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A New Confirmation of the Presence of Two Errors in Michelson's Analysis of his MMX, on the PCR Academic Website, for Riverboats Contest Times Calculation, and A New Demonstration, Contradicting the Solution in Physics

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ABSTRACT

We developed a New Interpretation of Michelson's analysis (NI16) of his experiments (MMX) by identifying and correcting Errors 1 and 2 (MER12) in the analysis (not in the experiment itself), including its faithful model based on the Two Swimmers Contest (TSC).

In NI16, Demonstrations 1, 2, and 3 were presented, all of which proved the equality of the total times, $t_1 = t_2$ (no winner), in the Water Frame (WF). However, this result contradicts current physics textbooks (PTB), which state the inequality $t_2 < t_1$ and conclude that the transverse swimmer (SW2) wins the contest. This conclusion is also applied to MMX.

Recently, we discovered that a numerical calculation similar to that presented in NI16 appears on the Physics Classroom (PCR) website. The calculation concerns Example 1 (EX1), involving the first crossing of a river 80 m wide with a current speed of 3m/s by a motorboat (BO2) moving at 4 m/s relative to the water. This calculation faithfully follows the rules of plane vector analysis and yields a first crossing time of t_{2a}= 20.0s

This result in PCR completely corresponds to the procedures and times obtained in NI16 within the WF. In contrast, the corresponding time given in PTB is t_{2a} = 30.20s. The resulting round-trip time is therefore t_2= 60.4s, whereas for BO1 the calculated time is t_1 = 91.4s. Thus, $t_1 > t_2$, SW2 wins the TSC, and, according to our analysis, the PTB treatment should be corrected.

Therefore, the PCR website provides Confirmation 4 of the correctness of NI16. Furthermore, based on a new geometric route for BO2 in the Bank Frame (BF), a trigonometric calculation yields $t_2 = t_1$, as obtained in NI16. This calculation therefore constitutes Demonstration 5 of the correctness of NI16 and, according to the authors, supports the reintroduction of the ether concept into physics, with numerous potential consequences.

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Abbreviations

ME81/87 or MMX	Michelson's Experiments from 1881 and 1887
NI16	New Intertpretation of Michekson Analysis from MMX
MER12	Errors 1 and Error 2 in MMX
RF	Referential Frame
EF/WF	Ether/Water Frame
PCT	Physics Classroom Tutorial
PCR	Physics Classroom Website
PTB	Physics Textbooks
TSC	Two Swimmers Contest
BO1/ BO2	Boat 1 or Boat 2
RC1/RC2	First/Second River Crossing
SB	Starting Block
PTB	Physics Textbooks
CMSP	Current Mainstream in Physics
SP	Starting Point (O)
MB1/MB2	Motorboat1/ Motorboat2
PA	Pevious Article
EX1	Example 1 from PCR
SW1, SW2	Swimmer 1, Swimmer 2
DF/BF	Device/Bank Frame

1. Introduction

In this article, we first refer to a numerical calculation of the well-known Two Swimmers/Boats Contest (TSC), presented here for a motorboat (BO) crossing a river. This calculation appears as Numerical Example 1 (EX1) on the educational website Physics Classroom (PCR), which is intended for the instruction and guidance of physics students and teachers [1]. In PCR, the calculation is performed only for the first river crossing (RC1) of the TSC. This contest is widely regarded as a faithful model of Michelson's interferometer experiments of 1881 and 1887 (MMX).

However, the calculation presented in PCR differs from the solution commonly found in Physics Textbooks (PTB), which, according to our analysis, incorporates Errors 1 and 2 of Michelson's analysis (MER12). These errors were first identified and demonstrated in our work published in 1996.

By contrast, the calculations and results obtained in PCR for EX1 are mathematically consistent with our previous investigations. These investigations led to the formulation of a New Interpretation of Michelson's Analysis of MMX (NI16), founded upon the identification and demonstration of MER12.

Therefore, the results obtained in EX1 on the PCR website constitute additional evidence supporting the existence of MER12 in Michelson's analysis, as identified in our earlier studies.

In this article, we extend the scope of the numerical calculations and procedures employed in EX1 from PCR to the analysis of the motorboat's second river crossing (RC2) in the Two Swimmers/Boats Contest (TSC). The purpose of this investigation is to provide further evidence and arguments in support of the existence of MER12 in Michelson's analysis.

In Section 2, the calculation presented in EX1 for the first river crossing (RC1) is reviewed in detail for ease of reference [1]. We note that, in the PCR tutorial, this calculation is presented in the river-bank frame (BF), although the authors do not explicitly mention the importance of this reference frame for the correctness of the analysis.

The numerical calculation in EX1 faithfully follows the rules of plane vector analysis and yields a first-crossing time of $t_{2a} = 20.0$s. However, this result differs from the time provided by the Current Mainstream in Physics (CMSP) and by Physics Textbooks (PTB), which are based on Michelson's Analysis (MA) of MMX. According to CMSP and PTB, the first-crossing time is $t_{2a} = 30.2$s, implying a round-trip time of $t_2 = 60.4$s.

For comparison, CMSP and PTB indicate that the time required to travel the same distance of 80 m along the river is $t_1 = 91.4$s. Thus, $t_1 > t_2$ (91.4s > 60.4s), leading to the conclusion that Agent 2 wins the contest according to CMSP and PTB.

Considering these differing values of t_{2a}, and given that EX1 yields $t_{2a} = 20.0$s, which is identical to the value obtained in NI16, EX1 may be regarded as a fourth confirmation of the existence of MER12, as proposed in NI16.

However, EX1 does not continue the analysis to include the return crossing (RC2) of BO2, nor does it address the discrepancy between the two methods that produce the values $t_{2a} = 20.0$s and $t_{2a} = 30.2$s.

The precision of the calculation presented in EX1 is also limited because the inclination angle θ_1 of the forward path RC1 is calculated with only one decimal place. Therefore, in Section 3, we repeat the EX1 calculation for RC1 using the river-bank frame (BF) and increase the precision of θ_1 to five decimal places.

In Section 4, we extend the EX1 analysis by determining the return path (RC2) of BO2 to its starting point (SP/O). This requires a more complex geometric construction in the BF frame, resulting in a return trajectory that is the inverse of the diagonal path followed during RC1. Two alternative geometric variants are developed and analyzed to establish the required points and trajectories.

The RC2 path obtained in the extended EX1 is analogous to the corrected trajectory of Light Ray 2 in MMX when described in the Device Frame (DF).

In Section 5, we continue the EX1 contest by performing the numerical calculation of the time t_{2b} for the second river crossing (RC2). In this calculation, we apply the same mathematical and logical principles used in EX1, also referred to the river-bank frame (BF) [1]. However, the analysis requires a more complex trigonometric treatment, resulting in $t_{2b} = 71.428571$s. Consequently, the total travel time for BO2 is found to be $t_2 = 91.428571$s.

To complete the contest, it is necessary to calculate the total travel time for BO1, which covers the same round-trip distance while moving parallel to the river current. This calculation, presented in Section 6, follows the classical and comparatively simpler approach, involving no ambiguities or controversies in the BF frame. The resulting total travel time is $t_1 = 91.428571$s.

Thus, equality of the two travel times, $t_1 = t_2$, is obtained by applying the logical principles and mathematical procedures employed in EX1 on the PCR website, which is widely used as an educational resource for physics teachers and students [1]. According to this analysis, the common textbook claim that BO2 (or SW2) wins the contest is incorrect, since a properly conducted contest results in a tie.

To further confirm the equality of t_1 and t_2 in both reference frames, Section 7 presents the complete trajectories of BO1 and BO2 in the Water Frame (WF). Based on these trajectories, the times $t_1 = t_2 = (2l/c)(1/\alpha^2)$ are derived. These calculations follow the mathematical and logical procedures proposed in our work since 1996 (NI16), which support the existence of MER12 in Michelson's analysis of MMX and provide the basis for our proposed corrections of PTB.

The equality of the times, $t_1 = t_2$, obtained using the same mathematical procedures employed in the PCR analysis, which is widely accepted as an educational resource in contemporary physics, constitutes an additional confirmation of the existence of MER12 in Michelson's analysis, as identified and corrected in our previous work. As a consequence, according to our interpretation, physics textbooks should be revised so that they also yield the equality $t_1 = t_2$ in MMX. Under this interpretation, the TSC should no longer be won by SW2 but should instead end in a tie.

In Section 9 the results from the TSC in Figure 4, in order to be more easily applicable to MMX, were superimposed in the same Figure 5 on the correct path in red lines, according to the TSC of ray 2, over the wrong path in black lines according to the MMX of ray 2, all presented in equivalent WF/EF.

In Section 9, A new calculation of the round-trip time t_2 for BO2 is performed in the river-bank frame (BF). In this analysis, the boat crosses and recrosses a river of width l_2 with speed c relative to the water, while the river current has speed v. The trajectories are represented in the BF frame, where the mathematical and logical treatment is more complex than in the Water Frame (WF). Nevertheless, the resulting value of t_2 is identical to that obtained in the WF.

Thus, this new derivation of the equality $t_2 = t_1$ in the BF frame constitutes Demonstration 5 of the correctness of NI16 and provides an additional confirmation of the existence of MER12 in Michelson's analysis of MMX.

2. Presentation of Example 1 from the PCR Website: Boat 2 on the First River-Crossing Path as in NI16, Constituting Confirmation 4 of the Existence of MER12

This article begins with the appearance on the PCR educational website of a worked numerical example intended for physics students and teachers. The presentation consists of a logical application of the rules of vector addition in a plane and is given in the form of Example 1 (EX1) [1].

In EX1, the river width, the river speed, and the speed of Boat 2 (BO2) are specified numerically. The objectives are to determine the resultant velocity of BO2, the time t_{2a} required for the first river crossing (RC1), and the downstream displacement of the boat upon reaching the opposite bank. These quantities are calculated numerically in EX1, although no general formulas are provided (Figure 1) [1].

This hypothetical race between two boats is equivalent to the well-known Two Swimmers Contest (TSC), which is commonly used as an analogy for Michelson's interferometer experiment (MMX).

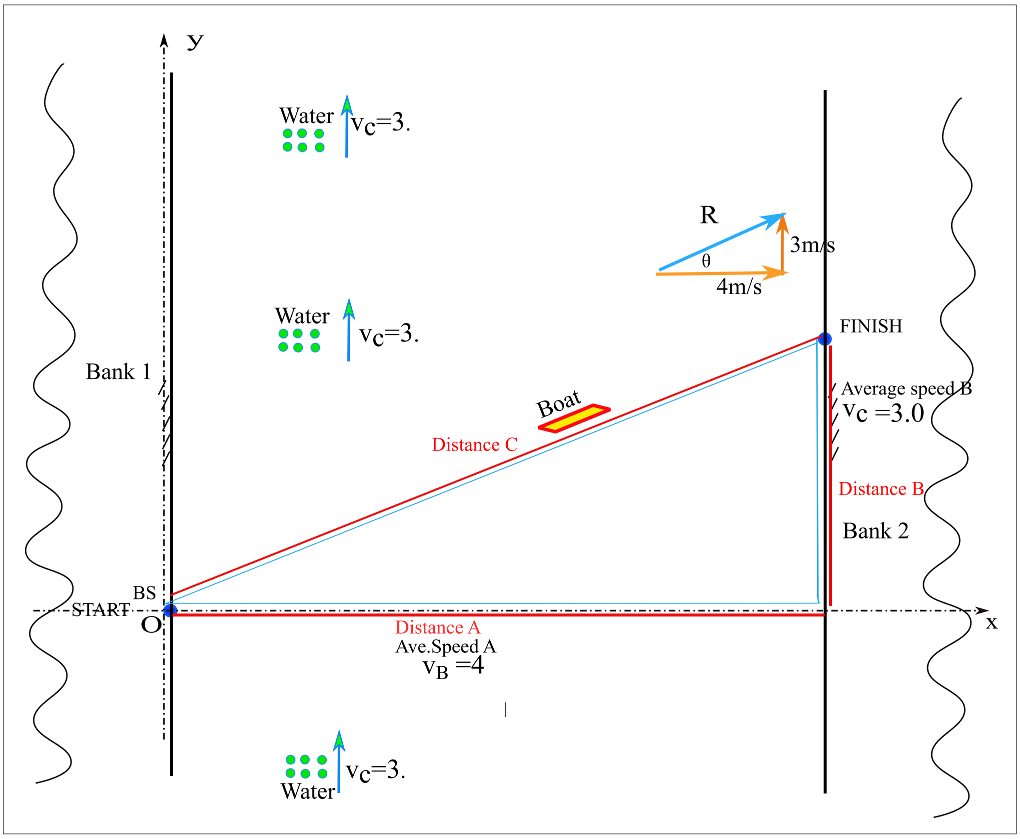

Figure 1: Scheme for the composition of the resultant velocity vector, (v_R=R), of Boat 2 (BO2) and the component distances associated with the First river crossing in the River-Bank Frame (BF), as in EX1 [1].

However, EX1 presents only the first part of the contest involving Boat 2 (BO2), namely the first river crossing (RC1), as illustrated in Figure 1. Nevertheless, the calculation is developed correctly and accurately, based on sound mathematical procedures and logical reasoning.

Although EX1 provides only a numerical solution, it is significant because it presents a logically justified and mathematically consistent calculation of the crossing time t_{2a}, together with a corresponding graphical representation of the first river-crossing path (RC1) of BO2 (Figure 1).

Furthermore, the RC1 trajectory presented in EX1 is similar to the departure path of Light Ray 2′ in MMX (but containing Error 1) . According to our interpretation, the solution presented in EX1 for the RC1 path and the corresponding time t_{2a} differs from the solution commonly presented in MMX analyses, specialized physics literature, and physics textbooks.

At the same time, however, the solution obtained in EX1 for the first river crossing (RC1) coincides with the solution that we have proposed since 1996 in our NI16 framework [2–12].

It should be noted that the topic of MER12 has been the primary focus of our research. To the best of our knowledge, this specific issue has not been explicitly addressed in published work by other researchers, research groups, or scientific organizations. Consequently, apart from our own publications, we are not aware of additional references that specifically discuss MER12 and could therefore be cited in the present article [2–12].

For ease of documentation, comparison, and analysis, we reproduce below the full text of EX1 (in italics) from the PCR tutorial [1].

We note, however, that the version reproduced here corresponds to the text available in January 2025, since the PCR website has subsequently been updated.

In its current form [1], EX1 is presented with a substantially expanded explanation (approximately 960 words compared with about 660 words in the earlier version). In this revised presentation of EX1, the solution adopted for the first river crossing (RC1) is discussed in greater detail. The text states that the "decision emerges from one's conceptual understanding (or unfortunately, one's misunderstanding) of the complex motion that is occurring."

In our interpretation, the reference to "misunderstanding" may be understood as referring to alternative treatments of the problem in PTB. The expanded discussion appears intended to provide additional mathematical and conceptual justification for the RC1 solution adopted in EX1.

Under these circumstances, we argue that the solution presented in EX1 for RC1 deserves careful consideration and comparison with the treatment commonly found in physics textbooks.

Example 1 [1]
Required (Figure 1):

1. *The resulting speed of the Motorboat (MB2)*
2. *The time required to cross the river bank with a width of l=80.0m*
3. *The distance downstream on the opposite bank that the MB2 will reach.*

It is assumed that the MB2 will cross the river straight (will aim straight for the opposite bank), so it will not reach the opposite bank at the point directly opposite the starting point because the river current, that will carry MB2 downstream (Figure 1). As a result, the resultant speed of MB2, R, relative to an observer on the bank, will be greater than 4.0 m/s. and inclined downstream.

1. Solution to Point 1
The Pythagorean theorem is applied to the resulting speeds:
$R^2=4^2+3^2$; *R=5 m/s*

2a. Solution to Point 2a
Direction. The angle θ_1 is determined trigonometrically:

$$\tan\theta_1=3.0/4.0;\ \theta_1=36.9° \ (36.86989)$$

2b. Solution to Point 2b
The time to cross 80.0m:

time=distance/speed.

From the known speeds, v_B=4.0m/s was chosen (and a lot of logic), and the time results were as follows:

$$t_1=80/4=20s$$

3. Solution to Point 3
The distance downstream is shown in Figure 1. The same equation from point 2b is applied. From the known speeds, v_C=3.0m/s was chosen (with some logical judgments), and the time results were as follows:

*distance=speed*time=3.0x20.0=60.0 m.*

Therefore, MB2 will be carried downstream at a distance of 60.0m while the river crosses".

These were the main ideas presented in EX1 from the PCR tutorial, as observed in December 2024 and January 2026, and briefly summarized above [1].

In the current version of the PCR website, EX1 is presented in a more extended form with a more detailed justification of the river-crossing solution. However, the numerical answers to the three questions remain unchanged compared with the earlier version.

Nevertheless, the precision of the calculation in EX1 is limited because the angle θ_1 (Figure 1), corresponding to the forward path, is given with only one decimal place. This level of precision is insufficient for more detailed comparisons.

3. Redoing the Calculation of Time t_{2a} from EX1 for BO2 at the First River Crossing, according to the Solution given by Current Physics Textbooks

We observe that EX1 from the PCR tutorial correctly and consistently describes, both mathematically and logically, the first half of the BO2 trajectory, namely the first river crossing (RC1) [1]. This corresponds to the first stage of the Two Swimmers/Boats Contest (TSC), which is widely known in physics textbooks as a double river-crossing problem.

It should be noted that, similarly to the TSC, there are other examples involving analogous motion problems (e.g., airplanes, boats, sound propagation) that must be solved using similar methods in EX1 and must yield comparable results regarding diagonal trajectories and crossing times t_{2a} as in EX1.

However, the value of the angle θ_1= 36.9^0, as presented in the tutorial and used in EX1, lacks sufficient precision. In the following calculations, we therefore use a higher precision value of θ_1= 36.86989^0 to ensure greater numerical accuracy and consistency in subsequent results.

Fortunately, the remaining results in EX1 are correct and consistent, including the diagonal trajectory inclined at θ_1= 36.9^0 and the first-crossing time of BO2: t_{2a}=20s.

The downstream displacement of BO2 is B=60.0m, which is also consistent with the theoretical solution we previously proposed in [2]. Thus, from [3], equation (4.7), or from [10], equation (1), we obtain the same time as in EX1.

$$t_{2a} = \frac{l_2}{c} = \frac{80}{4} = 20s \qquad (1)$$

However, across all examples in physics textbook chapters concerning river crossings by boats, planes, or swimmers, different values for the time t_{2a} at departure are currently accepted. Thus, from [13], equation (26.2), we obtain the following result for the EX1 case:

$$t_{2a} = \frac{L}{c\sqrt{\left(1-\frac{v^2}{c^2}\right)}} = \frac{80}{4\sqrt{\left(1-\frac{3^2}{4^2}\right)}} = \frac{20}{\sqrt{0.4375}} = \frac{20}{0.661437} = 30.2371578\ s \quad (2)$$

However, according to [13], the same time is obtained for the return journey:

$$t_{2b} = \frac{L}{c\sqrt{\left(1-\frac{v^2}{c^2}\right)}} = \frac{80}{4\sqrt{\left(1-\frac{3^2}{4^2}\right)}} = 30.2371578\ s \quad (3)$$

The total transverse time t_2, according to [13], is given as follows:

$$t_2 = t_{2a} + t_{2b} = 2 \times 30.2371578 = 60.474316\ s \quad (4)$$

This value is clearly less than the total longitudinal time t_1, which, according to standard classical calculations, is also consistent with equation (16) in Section 6:

$$t_1=91.428571s \quad (5)$$

$$\text{So: } t_2=60.474316s <91.428571s=t_1 \quad (6)$$

This result for t_2 from [13] is identical to that obtained in Michelson's analysis; however, it is considered incorrect in our framework because Michelson's analysis within MMX contains Errors 1 and 2, as we have previously demonstrated.

However, the author of EX1 in the PCR tutorial, for reasons that are not specified, does not continue the analysis to the second part of the BO2/TSC contest, namely the return journey.

In Section 5, where the correct solution for the return crossing (RC2) of BO2 is presented, the calculation contains several additional mathematical and theoretical difficulties, particularly of a logical nature. Some of these issues are also noted in EX1. These difficulties would need to be addressed and resolved if the RC2 case were treated in a fully consistent manner.

Notably, if the author of EX1 in the PCR tutorial had treated and solved part 2 of EX1 in the same manner as part 1—namely, the reverse crossing of the river by BO2—he would have obtained the same result as in [12], which we derived theoretically starting in 1996 and which is also obtained numerically in Section 5. Specifically, the reverse crossing time would be t_{2b}=71.428571s, yielding a total crossing time for BO2 of:

$$t_2=t_{2a}+t_{2b}=20.0+71.428571=91.428571s =t_1 \quad (7)$$

In (7), the resulting value of t_2 is identical to the corresponding value of t_1. If the author of EX1 had correctly computed the total time t_1 for the round trip of BO1, which moves parallel to the direction of the river current (a calculation that, according to Section 4, involves no mathematical or logical difficulties), over the same distance l_1=80.0m (Figure 1), he would have obtained t_1=91.428571s. In that case, the equality $t_1 = t_2$ would be observed directly. However, such a result is in clear contradiction with the results presented in standard physics textbooks, as reflected in equation (6) based on Michelson's analysis.

Furthermore, this equality of times derived in (7) is also in contradiction with the treatment presented in standard physics courses in the section on the Michelson interferometer experiment, as well as with the result for the Two Swimmers/Boats Contest (TSC) found in textbooks [13, Eq. (6)], which consistently states that $t_2 < t_1$. This inequality is used to justify the predicted fringe shift in the Michelson–Morley experiment (MMX) upon rotation of the apparatus and the corresponding conclusion that SW2/BO2 is the winning path.

However, no such fringe shift was experimentally observed in the Michelson–Morley interferometer, and the Two Swimmers/Boats Contest does not result in a clear winner but instead ends in a tie, according to the analysis in Section 4. Nevertheless, the predicted victory of SW2 or BO2 has not been experimentally confirmed.

Under these circumstances surrounding the solution of RC2 for BO2, the fact that the author of EX1 does not extend the analysis of BO2 to include the return path is not entirely unexpected, although no explicit justification is provided.

4. Presentation of the Correct Geometric Return Path of BO2 Following the Rules of EX1, Identical to NI16, in the BF Frame

However, in the following, we analyze the conditions of the return path RC2 of BO2 to its initial starting point O/BS (Figure 2).

In this analysis, we rely on the theoretical results previously obtained by us for this problem in MMX and the TSC framework [12].

At the same time, we apply the same mathematical and vector-calculation rules, as well as the principles of logical reasoning used in EX1 of the PCR tutorial by the author (including the conceptual justification discussed in Section 2).

We compute the relevant quantities for the second half of the contest, namely the return path of BO2 from point M on the opposite bank back to its starting point O/BS (Figure 2).

We also apply the fundamental principle introduced in our previous work [12], namely the precise definition of the reference frame used to describe the motion of the objects involved in the problem. In this case, we adopt a Cartesian reference frame Oxy attached to the river bank (BF), with the origin O fixed at the starting point of the boats on the initial bank, coinciding with the official start position (BS) of the contest (Figure 2). In Figure 2, angular quantities (e.g., L°) are denoted using the same capital letter as the corresponding vertex point of the angle (L° ≈ L).

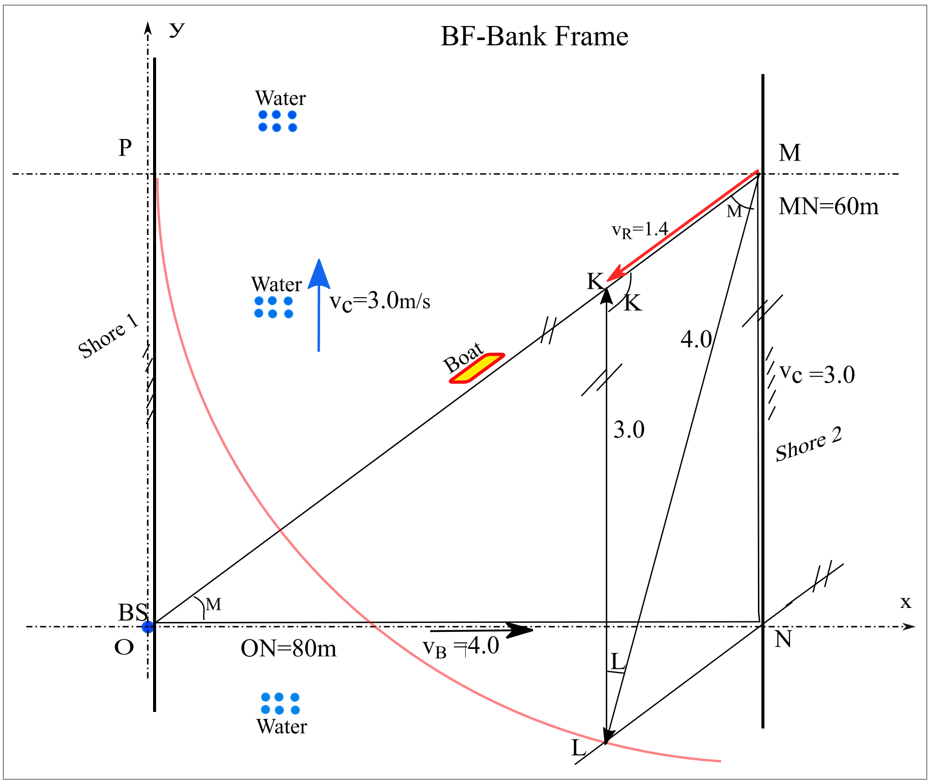

Figure 2: Scheme illustrating the composition of the resultant velocity v_R of Boat 2 from the vector sum v_B+v_C, together with the component distances along the second river-crossing trajectory in the River-Bank Frame (BF)

For the return journey, BO2 must retrace the same path (MO) (in the BF frame), following the reverse diagonal trajectory (path C from EX1; see Figures 1 and 2), in order to return to (O/BS),distance which also corresponds to the shortest return path to point (O).

However, when the situation is analyzed logically in a consistent vector framework, BO2 must maintain the same intrinsic boat speed v_B = 4m/s relative to the water, but with an initial orientation at point M such that the resultant velocity $v_{Cb}=v_R$ (Figures 1 and 2), obtained from the vector composition (v_B+v_C), is directed along the diagonal path (C/MO).

Consequently, the resultant velocity vector $v_{Cb}=v_R$ must form the same angle θ_1 as the forward resultant velocity v_{Ca} of BO2 during the outward journey, with magnitude θ_1=M=36.86989^0 (Figure 2), ensuring the return of BO2 to the starting point (O/BS) against the river current (Figure 2).

The magnitude of the resultant velocity during the return differs from that of the forward motion, since the relative directions of v_R and v_C are reversed in the two cases.

To achieve this orientation θ_1 relative to the river-bank normal, the boat operator at point M must direct the boat toward point (O/BS) at the moment of turning. This procedure does not require explicit knowledge of the numerical value of θ_1 and does not violate fair-play conditions.

Thus, by vector composition of the boat velocity v_B=3m/s directed toward (O/BS) and the river current velocity v_c =4m/s parallel to the bank, the resultant velocity v_{Cb} is obtained with the inclination angle θ_1=M=36.86989^0

Note 1: Under these conditions, the boat operator does not require precise information about either the angle θ_1 or the magnitude of the current velocity v_C. In contrast, in standard textbook treatments of similar problems, such information is typically assumed to be known in advance by operator, which would not be realistic in a fair-play contest setting.

In the present vector construction, the velocity components are no longer orthogonal, and therefore the Pythagorean theorem is not directly applicable, as it is in the first crossing of EX1. This is due to the planar vector composition of velocities, where v_B= 4.0 m/s is inclined at angle θ_1, while the river current velocity v_C =3.0 m/s is directed at 90^0 to the river bank.

In this way, triangle KLM (Figure 2) is fully defined. The magnitude of one side v_C=3.0m/s and the directions of the sides are known: the current is oriented along KL (parallel to the Oy axis or MN), while the resultant velocity is directed along MK or MO. Thus, in triangle KLM, one side length and two directions are known, so the triangle is geometrically determined.

To compute the remaining elements of the triangle required for determining the reverse crossing time t_{2b}, the following geometric construction steps are required (Figure 2):

- First, point M is located using the vectors ON=v_C=3m/s and NM=v_B=4,0m/s, drawn to scale with known directions (Figure 2).
- Then, in the triangle KLM, points L and K are determined as follows:
- A circle centered at M with radius MP=v_B=4.0m/s is drawn (Figure 2). From this construction, two possible variants arise:

Variant V1

- Point L is located at the intersection of a circle centered at M with radius ON=MP, passing through P, and a line through N parallel to side OM (Figure 2).
- Point K is located at the intersection of a line through L parallel to side MN and side OM, at point K.

Variant V2

- Points K and L lie on a line parallel to MN, positioned such that it intersects a segment of length KL = 3 (at the same scale of the drawing), between line OM and the constructed circle of radius MP. On this parallel line, points K and L are determined (Figure 2).
- As a result, triangle KLM is fully determined.

We observe that at point M, at the moment of BO2's return, Boatman 2 must perform a simple operation: he must direct BO2 precisely toward the starting point of the block-start O/BS on the opposite bank. In this way, he sets the direction of the boat's velocity v_B=4.0m/s, such that BO2 continuously follows the path MO, while the resultant velocity becomes v_R=MK=1.4m/s, according to Section 5 (Figure 2). Consequently, BO2 returns to the starting point O/BS after a time t_{2b}, which is computed in Section 5.

5. Presentation of the Calculation of the Return Time t_{2b} of BO2 Using the Rules in EX1, Identical to NI16, in the BF Frame

In triangle KLM (Figure 2), the angle at K can be determined as follows:

$$K=180-(-36.86989+90) = 180-53.13001=126.86989^0$$

We also know that *KL*=3.0m/s and *ML*=4.0m/s .

In triangle KLM, the length of side MK can be determined as follows:

From the sine rule, it follows that (Figure 2):

$$\frac{\sin K}{ML} = \frac{\sin M}{KL} = \frac{\sin L}{KM} \quad (8)$$

Therefore, it can also be written as:

$$\frac{\sin K}{ML} = \frac{\sin 126.86989^0}{4} = \frac{\sin M}{3} = \frac{\sin L}{KM} \quad (9)$$

However, we have:

$$\sin K=\sin 126.86989^0=0.80000$$

From the first equality of (8), we obtain:

$$\sin M=KL\times \sin K/ML=3.0\times \sin K/KL=3.0\times 0.80000/4=0.60000$$

The angles M and L are obtained as follows:

$$M=\arcsin 0.60000=36.869897^0$$

$$L=180-(K+M)=180--126.86989--36.869897=16.26021^0$$

$$\sin L=\sin 16.26021^0=0.28000$$

From the second equality in (8), we have:

$$\frac{\sin L}{KM} = \frac{\sin M}{KL} \quad (9b)$$

or: 0.28000/KM=0.6000/3.

The resulting speed is given as follows:

$$v_{Rb}=MK=0.28000\times 3/0.6000=1.40m/s$$

We can now calculate the time t_{2b} for BO2's return journey as follows (Figure 2):

$$t_{2b}=OM/v_{Rb}=OM/KM$$

However, according to the classical notation used in the MMX experiment and the equivalent Two Swimmers/Boats Contest (TSC), we have:

$$ON=l_2 \quad (10a)$$

$$OM = \sqrt{ON^2 + MN^2} = \sqrt{80^2 + 60^2} = \sqrt{10000} = 100m \quad (10b)$$

$$t_{2b} = \frac{OM}{v_{Rb}} = \frac{100}{1.40} = 71.428571s \quad (11)$$

The total round trip time of BO2 is as follows:

$$t_2 = t_{2a} + t_{2b} = 20.0 + 71.428571 = 91.428571s \quad (12)$$

6. Presentation of the Calculation of the Round-Trip Time to the Starting Point (BS) for BO1 Using the Rules of EX1, Identical to NI16, in the BF Frame

We now calculate the time required for BO1 to complete the round trip, where each segment of the trajectory has length l_{1a} and l_{1b}, respectively. In the BF frame, we have $l_{1a}=l_{1b}$(Figure 3).

In Figure 3, the BF reference frame is used as defined in [12].

The speed during the outgoing trip of BO1, in the direction of the current, is given by the resultant velocity v_{Ra}, obtained by vector addition of the two parallel velocities (Figure 3):

$$v_{Ra} = v_B + v_C = 4.0 + 3.0 = 7.0 \text{ m/s}.$$

The corresponding outgoing time is given by:

$$t_{1a} = \frac{l_{1a}}{v_{Ra}} = \frac{OP}{v_a} = \frac{80}{7} \quad (12b)$$

The speed during the return trip of BO1, opposite to the direction of the current, is given by the resultant velocity v_{Rb}, obtained by vector subtraction of the two velocities (Figure 3):

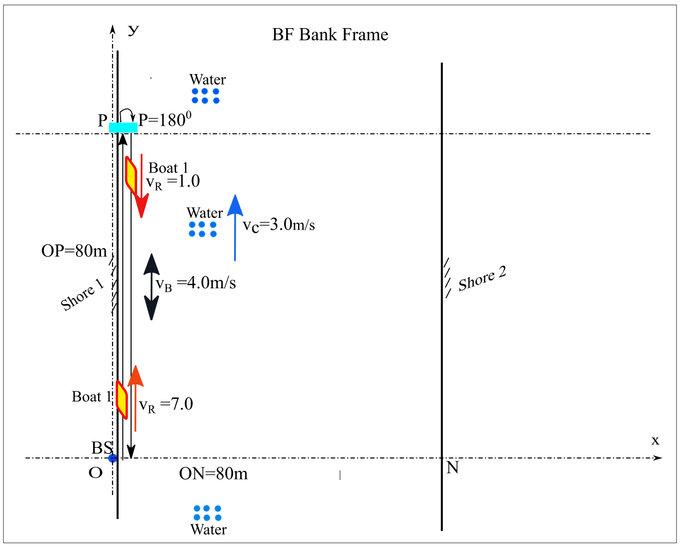

Figure 3: Scheme illustrating the composition of the two resultant velocities v_{Ra} and v_{Rb} of BO1, together with the component distances during the round trip in the River-Bank Frame (BF)

$$v_{Rb}=v_B-v_C=4.0\text{--}3.0=1.0 \text{ m/s}.$$

The time corresponding to the return trip is given by:

$$t_{1b}=\frac{l_{1b}}{v_{Rb}}=\frac{PO}{v_{Rb}}=\frac{80}{1}=80 \text{ s.} \tag{14}$$

The total round-trip time of BO1 is therefore:

$$t_1=t_{1a}+t_{1b}=\frac{l_{1a}}{v_{Ra}}+\frac{l_{1b}}{v_{Rb}}=\frac{l_1}{v_B+v_C}+\frac{l_1}{v_B-v_C}=\frac{2l_1v_B}{v_B^2-v_C^2}. \tag{15}$$

Numerically, we obtain:

$$t_1=\frac{2\cdot 80\cdot 4}{4^2-3^2}=\frac{160\cdot 4}{16-9}=\frac{640}{7}=91.428571 \text{ s.} \tag{16}$$

Therefore, if the two segments are equal, $l_2=l_1=80\,\text{m}$, from (10), (12), and (16), we obtain the equality of the two times:

$$t_2=t_1 \tag{17a}$$

Moreover, numerically, from (12) and (16), we obtain:

$$t_1=91.428571 \text{ s} = 91.428571 \text{ s} =t_2. \tag{17b}$$

We note that, from our previous theoretical analysis of the Two Boats/Swimmers contest in the WF frame [3], equations (4.1) and (4.18), or in [10], equations (26) and (27), the same time values for $t_1$and t_2 are obtained, consistent with the results derived in the WF frame and presented in Section 7.

$$t_2=\frac{2l_2}{c}\frac{1}{\alpha^2} \tag{18}$$

$$t_1=\frac{2l_1}{c}\frac{1}{\alpha^2} \tag{19}$$

7. Presentation of Previous Calculation of the Total Travel Times $t_1$and t_2 for Boats 1 and 2 in the WF Frame

In our previous work [12] on the Two Swimmers/Boats contest, we performed parallel analyses in the River-Bank Frame (BF) and corresponding calculations in the Water Frame (WF), where the computation is simpler, in order to determine the correct trajectories and subsequently evaluate the travel times t_1 and t_2 along the two orthogonal directions of motion of BO1 and BO2 (Figure 4).

The resulting expressions for the times $t_1$and $t_2$in the WF frame [11] were as follows:

$$t_2=\frac{2l_2c^2}{c\left(c^2-v^2\right)}=\frac{2l_2}{c}\frac{1}{1-v^2/c^2}=\frac{2l_2}{c}\frac{1}{\alpha^2} \tag{20}$$

$$t_1=t_1'+t_1''=l_1/(c+v)+l_1/(c-v)=\frac{2l_1c}{c^2-v^2}=\frac{2l_1}{c}\frac{1}{\alpha^2};with \quad \alpha=\sqrt{1-v^2/c^2} \tag{21}$$

Therefore, if $l_2=l_1$, then from (20) and (21) it follows that the final result of our previous calculations for the Two Boats/Swimmers contest in the WF frame is:

$$t_2=t_1; \quad ;and \quad \Delta t=t_2-t_1=0 \tag{22}$$

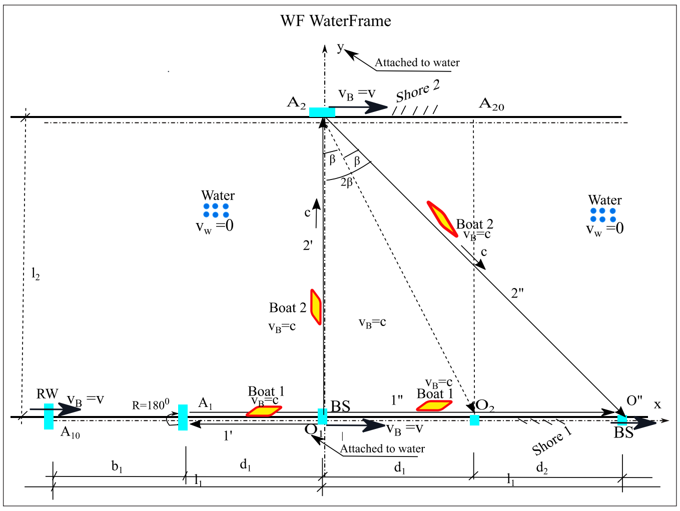

Figure 4: Scheme illustrating the composition of the round-trip paths of BO1 and BO2 in the Water Frame (WF), together with the component distances, yielding the same travel times $t_1$and $t_2$as in the River-Bank Frame (BF).

Therefore, it follows from (22) that the Two Swimmers/Boats contest ends in a tie, and that no fringe displacement should occur in the Michelson–Morley interferometer (MMX), as is in fact observed experimentally, because of time correct resultas in [22].

Thus, the nearly null fringe displacement measured in MMX should not be interpreted as a “failed experiment,” but rather as a theoretically explainable result under the assumption of ether existance

This result also implies that the Michelson–Morley experiment (1881/87) could not determine the relative velocity between the

Earth and the ether. Consequently, the ether hypothesis should not be regarded as having been eliminated from physics on the basis of Einstein's 1905 formulation of SRT.

8. Comparative Presentation of the Roads of Ray 2, according to MMX Containing Error 1, and according to TSC with Error 1 Corrected

The result of times t_2<t_1 obtained by Michelson is due to Errors 1 and 2 that he made in his Analysis within MMX [14].

Error 1 in Michelson's Analysis consists in the departure path of ray 2 wrongly chosen by Michelson to be inclined at an angle of 90^0+β, constituing Error 1 (Figure 5). Error 1 occurs because the plate P inclined at 45^0 in the interferometer (Figure 5) knows/can reflect light rays only at an angle of 90^0 when ray 2 from source s, arrives on the P disposed exactly at 45^0, according to optics (Figure 5).

It should be noted here that Michelson's drawing in [14] and reproduced with black lines in Figure 5, was represented in the reference frame of the Ether but without specifying an RF: EF (Ether frame), or DF (Device Frame), according to our permanently indications. This EF is true, because the parts of the interferometer (P plate,) move in the drawing, so the device cannot constitute an immobile reference support, but so, the Ether does.

But Michelson does not indicate anywhere the reference frame used, which could even have contributed to the occurrence of his Error 1.

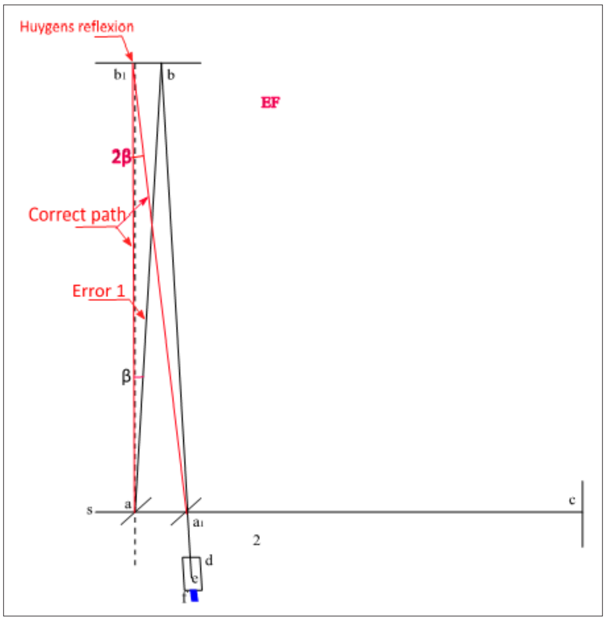

Figure 5: Representation of Figure 2. from [14] (using unspecified EF frame), indicating Michelson's Error 1, with ray 2 inclined at an angle of 90^0+β, but here we showing in red lines the correct path of ray 2 starting at 90^0 and reflected at an angle of 2β according to Huygens' principle of reflexion.

But the correct departure path of ray 2 is the one perpendicular to ray 1, so inclined at 90^0 and depicted with text and red lines in Figure 5.

And at point b_1 ray 2 is reflected according to Huygens' principle of reflexion, in any direction (same as in laser measurement), therefore also directly towards the observation/departure point a_1. This correct return path b_1-a_1 of ray 2 (Figure 5). actually occurred, because the light interference in the interferometer actually occurred, a fact possible only by the arrival there, including the ray 2, therefore the ray 2 reflected from point b_1, according to Huygens' principle.

This result of the correct path of ray 2 as a right triangle, synthetically presented in red lines (Figure 5). just above the reproduction of Michelson's original drawing in black from [14], which was considered by Michelson in EF, as a isosceles triangle, but containing Error 1 (Figure 5).

The Error 1 was studied by us in detail in the previous analysis [12] made on the contest of the two swimmers (TSC) which represents a faithful model of MMX.

The results obtained in the TSC, presented in detail in Figure 4, also using WF, equivalent to EF, giving the correct path of the swimmer SW2, in the form of a right triangle, and resulting for times again t_1=t_2. But the same correct, equal result of the times in TSC should be 100% obtained also in MMX if it will be correctly analyzed (Michelson's analysis must be corrected).

This result can be confirmed, observing the complete similarity of red paths of ray 2 from Figure 5. with paths of swimmer SW2 from Figure 4.

But through the calculations made by Michelson in his Analysis in MMX, based on the wrong path a-b-a_1 of ray 2, inclined at 90^0+β (Figure 5), so containing Error 1, also Michelson's Error 2 for times calculation t_2<t_1, resulted.

So the result of the practically null fringe displacement measurements in MMX, is explained by the error-free path a-b_1-a_1 with red lines in Figure 5, so MMX should no longer be considered the greatest negative experiment in physics as in AMSP, but a perfectly theoretically explainable experiment, in the case of the admitted presence of the ether, and a new correct analysis ".

9. New Calculation of the Total Travel Time $t_2$of BO2 in the BF Frame (Demonstration 5 of the Existence of MER12)

To reconfirm the results obtained in the WF frame (Section 7), we now compute the total time t_2 for BO2 in the BF frame, where the boat completes a round trip over a river of width l_2, with boat speed cand current speed v. The trajectories are represented in the BF frame (Figures 1 and 2).

We note that the calculation of t_2 in the BF frame involves greater mathematical and logical complexity than the corresponding computation in the WF frame.

For BO2, the full trajectory RC1+ RC2 is shown in Figures 1 and 2.

For the forward path RC1(segment OM in Figure 2, or AC in Figure 1), the resultant velocity of BO2 can be written as:

$$v_R^2 = ON^2 + NM^2 = c^2 + v^2, v_R = \sqrt{c^2 + v^2}. \quad (23)$$

However, the travel time t_{2a} is obtained most simply along segment ON (Figure 2), moving at speed c, similar to EX1:

$$t_{2a} = \frac{ON}{c} = \frac{l_2}{c}. \quad (24)$$

For BO2, the return path RC2 corresponds to the hypotenuse (MO) of triangle ONM in Figure 2. From the right triangle ONM, we can write:

$$M+L=90^\circ-M \tag{25}$$

From triangle KLM, we obtain:

$$K+M+L=180^\circ \tag{26}$$

or

$$K=180^\circ-(M+L) \tag{27}$$

Inserting (25) into (27) yields:

$$K=180^\circ-(90^\circ-M)=90^\circ+M=90^\circ+\beta \tag{28}$$

From (26), we can also write (Figure 2):

$$L=180^\circ-(K+M)=180^\circ-(90^\circ+\beta+\beta)=90^\circ-2\beta. \tag{29}$$

Now, from (8), we can write:

$$\frac{\sin L}{KM}=\frac{\sin K}{c}. \tag{30}$$

From (30), we obtain:

$$v_R=KM=\frac{c\times\sin L}{\sin K}=\frac{c\times\sin(90^0-2\,\beta)}{sin(90^0+\beta)} \tag{31}$$

The projection of KMon NO(Ox-axis) is (Figure 2):

$$KM_{pr}=\cos\beta\times v_R=\cos\beta\times\frac{c\times\sin L}{\sin K}=\cos\beta\times\frac{c\times\sin(90^0-2\,\beta)}{sin(90^0+\beta)}=v_{Rpr} \tag{32}$$

The time to return along the actual path *MO* (Figure 2) is equal to the time along the projected path *NO*, which corresponds to motion with the projected resultant velocity. Therefore:

$$t_{2b}=\frac{NO}{v_{Rpr}}=\frac{NO}{\cos\beta\times v_R}=\frac{l_2}{\left[cos\beta\times\frac{c\times\sin(90^0-2\,\beta)}{sin(90^0+\beta)}\right]} \tag{33}$$

Thus:

$$t_{2b}=\frac{l_2}{cos\beta}\times\frac{sin(90^0+\beta)}{c\times sin(90^0-2\beta)}=\frac{l_2}{c}\times\frac{sin(90^0+\beta)}{cos\beta\times\sin(90^0-2\beta)} \tag{34}$$

Using the trigonometric identities:

$$\sin(90^\circ+\beta)=\cos\beta,\cos2\beta=2\cos2\,\beta-1,$$

equation (34) becomes:

$$t_{2b}=\frac{l_2}{c}\times\frac{cos\beta}{cos\beta\times\cos2\beta}=\frac{l_2}{c}\times\frac{1}{cos2\beta}=\frac{l_2}{c}\times\frac{1}{2cos^2\beta-1} \tag{35}$$

We also use, from trigonometry:

$$\cos^2\beta=1/[1+tg^2\beta\ ]$$

$$t_{2b}=\frac{l_2}{c}\times\frac{1}{2\cos\beta^2-1}=\frac{l_2}{c}\times\frac{1}{\frac{2}{(1+tg^2\beta)}-1}=\frac{l_2}{c}\times\frac{1}{\frac{2-1-tg^2\,\beta}{1+tg^2}}=\frac{l_2}{c}\times\frac{1+tg^2\,\beta}{1-tg^2\,\beta} \tag{36}$$

Hence:

$$t_{2b}=\frac{l_2}{c}\times\frac{1+{v^2}/{c^2}}{1-{v^2}/{c^2}} \tag{37}$$

Therefore:

$$t_{2b}=\frac{l_2}{c}\cdot\frac{c^2+v^2}{c^2-v^2}. \tag{38}$$

The total travel time t_2 of BO2 for the two river crossings is:

$$t_2=t_{2a}+t_{2b}=\frac{l_2}{c}+\frac{l_2}{c}\times\frac{c^2+v^2}{c^2-v^2}=\frac{l_2}{c}\left[1+\frac{c^2+v^2}{c^2-v^2}\right]=\frac{l_2}{c}\frac{c^2-v^2+c^2+v^2}{c^2-v^2}=\frac{l_2}{c}\frac{2c^2}{c^2-v^2}=\frac{2l_2}{c\left(1-{v^2}/{c^2}\right)}=\frac{2l_2}{c}\frac{1}{\alpha^2} \tag{39}$$

In (39), we define classically:

$$\alpha^2=\frac{1}{1-v^2/c^2}. \tag{40}$$

Equation (39) shows that the total time t_2 of the double crossing of BO2 in the BF frame is obtained, which is equal to the total time t_2 in the WF frame [11,12].

Moreover, the times t_1 and t_2 are equal in both frames, i.e., $t_1=t_2$.

These results suggest that Michelson's analysis in MMX contained Error 1 and Error 2, as they were identified and corrected in NI16, including the reintroduction of ether by us since 1996.

10. Conclusions and Consequences

From the above contest analysis for the BO/TSC, which is also applicable to the MMX analysis, and using the correct rules from our previous Demonstrations 1, 2, and 3 (constituting NI16, initiated in 1996), together with the rules presented in EX1 from the PCR Physics website (intended for training physics teachers and students), the correct travel times for BO1 and BO2 result in $t_1=t_2$.

However, this result does not coincide with the times given in standard physics textbooks, which state that $t_1>t_2$. This suggests, in our view, the existence of MER12 in these textbooks, arising from Michelson's erroneous MMX analysis, as demonstrated in NI16. Therefore, the result $t_2=t_1$, obtained by also applying the rules in EX1, constitutes Confirmation 4 of the correctness of NI16.

At the same time, we previously calculated the total time t_2 for BO2 in RC1 + RC2. However, this was our first analysis in the more complex BF frame, for the general case of the TSC or MMX, which again yields $t_1=t_2$. This calculation constitutes Demonstration 5 of the existence of MER12 in Michelson's analysis.

From the main result $t_2=t_1$ obtained in the BOs/TSC contest analysis, and applied also to Michelson's MMX experiments (1881/1887), where MER12 was identified and corrected, it follows—within this framework—that the ether should no longer be excluded from physics, as Einstein did in 1905, relying on the then-uncorrected interpretation of MMX.

Based on the results from NI16 regarding TSC and MMX, including those presented in this manuscript, it is argued that corresponding revisions would be required in the relevant chapters of current physics textbooks, or alternatively that the PCR website should be updated accordingly.

From the reintroduction of the ether concept in this framework, several further consequences are developed, including the formulation of the HM16 ether model (currently under development).

Additional principles and implications of ether existence have also been derived, beginning with a new theory of gravitation (NTG16), followed by a broader New Physics Theory (NPT16), both of which remain under development and are intended to be extended across multiple branches of science.

NTG16 is based on interactions described in terms of mechanical forces between electric dipoles F_{DC}. These dipoles constitute matter according to a completed Coulomb-type interaction F_{CC}, acting between microparticles (MPs) through mechanical vibrational or impulsive interactions p_i transmitted via the ether.

In this model, a microparticle (MP) is composed of structured ether cells (ECs), which vibrate and/or gyrate with energy equivalent to the rest mass m_0 of the MP. These motions generate fundamental vibrations (FVs) in the surrounding ether, associated with charges of type $+q$ and $-q$. MPs also interact through impulsive forces p_i, which depend on the type of charge. Depending on whether MPs undergo translational or rotational motion, these interactions are associated with the emergence of effects analogous to electric fields E and magnetic fields H.

Some consequences derived from NI16 have been summarized above; however, their full scope, along with additional implications, remains open for further investigation within a proposed New Stream in Physics (NSP), which may initially extend CMSP.

All these consequences are presented as logically and mathematically derived from NI16 within the stated framework.

Conflict of Interest

The authors declare that they have no conflicts of interest related to this manuscript.

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