The Empirical Interpretation of Time Dilation in Special Relativity

Harry H. Ricker III
114 Parkway Drive, Newport News, VA 23606
e-mail: kc3mx@yahoo.com

This paper takes a look at the interpretations of the physical concepts of time in special relativity, which is usually interpreted in terms of time dilation. The usual understanding of the theory is that the postulate of the constancy of light velocity implies a change in the structure of space and time, or as it is usually termed "space-time". This interpretation is reassessed from a different viewpoint and it is found that with respect to the experimental evidence, the interpretations given within the context of special relativity are not logically consistent or supported by the facts of experiments or by engineering practice in the GPS system. The failure to find a clear and convincing argument which connects the postulates of special relativity with the experimental facts shows that the theory has no substantial empirical verification and should be rejected.

1. Introduction

This paper takes a revisionist look at the interpretations of length contraction and time dilation that typically arise in discussions of the special theory of relativity. The usual understanding of the theory is that the postulate of the constancy of light velocity implies a change in the structure of space and time, or as it is usually termed "space-time". The usual understanding is that space is contracted and time is dilated in order to establish that the velocity of light is always measured to be a constant value called *c*. Furthermore, it is claimed that these effects are observed in experiments that validate the theory.

In this paper, two aspects of the empirical predictions derived from the theory through its mathematical implementation are examined. In the first case, the theory of the Michelson-Morley Experiment (MMX) is re-examined from the viewpoint of a change in time rather than change in space. In the MMX, the null result is interpreted as the result of a contraction of time in the longitudinal direction of motion. This is analogous to the Lorentz contraction of space, which has never been observed.

The second aspect examined is the problem of the inconsistent prediction of time dilation that produces the twin and clock paradoxes. The way this difficulty is avoided in special relativity is based upon the claim that there is no absolute simultaneity. However, the empirical facts which support the implementation of the Global Positioning System (GPS) imply quite a different conclusion. The GPS relies upon the Global implementation of an absolute system of time for the earth and an orbiting system of satellites. This refutes the claim that time is a purely relative phenomena and hence the empirical evidence refutes the fundamental claim of relativity of simultaneity that is the foundation of relativity theory.

Based upon these two different methods of approach, it is concluded that there is no empirical support for the frequently made claims that appear in the scientific literature that the relativity theory is well verified by the experimental evidence.

1.1. Background

The controversial nature of Einstein's theory of relativity has been the focus of discussion in the physics community since its acceptance as valid physics in the second decade of the last century. This critical discussion and lingering skepticism remains a focus of the NPA relativity discussion group after 100 years of acceptance of the relativity theory by mainstream physics. The continuing skepticism regarding the validity of relativity stems from the rather obscure nature of its fundamental ideas, its clumsy mathematical demonstrations, and its lack of a clear and easily demonstrable empirical foundation and experimental validation [1].

The objective of the theory of relativity is the unification of the Maxwell-Lorentz electromagnetic aether theory, with the Galilean relativity principle. Unfortunately the drastic modifications required of the Newtonian mechanics made this unification controversial as many rejected the modifications required of Newtonian mechanics. The unification also requires the imposition of the relativity principle upon the aether based electromagnetic theory of Maxwell-Lorentz and that continues to be the main weakness of the proposed unification, since the imposition of the relativity principle in electromagnetism results in a very paradox rich result.

The resulting theory employs two postulates written in such a way that they are not subject to experimental or theoretical validation. The first postulate states that there exists a stationary or rest frame in which the velocity of light is constant and isotropic value independent of the state of motion of either the source or observer. This is essentially the postulate of the electromagnetic theory of Maxwell-Lorentz. The second postulate, which is the essence of the controversy, states that the properties of the first postulate, that is the constant and isotropic nature of the velocity of light, which is independent of the source and observer motion, applies to more than one frame of reference. The essential character of Einstein's theory of relativity is the attempt to frame these two different postulates in a manner which appears to constitute a mathematically consistent theory that has been thoroughly empirically verified [2].

Unfortunately, this program of unification via the construction of two postulates which incorporates the aether hypothesis of Maxwell-Lorentz with the relativity principle of Galileo requires addition suppositions and modifications. The main one of

these is the supposition that the measurement of time is not absolute but relative. This is known as the relativity of simultaneity. This concept involves an ambiguity which obfuscates the problem of time measurement.

In time measurement there are two difficulties. The first is the definition of a clock unit second, known as the standard time unit, and the establishment of a universal instant of time as a date or coordinate of measure. This later concept is the main difficulty in that relativity denies as a fundamental principle that it is possible to establish such a universal or absolute measure of simultaneity. Such a claim boils down to the impossibility of establishing a fixed system of coordinated time measurement.

1.2. Approach

The method of approach used to investigate the empirical support for the fundamental ideas that are embodied in the theory of relativity begins with a close examination of the empirical foundation of the theory which Einstein clearly defined as embodied in the Michelson-Morley experiment. That this is the empirical foundation of his theory was made clear in his papers following his initial paper published in 1905, which left the empirical foundation of his physical approach unexplained. Here we will see that his claims regarding time dilation are incompatible with that experiment [3].

The second aspect addresses the attempted imposition of the relativity principle through the use of the relativity of simultaneity. It is well known that the claim that there are multiple rest frames in relative motion for which the velocity of light is a fixed isotropic constant produces paradoxes. The clock and twins paradoxes being very well known. These paradoxes are claimed to be real relativistic effects because of the relativity of simultaneity. Under this type of argument, the proofs produced by Herbert Dingle and others, including this writer, have been refused by mainstream science. Such refutations of proofs that the relativity theory is a mathematically inconsistent system of equations rely upon the unproved claim that there is no such thing as absolute simultaneity. Obviously if a system of absolute simultaneity could actually be constructed, this claim would be rendered false and the relativity theory rendered totally obsolete. Such a system actually exists in the form of the Global Positioning System (GPS) and this will be used to demonstrate that the claims of relativists are entirely false based upon empirical and theoretical arguments.

1.3. Objectives

This paper will demonstrate that the conception of time dilation, that is an increase in the duration of physical processes in moving frames relative to rest frames is incompatible with the concept of length contraction. The fundamental empirical evidence for this incompatibility is found in the Michelson-Morley experiment. In addition, it will be shown that the idea of symmetrical time dilation is incompatible with the empirical foundations of the Global Positioning System (GPS). Finally, it will be shown that the inherent difficulty that invalidates the ideas of relativity derive from a fundamental hypothesis that there is no absolute simultaneity used in that theory. This hypothesis is used to obscure the fact that the claims of time dilation are mathematically impossible in concert with the idea of length contraction. It is shown that as a physical hypothesis this assumption is empirically impossible and that the GPS is an example of a physical system that operates entirely with the hypothesis that there is an absolute system of time simultaneity in contradiction to the claims of Einstein's relativity theory.

2. The Measurement of Velocity

When we are dealing in physics we are concerned with the measurement of physical entities. The one we are concerned with here is velocity. There is immediately a difficulty. One cannot measure a velocity unless one establishes a fixed measurement of either time or space. Here we will talk about distance or length as a measure of space. To measure velocity, one establishes a known measure of distance and measures the time to traverse this known distance or length. The average velocity to cover the fixed measured distance is calculated by dividing the fixed measured distance by the measured time interval to traverse the fixed distance. This is the procedure Einstein assumes in his analysis. There is however an alternative method, that is to measure the distance traversed in a specified or fixed interval of time. However, this method is not very practical, so the first method is the preferable one that is almost always used in practical applications. That is the time to traverse a fixed known distance is measured.

The two methods can be understood as forming a kind of duality. The first method fixes distance, and measures time while the second method fixes time and measures distance. The duality is formed by interchanging the roles of time and distance. This duality will be an important conception in the discussion that follows regarding the Michelson-Morley Experiment, which is abbreviated as MMX. The MMX is taken to be the foundation of the special relativity theory as discussed by Einstein in his papers written after 1905.

2.1. MMX from the Space or Distance Viewpoint

In the MMX, the usual interpretation is that it measures the time to traverse two different fixed distance courses, which are simultaneously compared for two different directions in space. An interference of light is used to measure "fringe shifts" where a fringe shift is a change in the phase of the interfering light beams that traverse the different paths. The meaning of these words deserves detailed discussion. There is an assumption that the earth is moving through space and that this motion ought to change the time for the light to traverse different directions in space because of the velocity addition effect. That is the vectorial addition of the earth velocity and the light velocity is different at different times and orientations of the instrument because of the motion of the earth, which includes an orbital velocity component and a rotation component. No difference in light time to traverse the same path in different directions is detected by this experiment which leads to two historical hypotheses for explaining this result. One is the length contraction hypothesis of Fitz-Gerald and Lorentz, and the other is the constancy of light velocity hypothesis of Einstein.

Length contraction assumes or postulates as an axiom that there is a physical change in the distance traversed by the light when it moves in different directions. That is that the addition of velocity of earth to the light velocity implies a change in average

velocity for the path so that there should be a time difference. No such time difference occurs and so it is supposed that a change in length of the travel distance arises that makes the travel times the same. This distance change is a change that makes the distance traveled less than the rest distance traveled. So the length is said to contract in motion.

The assumption used, is that there is a change in velocity that would increase the time of flight so that to compensate for this effect a decrease in distance is required to make the travel times the same. This hypothesis, which is called the FitzGerald-Lorentz contraction, has the consequence that it makes the measured velocity of light the same in all directions of an abstract space, in which the earth is supposed to be in motion, exactly the same. In other words, the hypothesis of space contraction makes the velocity of light an isotropic constant for the purpose of the explaining the MMX result that the time to traverse different paths is unchanged.

Einstein assaulted this explanation and disparaged the hypothesis of FitzGerald and Lorentz as an ad hoc hypothesis. He introduced two postulates, which he claimed better solved the dilemma presented by the MMX. This was probably a mistake as Einstein later tried to modify his two postulates and make them into only one. The hypothesis that is usually invoked is the constancy of light hypothesis. But this is not really a different hypothesis form the hypothesis of the FitzGerald-Lorentz contraction.

The difference is that FitzGerald and Lorentz assume the length contraction effect to achieve the result that the directional velocity of light is a fixed constant for all directions in space surrounding the earth. Einstein simply reverses the process, by assuming a constant velocity and then deduces that this implies a contraction of space or distance and length. The reader should mark and take note of this conclusion. That is that the light constancy hypothesis of relativity and the FitzGerald-Lorentz contraction hypothesis amount to essentially the same thing. This is an unfortunate fact that relativists, those who embrace Einstein's relativity theory, don't appreciate. This consequence of this is that there is no way that the MMX can prove relativity or disprove the Lorentz aether theory. Additional facts are needed to do that.

2.2. The MMX From the Time Viewpoint

In the preceding it was supposed that it was space or distance or length that was changed in motion. If we suppose that time changes what is the result? This problem has not been examined to my knowledge. It is obvious that if a contraction of distance makes the velocity of light constant for all directions in space, then a complementary contraction in time should accomplish the same result. Here we see that there is a distinct discrepancy that arises.

In the time viewpoint, the interpretation of the experiment can be "dualized" as discussed above, by interchanging the roles of time and space or distance. We can view the null in fringe shift as indicating that the two beams traverse, in the same times, the same distances rather than as traversing the same distances in the same times, because we are taking the time viewpoint of distance measurement. Since in either case there is no shift or change in the fringes when the orientation of the instrument is changed, it is immaterial which viewpoint we choose to take, but it is important that one or the other viewpoint is defined. As discussed above, the FitzGerald-Lorentz contraction hypothesis results when one takes the view that it is a time difference that is being measured, so that the null result is attributed to a change is length.

In the hypothesis of length contraction it is obvious from the usual measurement of velocity, that measures the time to traverse a fixed distance, that to make the time the same the distance is decreased or contracted. It is not so obvious that a similar effect ought to be deduced for time. That is that the time has to contract or speed up in order for the velocity of light to be perceived to be a constant in the MMX. This result is most obvious from the principle of duality, that says that simply interchanging the roles of time and distance produces a second true statement about the theory. In this case, however, the theory apparently is incorrect because it asserts that a contraction of time implies that time is slow or dilated. This is, sadly, an unfortunate blunder, and the correct result must be that time speeds up for the light in one of the beams, so as to insure that the beams arrive at the interference point, so that they have traversed the same distance in the same recorded time. Thus, in order for the speed of light to be constant in the MMX, it is required for the distance viewpoint that distance contract and for the dual viewpoint that time contract as well. (But not both at the same time. It is one or the other, but not both.) Since relativity asserts that time dilates, that theoretical deduction is obviously in error from the viewpoint of the MMX.

The conclusion of this section is that, based upon the MMX as the critical empirical information, the hypothesis that the velocity of light is a constant independent of the motion of the earth, is essentially the same as two dually equivalent hypotheses: That the distance is contracted in the direction of earth motion, or that the time of light travel applicable to the light in the direction of motion is contracted. The second hypothesis is equivalent to the idea that time speeds up or goes faster. This conclusion contradicts the conclusion of special relativity theory, which uses a different method to reach the conclusion that time is dilated or slows down [4].

3. Time Dilation In Special Relativity

This section takes a simplified traditional look at the derivation of the time dilation prediction of special relativity. The method was introduced by Einstein in his first paper and remains in use. The difficulties in this method were pointed out by Dingle who demonstrated that the derivation of a time dilation based on the principles of special relativity has no unique solution. The result of a time contraction i.e., that clocks run fast is just as valid as that clocks run slow. In fact, there is no physical reason why either one of these should be preferred over the other based upon the principles of special relativity.

Einstein derived the claim of a time dilation, rather than a time contraction, and gave no reason for this arbitrary choice. In the preceding section we see that according to the MMX experiment, the prediction should have been one of a time contraction. In other words, given a purely theoretical analysis devoid of any physical conditions, the result has no unique determination. However, in light of the MMX experiment and the result of a

length contraction derived from that, the resulting prediction derived by Einstein should have been a time contraction and not a time dilation as he predicted. This is problem number one. Stated as follows, there is no theoretical reason for the prediction of time dilation as opposed to time contraction in special relativity, while the empirical evidence derived from the MMX indicates that the correct prediction should be a time contraction. Hence, there is a discrepancy.

3.1. The Clock Paradox Discrepancy

The second discrepancy, discussed here, is the more serious one. There is nothing new in the method of approach as the argument is an old one discovered by Dingle in the 1950s and thoroughly debated in Nature during the 1960s. What is new in this discussion, is the way that the argument used by relativists to avoid the difficulty is refuted by the use of absolute simultaneity in the GPS.

The argument is outlined as follows. The objective is to calculate the length of the unit second in the moving frame as a function of the unit second defined in the stationary frame. The method proceeds by seeking a solution of the Lorentz transformation for the condition $x = 0$. The solution is $t' = \beta t$, where the beta symbol is defined as the relativistic factor in the usual way. This is the basis of the time dilation prediction, because the length of a unit second in the moving frame t' is predicted to be β times the length of the unit second in the stationary frame. Here the symbols t and t' refer to the length of the unit seconds. Hence, since the unit second is predicted to be longer in the moving frame the scale of time in that frame is said to be dilated.

The difficulty arises in the following manner. The same procedure, when applied to the calculation of the length of the unit second in the stationary frame, now taken to be moving relative to the moving frame, is solved as follows: $t = \beta t'$, where the symbols have the same meaning as before. Here the inverse Lorentz transformation was solved for the condition $x' = 0$. Hence, we have the following two simultaneous equations that must be solved: $t' = \beta t$ and $t = \beta t'$. There is one and only one such solution, $t = t'$ for the case where $\beta = 1$, which occurs when $v = 0$. Hence the conclusion derived from the mathematics of the simultaneous solutions must be that the equations of special relativity can only be solved for the trivial case, $\beta = 1$, when there is no relative motion of the coordinate frames of reference. This problem is also known as the clock paradox or the twin paradox. There are similar paradoxes involving the length contraction.

The point of this discussion is that these paradoxes result when one attempts to solve the two simultaneous equations for the transformation of the unit second between relatively moving frames of reference. A procedure that is the basis of the predictions of the entire relativity theory. The proof shows that no solution is possible when the reference frames are in relative motion. Therefore one wonders, why are these predictions accepted in the theory when the obvious conclusion is that such solutions are not mathematically valid? The answer is that the proponents of the relativity theory claim that the proof is invalid because there is no such thing as absolute simultaneity, and since the proof relies upon the simultaneous solution of the two equations, then that claimed solution is an invalid concept within the theory [5].

3.2. The Problem of Relativity of Simultaneity

The relativity of simultaneity is the way that W.H. McCrea and others refused Dingle's arguments during the debates published in *Nature*. McCrea's argument is that the symbols t and t' do not have the same meaning when applied to the solution of the Lorentz and inverse Lorentz transformation equations. That is to say that the definition of the unit seconds are different for the two cases of solution. Of course this argument seems to be merely an ad hoc evasion of the difficulty. If the definitions of the symbols do not have a definite meaning in the simultaneous solution of both equations then they cannot have any definite meaning in the non simultaneous solutions either. This conclusion thereby invalidating the basis of the time dilation predictions of the theory.

The solution to the difficulty, used by relativists, is to appeal to the relativity of simultaneity as the justification for the refusal to accept the obvious conclusion of the mathematics, that the equations of relativity used to predict time dilation are invalid for reference frames in relative motion, and the only solutions arise for the case of absolute rest. In other words, the relativity theory of Einstein is invalid for frames in relative motion and the Lorentz transformations can only be used to obtain solutions where there is an absolute rest frame which defines a system of absolute rest. Hence the difficulty is as follows. The mathematical analysis leads to the conclusion that the relativity theory is invalid, because its two postulates cannot be applied to multiple frames of reference as claimed by Einstein and so the theory reduces to the absolute aether frame theory of Maxwell and Lorentz which relativity was intended to replace. This conclusion is unacceptable to many physicists and so they rely upon the claim that the principle of the relativity of simultaneity invalidates the physical basis for the claim that relativity is invalidated by the mathematical proof presented here.

3.3. GPS Evidence Against Relativity of Simultaneity

The principle of relativity of simultaneity is at the most basic level the foundational principle of relativity. It implies that there is no absolute system of time measurement. The claim is difficult to comprehend given the modern establishment of a universal system of time UTC. This system of universal absolute time has a specific physical implementation in the Global Positioning System or GPS.

There are two claims of relativity, that the GPS shows must be false. The first is the claim that there can be no system of absolute simultaneity. The second is the symmetrical nature of the time dilation prediction. In the GPS system the empirical application of both principles is negated. In the first place an absolute universal system of time, a universal now is postulated and used as the basis of the fundamental principle of the system design. That is, there is postulated in the GPS design, the ability to construct a system of global position measurement based upon the validity of one way velocity of light as a constant *c*, and the use of this constant combined with a universal system of time to measure position on the earth. The use of this fact in the system design contradicts the fundamental principles of relativity.

The GPS system uses the empirical fact of time dilation to correct the clocks in orbiting satellites, but does not apply the required symmetrical time dilation to the clocks in the ground re-

ceivers. Hence, the GPS implementation does not incorporate the symmetrical prediction of clock dilation of special relativity. This makes sense since it is known from the clock paradox discussed above that there is no mathematically permitted simultaneous solution that produces a time dilation effect for both the orbiting and ground clocks simultaneously. That proof was shown in section 3.1. The conclusion that must result from the empirical facts derived from the GPS implementation is that the principle of relativity of simultaneity does not apply to the GPS system and so its claim that there is no way such a system of absolute simultaneity can exist is refuted by the physical implementation of GPS.

4. Conclusion

The fundamental problem of Einstein's relativity is that it is based upon philosophical principles. Such principles cannot be proved or disproved by theoretical reasoning, but must make appeal to empirical facts to see if the philosophy is reflected in the facts of nature. In the case of Einstein's relativity, we find that although the philosophy of the relativity of reference frames is persistently claimed to be demonstrated by the facts, such claims remain elusive to prove empirically, while the theoretical proof remains mired in controversy.

4.1. Conclusion

There are two main conclusions. The first one is that the claim that relativity predicts a time dilation effect, which is verified in empirical evidence, is unsupportable. That means that it is not possible to use the Lorentz transformation equations to predict a time dilation effect. As shown here, one can see that this prediction is not unique and that a time contraction should be expected based on the evidence of the MMX and similar experiments. The second conclusion is that the claim that the principle of relativity applies when using the Maxwell Lorentz electromagnetic theory in inertial frames of reference in relative motion is invalid. A mathematical proof of this fact has been demonstrated and it is further shown that this proof is validated in the GPS system design. Hence there is no empirical evidence that supports either the time dilation prediction or the concept of relativity of simultaneity in the empirical facts derived from the GPS.

4.2. The Main Conclusions Further Discussed

The usual procedure in empirical science is to validate the philosophical principles employed in a theory through experimental test. The procedure demands that the theory clearly demonstrate that the experimental predictions follow from the principles in a unique manner. Such a demonstration has not been possible with the theory of relativity, because of its well documented controversial paradoxes.

The empirical basis of the claimed experimental validity of special relativity rests primarily upon the observations of time dilation in the Ives-Stillwell and muon decay experiments. There is further apparent confirmation in the GPS system, which employs the time dilation predictions of relativity and sees in the successful application of these principles a confirmation of the theory. In this paper it has been shown that the prediction of time dilation cannot be shown to follow from the fundamental principles of relatively. Instead it is shown through an analysis of the theory, that the MMX experiment implies that the correct prediction ought to be a time contraction effect, which has unfortunately not been experimentally confirmed. Hence one cannot conclude that the claimed experimental validation of special relativity, due to the experimental observations of time dilation constitutes an empirical validation of that theory, because the time dilation prediction does not uniquely follow from the principles of the theory. In fact it leads to paradoxes, which cannot be resolved in the theory without recourse to the principle of the relativity of simultaneity.

Underlying special relativity is the claim that there is no principle of absolute simultaneity that can be applied in physics. Hence any empirical evidence that shows that such a system of absolute simultaneity does exist is a disproof of the fundamental principle upon which the relativity theory is based. Such a system of absolute simultaneity exists in the GPS implementation. Hence, the fundamental basis of the relativity theory which resides in the claim that there is no possible way for the one way velocity of light to be measured is disproved. The GPS system in fact, relies upon the establishment of an absolute universal system of time and the known one way velocity of light to establish the positions of ground receivers at any location around the world. The system depends on two established facts, the existence of an absolute universal coordinate time, and the isotropic constancy of the velocity of light in an absolute rest frame. Both assumptions which the theory of relativity denies.

4.3. Final Remarks

Einstein's relativity theory has been marred from its inception by controversy and disagreement. That problem has persisted for 100 years, and the controversy over the validity of relativity has not abated. No definitive arguments or empirical facts have been discovered that resolves the controversy. The emergence of the GPS in the last 20 years has only increased the difficulties for the relativity theory, because the GPS design principles do not confirm the philosophical principles of the relativity theory. Hence the members of the NPA are fully justified in rejecting the unproven relativity theories and justified in exploring alternatives [6].

References

Referenced sources for author's work can be found at the General Science Journal (*GSJ*): http://wbabin.net/papers.htm#Ricker/ and at the author's page in the World Science Database (*WSD*): www.worldsci.org.

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