frac{v}{c_0}\right)^2} \tag{21}$$

And the total vertical distance is

$$d_V = 2 * d_3 = 2D\sqrt{1 + \left(\frac{v}{c_0}\right)^2} \tag{22}$$

Again we see that (22) is same as what MM obtained in (5). Thus MM used, unknowingly, Newton for vertical direction and Einstein for horizontal direction or they did not take sufficient care to maintain correct reference frame. We see inconsistency in MM calculations.

The horizontal and vertical distances are not same. Expanding in series, we get approximately, from (21) the following

$$d_3 = D\sqrt{1 + \left(\frac{v}{c_0}\right)^2} \approx D\left[1 + \frac{1}{2}\left(\frac{v}{c_0}\right)^2\right] \tag{23}$$

Thus the difference in the horizontal and vertical distances can be written as

$$2d_3 - (d_1 + d_2) = D\left(\frac{v}{c_0}\right)^2 \tag{24}$$

The result in (24) is same as what MM derived in (6). Interestingly, our horizontal distance did not match with MM but the vertical and total difference matched. As we have mentioned, however, to explain the null result we have to compute the phase difference between the two paths of the light. We show later using (34) that the horizontal distance did not match because MM did not use Newton's method for x-axis calculations.

At this point MM stopped their calculations and made a fatal assumption: if the difference in distances is non-zero as in (24), then there will be a difference in phases also. We calculate the phases in the next section to verify that there will be no phase differences between the two beams.

4.4 Phase Calculations

At this step we know all values of all variables: distances, velocities, and times. All of them are referred to the stationary reference frame situated outside earth. We use them to compute the phase angle of each beam at the detector. All three paths have different velocities, therefore each path has different phase angle also. The phase angle

of each path is converted to the phase angle of light velocity at vacuum for proper comparison. This is a kind of normalization procedure.

Many authors [22, 23] have considered Doppler Effect. We should point out that there is no Doppler effect here, because there are no relative motions among various mirrors, beam splitter, and telescope. All items remain at fixed distances with respect to each other. Doppler Effect happens only when there is a relative motion between the source and the observer. The complete MM setup is moving as a unit in this case. However, since there are different velocities in different paths, wavelengths will change.

While calculating the total phase for each path we assume that the frequency of light in all paths remain constant. Since energy is related to frequency, and energy is not changing in MM experiment, our assumption seems meaningful and is similar to the case of refractions [4, p.1104]. Thus we can write, using wavelength λ, as in (25):

$$f_0 = \frac{c_0}{\lambda_0} = \frac{c_1}{\lambda_1} = \frac{c_2}{\lambda_2} = \frac{c_3}{\lambda_3}$$
$$or \quad \lambda_i = \lambda_0 \frac{c_i}{c_0}, \quad i = 1,2,3 \tag{25}$$

Since light is travelling at different velocities in different paths, we convert all phases to the equivalent phase at velocity in vacuum. Since frequency is proportional to inverse of time, it is independent of reference frames. As mentioned before all distances are also measured with respect to the external stationary frame. We calculate distance [24] in terms of wave length as shown in (26).

$$d_i = \left(N_i + \frac{\varphi_i}{2\pi}\right)\lambda_i = \left(N_i + \frac{\varphi_i}{2\pi}\right)\lambda_0 \frac{c_i}{c_0}, \quad i = 1,2,3 \tag{26}$$

Here N_i is an integer. Then redefining we can get the expression of total phase as shown in (27).

$$\Phi_i \triangleq \left(N_i + \frac{\varphi_i}{2\pi}\right)\lambda_0 = \frac{d_i}{c_i}c_0, \quad i = 1,2,3 \tag{27}$$

Observe from (27) that the phase is related to both distance and velocity. Using (27) we can write the phases for each path as shown in (28-30).

$$\Phi_1 = \frac{d_1}{c_1}c_0 = c_0 \frac{D\left[1 + \frac{v}{c_0}\right]}{c_0 + v} = D \tag{28}$$

$$\Phi_2 = \frac{d_2}{c_2}c_0 = c_0 \frac{D\left[1 - \frac{v}{c_0}\right]}{c_0 - v} = D \tag{29}$$

$$\Phi_3 = \frac{d_3}{c_3}c_0 = c_0 \frac{D\sqrt{1 + \left(\frac{v}{c_0}\right)^2}}{\sqrt{c_0^2 + v^2}} = D \tag{30}$$

We can then see that the total phase difference between the two beams is zero:

$$(\Phi_1 + \Phi_2) - 2\Phi_3 = (D + D) - 2D = 0 \tag{31}$$

Although the total difference in distance is nonzero, but the total difference in phase is zero and this has happened because of velocity differences. MM did not calculate the phases. This was a major assumption behind the theory of MM. Our derivation shows that it was a fatal error that changed history.

The phase calculation shows that the design of the MM experiment was not correct. The setup did not satisfy the core requirement of the experiment – measure speed of earth using phase difference. That is, this MM experimental hardware setup cannot produce phase difference. However, that does not mean MM experiment approves STR. It only means this specific MM experimental setup cannot measure the speed of earth and it also

does not say that there cannot exist any other method for measuring the speed of earth. But Einstein assumed that there cannot exist an experiment without giving any proof, as we point out later.

The two light beams will also have phase changes due to reflections and refractions. We consider them as the secondary effects. However, it is believed [9] that these secondary effects will allow us to measure the absolute velocity of earth using the MM setup.

4.5 Phase Change Due to Reflections

Normally, the textbooks [4, p.1189] say that phase of the reflected light changes by 180 degrees. However the research papers [25, 26] say that the phase change depends on the angle of incidence, wave length, as well as on the material properties and depth at which light reflects. The total angle can change from 130 degrees to 200 degrees. In this paper, for simplicity, we consider all reflections cause same amount of phase changes. Conceptually we can apply the linear transformation theory along with the postulate (A) of STR.

If we imagine stopping the earth by adding a velocity v in the opposite directions then the MM setup will remain stationary, and all light beams in all directions will have same velocity. Therefore we can assume that all phase changes due to reflection will be same also. We can see from Figure-1 that there are two similar reflections for both beams, therefore both beams will be equally affected and the difference in phase due to reflections will also be zero.

Now, if we remove the added velocity, then both the mirrors and the beams will be affected equally. That is, the relative velocity of the mirrors with respect to the light beams will remain unchanged. So the phase angles will also remain same. Thus the net phase change due to reflections will be of second order in nature due to slightly dissimilar angles of incidence at beam splitter and materials of the mirrors.

4.6 Phase change due to refractions

We can use the same principle as before, that is, we can stop the earth by adding a velocity v in the opposite direction and examine the refraction status of the MM setup. In this case we see from Figure-1 that there are two similar refractions at beam splitter, one each for vertical and horizontal paths.

The vertical path refracts when light travels from mirror b to the telescope through the beam splitter. The light refracts through it at 45 degrees angle. In the same way, when the light travels from the source to mirror c it refracts through the beam splitter a at 45 degrees angle. We can assume, neglecting the secondary effects, that these two refractions cause same amount of phase change in both beams. Thus the net difference in phase change due to refraction is negligible.

When the added velocity is removed, the earth will move again. The relative velocities and positions, between the beams and splitter a will remain same, causing no difference in the phase change. We can then conclude that phase difference between the two beams is zero. Therefore when the MM setup will be rotated by 90 degrees the phase difference will also remain zero, causing no change in the fringe shifts.

Therefore, it is clear from our calculations that to explain the null result of the MM experiment we do not need Einstein's special theory of relativity and Lorentz's contraction formula. Newtonian theory is quite adequate. In this sense our calculations show that MM experiment validates the Newtonian concepts.

5. EINSTEIN'S METHOD

Apparently Einstein did not check the hardware and the theory behind the MM experiment. He assumed that both were correct and created his STR. But we have shown using linear transformation that the hardware was not capable of measuring earth's speed. The idea behind this linear transformation approach also matches with the postulate (A) of STR. In previous section, we have shown Newton's method was adequate to correct the theory of MM. However, researchers have focused for many years to correct the theory part of the MM experiment using many methods. In one sense, this theory effort was redundant, because we knew the hardware was wrong from postulate (A). But as we show, there are important lessons to be learnt from using Einstein's method for correcting the MM theory.

Using the special theory of relativity (STR) of Einstein, only time calculations are enough for MM experiment, because light travels at same speed in all directions and in all frames according to STR. Thus if times are same for both beams then there will be no phase difference at the detector. However the distance contraction formula has to be used to get the final null result. But Newton's method required the phase calculation instead. We briefly discuss the method presented in [2] to show the differences with the Newtonian method and also to raise an important question, related to MM experiment, which remained unanswered by the STR method.

According to STR [2] the time calculation, in the horizontal direction from a to c, is given by:

$$c_0 * t_1 = D + v * t_1 \tag{32}$$

$$t_1 = \frac{D}{c_0 - v} \tag{33}$$

Expression (32) is bit confusing and inconsistent. The right hand side is based on stationary frame outside earth, and then left hand side must also be with respect to the same stationary frame. But because of STR, c_0 did not change. Whereas for Newton's method we must increase the velocity c_0 to derive (34):

$$(c_0 + v) * t_1 = D + v * t_1 \tag{34}$$

In (32) STR assumes light velocity c_0 cannot change in any direction. Thus (33) gives, for total time

$$t_1 + t_2 = \frac{D}{c_0 - v} + \frac{D}{c_0 + v} = 2D\ \frac{c_0}{c_0^2 - v^2} = \frac{2D/c_0}{1 - v^2/c_0^2} \tag{35}$$

Notice that (35) is same as expression (3) used by MM. Thus MM did not use Newton's method (34) for horizontal velocity calculations, and unknowingly used Einstein's method, or did not track the reference frames correctly. We can see then that MM used a mixture of methods, Einstein's method for horizontal beams, and Newton's method for vertical beam. The most important problem was that MM did not consider the phase changes. These discrepancies caused erroneous final formula leading to a major change in history of physics.

The distance D in (35) must be contracted, to match the time of vertical or y-axis formula, which is derived below in (38). So (35) is modified to give:

$$t_1 + t_2 = \frac{\left[2D\sqrt{1 - v^2/c_0^2}\right]/c_0}{1 - v^2/c_0^2} = \frac{2D/c_0}{\sqrt{1 - v^2/c_0^2}} \tag{36}$$

This contraction formula was suggested by Lorentz, and was motivated by the experimental results of MM, where the calculations were done erroneously. We comment on this contraction formula in a later section.

5.1 STR and Unanswered Question

There is an important unanswered question, as mentioned before, and is illustrated in Figure-11, which is essentially a duplication of Figure-8, with minor modifications. It should also be pointed out that this Figure-11 is very similar to Figure-2 of the original theory presented in the MM paper.

As we can see, in this STR case, the light velocity is c_0 in the diagonal path a to b_1. However the question is, light photon started along the y-direction from a to b_0 at velocity c_0, but then why it changed direction to go diagonally to hit the mirror at position b_1. How can this happen without the vector addition concept using parallelogram law discussed in Figure-8? The path ab_1 is the real path that will be visible from the stationary reference frame in space where we have placed the eye of the observer. It seems this observation can only be explained if we mix the two theories, Newton for vector direction and Einstein for vector magnitude. But this appears quite unacceptable. The parallelogram law indicates increase in velocity, whereas STR dictates constant velocity. This is a contradiction that STR cannot properly explain.

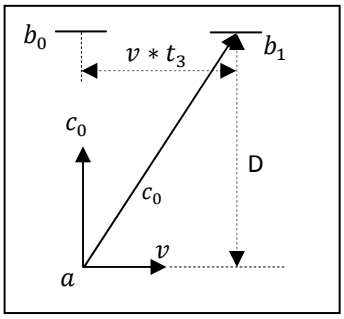

Fig.11: Vertical path according to STR

If light bends on its entire travel path in space, then it must have been affected by a force or velocity which was in a direction different from that of the light's original direction. Thus for light to bend, it must experience the effect of vector addition of two velocity vectors. The phenomenon will be difficult to explain and verify experimentally. Notice that the change in direction was not random but it was consistent with the vector addition method of Newton. The light always traveled to the mirror at the end of the y-axis in a diagonal manner.

According to STR the time t_3 is given by, see Figure-11:

$$(c_0 t_3)^2 = D^2 + (v * t_3)^2 \quad or \tag{37}$$

$$t_3^2(c_0^2 - v^2) = D^2 \quad or \quad t_3^2 = \frac{D^2/c_0^2}{1 - v^2/c_0^2}$$

Thus total vertical time is

$$2t_3 = \frac{2D/c_0}{\sqrt{1-v^2/c_0^2}} \tag{38}$$

which matches the total horizontal time in (36).

There are then two unanswered questions for STR – (a) how to justify the contraction patch work and (b) the direction change of light. These problems are not there in Newton's method, and yet Newton answers all questions correctly for the MM experiment. Thus we can say that the MM experiment actually validates the Newton's theory and not the STR as popularly claimed.

6. POSTULATE CONTRADICTIONS

In this section we show how under different frames the two postulates of STR become inconsistent. In the past we have used stationary frame, moving frame, and linear transformation. Postulate (A) of STR is consistent with all other physical experiences. A truly inertial frame is non-existent in nature, but the conclusion that all laws of nature will be independent of inertial frame appears to be meaningful. The laws of nature are unique and universal. Therefore they cannot depend on interpretations based on reference frames. Linear transformation theory of vector space should not also affect any experimental results. These transformations affect only the points, distances, and topology of underlying real 3-dimensional spaces. Literature shows that the postulate (B) has not been proven yet and therefore remains an assumption. In this paper, however we have shown that the MM experiment did indeed prove that light velocity is not constant.

Stationary Frame

If we take the MM hardware at the origin of the stationary frame and perform the experiment, we will find that it will give null result, because the hardware is perfectly symmetrical in both x and y directions and there is no external velocity to affect the instrument. Here we have assumed that both the hardware and the observer are on the same stationary frame.

Moving Frame

Now if we bring the hardware back on earth, which has a moving frame with linear constant velocity v, according to postulate (A) it should also give null result. According to linear transformation theory all points in the MM hardware will get the velocity of earth. Therefore everything will be affected linearly and therefore the experimental results will still remain valid, that is, we get null result. Again, the observer is on the moving frame.

We can also analyze the MM experiment based on the moving frame. In this frame we do not experience any velocity of earth. This is equivalent to adding an opposite velocity to stop the earth. According to linear transformation theory, this opposite velocity will affect every item on the MM hardware. Thus v should then be considered zero. To an observer on this moving frame everything will appear stationary on earth. Therefore the system will give null result since the hardware is symmetric.

The Newton's method that we have derived in this paper is based on the observation from external stationary frame. If we set v = 0 in all our equations, then the results will represent observation from the moving frame. It will indicate a null result. Thus we find null result in both stationary and moving frames and is consistent with the predictions of postulate (A).

FOG Analysis

In the analysis of a FOG we have used both stationary and moving frames, but both were located on earth. The FOG was mounted on a separate rotating platform on earth. This rotating platform will be the moving platform on earth, because it is rotating with respect to earth. On the other hand the earth itself will be the stationary platform because from this stationary platform we see the FOG platform is rotating.

Observing from both frames we see a validation of postulate (A) for the FOG result. The FOG measured a non-zero phase shift indicating the rotation of its platform. On the moving frame of the FOG platform the distances for the two beams were identical, therefore to get a phase shift we had to violate the postulate (B) and assume different velocities of light in two counter rotating directions.

Newton's Method

In Newton's method shown in this paper, we kept the hardware on the moving frame of earth, and analyzed the experimental results looking from the external stationary frame. In this case the velocity of light must be considered non-constant to derive null result. Thus if we assume postulate (A) is correct then we see it contradicts postulate (B). Here we found horizontal and vertical distances were different causing a phase shift. Digging deeper, we examined the phase shift to find them equal, and therefore produced a null result.

Einstein's Method

In this method the MM instruments were on the moving frame of the earth, but we observed from the stationary frame located outside earth.

If we assume postulate (B) as true then we see that, according Einstein's calculations, horizontal and vertical times are different. Since velocity is constant, and times are different they will produce a phase difference causing a non-null result, violating postulate (A). Thus to make the two postulates consistent Einstein had to introduce the contraction formula to make the two time values equal.

7. DISCUSSIONS

This paper is not about criticism of Einstein's STR. Its purpose is to show that MM experiment proves that light velocity is not constant. We needed a discussion on FOG to explain why MM design was not correct for measuring phase difference. To make proper analysis we had to bring in reference frames and linear transformation theory, which in turn took us to the STR postulates. The objective of every research should be to find the unique universal truth that nature presents to us. This is an effort along that direction.

A very important concept of Newtonian mechanics is that velocity of light, and distances travelled by light, are equally affected in all directions by the earth's velocity. This basic observation, validated by linear transformation theory and STR postulate (A) was ignored during the design of MM experiment. According to Newtonian principles light should be treated as a vector. Our calculations are based on this principle and the theoretical results match the MM experimental results. This equal effect by velocity does happen inside gyro also for both counter rotating beams. The resulting effect, with FOG on earth platform, still produces a phase difference as we have discussed in the fundamental section.

MM had inconsistencies in their theoretical calculations. They used constant velocity in the x-direction and parallelogram velocity in y-direction. They also made a significant assumption that non-zero path difference will produce non-zero phase difference, and overlooked phase calculations. This is not correct in their experimental setup because light has different velocities in different paths. Under constant energy system, the frequency will remain constant but wavelength will change causing phase differences. However, we have shown that the experimental setup is such that these phase differences cancelled out also. MM and other literature did not perform phase calculations.

MM spent lot of effort in fixing many hardware problems of their setup, but almost ignored the theory part of their formulations. This has happened even after someone pointed out about a formula error in their first paper as mentioned in [1]. Unfortunately Einstein also did not verify anything about this MM experiment.

MM in their experiment got some fringe shifts, but did not get the actual amount that they expected. This small phase difference is the result of many secondary effects [27]. This small result however, has been used as reported in [9], in a gas filled chamber, to find the absolute speed correctly, as opposed to orbital speed of earth, which matches the result of NASA COBE absolute speed data. The MM experiment when performed in a gas filled chamber gives different speed of light due to different refractive index. Thus it is experimentally possible to measure the absolute speed of earth, contradicting Einstein's conclusion [5].

Lorentz transformation used in STR based calculations in (36) was specifically created to justify the null results of MM experiments. This is what Feynman, a Nobel Laureate in physics, said [2] about this transformation –

"Although the contraction hypothesis successfully accounted for the negative results of the experiment, it was open to the objection that it was invented for the express purpose of explaining away the difficulty, and was too artificial". A paper from Max Planck Institute [28] says "Taking the experimental evidence together, sufficient proof has been presented that the Lorentz transformation does not represent a physical law which is realized in nature. Its underlying principle, that optical phenomena depend only on relative velocities, cannot be maintained". However, Einstein believed that this transformation was correct and it was a basic foundational tool for his STR. Einstein said [5] – "At that time I firmly believed that the electrodynamics equations of Maxwell and Lorentz were correct". Our analysis of MM experiment, based on Newton's method, has shown that this contraction principle is not necessary to justify MM null result, phase calculation was enough.

The second conclusion of Einstein, "the motion of the earth cannot be detected by any optical experiment" [5] is also not correct. The Sagnac effect is an optical experiment, and can detect [21] the rotation of earth around Earth's own spin axis and around the orbital axis. It should be recognized that it is not necessary for the gyroscope to rotate around its own axis as shown in the Michelson and Gale experiment [20]. Sagnac effect has been successfully used to manufacture fiber optic gyroscopes, which are being used in military grade inertial navigation systems [29]. An experiment [30], with accuracy of 3 times better than that of MM, was performed using Infrared Maser and still null results were obtained verifying our calculations, and linear transformation theory, presented in this paper.

The fact that MM optical experiment did not provide desired result, only means it was not designed correctly. It establishes that light should be treated as vector and Newtonian principles can be used to get correct results. It is normally considered that MM experiment validates STR; instead we have shown that it validates Newtonian classical mechanics. On the other hand application of STR to MM experiment produced two new unanswered questions mentioned before.

Sagnac was lucky that in his experiment the laser light did not get locked. Today a dither is applied [29] in optical gyros to keep the beams unlocked. The paper [31] said – "History would no doubt have taken a different turn had the Sagnac test results given a zero result, which would have been the case had the equipment been rock steady; in that case it would have been taken as proof positive of SRT". The calculations, presented in our paper, establish another time how a century back a false null result of MM experiment has changed the history.

All the experiments and thoughts that have been presented for and against STR are critically reviewed in [32]. Most important of them is the Sagnac effect that is used in modern gyroscopes to detect earth's rotation rate around its spin axis. Because of the same principle a highly accurate laser gyro will also be able to detect rotation around any other axis, like orbital axis around the sun, which was the objective of the MM experiment. Sagnac effect gave us the confidence that MM experimental hardware had a design flaw. The important lesson learnt is that if the hardware is not correct, no amount of theory, including STR, will extract a law of nature from it.

8. CONCLUSIONS

Using Newtonian Theory we have presented the calculations of the Michelson-Morley (MM) experiment and have shown that the result of the experiment should be null as observed, confirming that MM hardware was inadequately designed. In our calculations we have treated light velocity as a vector. We have also shown that it is necessary to compute the phase difference between the two beams, because the light beams have different velocities. Our analysis shows that MM experiment validates the non-constancy of light velocity. A question remained unanswered - Special Theory Relativity cannot explain why light bends and travels diagonally, when it is projected vertically from a source which is moving horizontally, like in MM experiment.

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