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An Analysis of the Theoretical Foundations of Special Relativity

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The concept of the relativity of time, space and simultaneity as specifically proposed in the Special Theory is proven to be logically untenable. It is shown that assumptions regarding absolutism or relativism cannot be substantiated within the context of the two postulates and that a re-interpretation of the constancy of the speed of light effectively accounts for the null result of the Michelson-Morley experiment.

1. INTRODUCTION

The Special Theory has withstood the scrutiny of countless investigators over the past ninety years and has become one of the intellectual cornerstones of modern physics. Despite this, it is contended that the kinematic aspects of the theory contain a number of serious philosophical and logical inconsistencies which effectively nullify it as a basis for dynamic considerations. Among these are the unsatisfactory interpretation of the first postulate, the arbitrary limitations imposed on the means to determine synchronism and simultaneity, and the total exclusion of one-dimensional aspects in the justification for, and calculation of space-time modifications.

2. THE SPEED OF LIGHT

In his original paper on the Special Theory [1] , Dr. Einstein confirms the Galilean equivalence of inertial frames of reference and adds a second postulate which states -

"...light is always propagated in empty space with a definite velocity [c] which is independent of the state of motion of the emitting body."

There is at least an implied ambiguity in this postulate since he later states -

"Any ray of light moves in the "stationary" system of coordinates with the determined velocity [c], whether the ray be emitted by a stationary or by a moving body"

We may therefore identify two possibilities regarding the convection of light. It may be assumed an universal constant independent of all frames of reference, or conversely, it may be assumed to propagate at a constant speed in any direction only within the observer's frame of reference. In an Euclidean (isotropic) space-time continuum, the former would result in compound velocities for a frame of reference moving relative to the beam unless contraction-dilation effects were introduced. The latter possibility requires no such modifications, but does not preclude same. It should be noted that in either case, **light can only be measured in the observer's frame of reference**.

It is further stated by Dr. Einstein that a common time for coordinates A and B occupying the same inertial frame and separated by a distance cannot be defined unless it is established by definition that the time required by light to travel from A to B equals the time from B to A. Since experiments to accurately determine the speed of light have, to this point, been averages of two-way motion, this arbitrary definition is of no practical use unless an Euclidean space-time continuum at absolute rest is assumed . Averaging is confirmed by Dr. Einstein since he states -

"In agreement with experience we further assume the quantity $2AB/(t'_A - t_A) = c$ *to be a universal constant-..."* , (where t and t' are the initial emission and final arrival time at point A.)

Note that with variable space-time and averaging, there is no conceivable way that a quantitative evaluation of the "universal" speed of light can be made. As Newton stated some three centuries ago [2] ,

"Wherefore, entire and absolute motions can be no otherwise determined than by immovable places;..."

The Minkowski substitution of an abstract, supra-ordinate continuum for the fixed ether may be adopted but this is excessively metaphysical and beyond any experimental verification. It should therefore be patently obvious that a presumed **universal constancy for the speed of light is meaningless without an equivalent designation for time and space**.

3. SIMULTANEITY

It is evident in the above that Dr. Einstein has chosen the first possibility regarding the speed of light in his treatment of synchronism and simultaneity of events since he states-

"Let a ray of light depart from A at the time t_A. *Let it be reflected at B at time* t_B *and reach A again at time* t'_A. *Taking into consideration the principle of the constancy of the velocity of light we find that -*

$t_B - t_A = tAB/c-v$ *and* $t'_A - t_B = tAB/c+v$

where tAB is the length of the moving rod measured in the stationary system."

He concludes from this that *"we cannot attach any absolute significance to the concept of simultaneity"* since clocks synchronized in one frame of reference (through the use of light waves,) would be found asynchronous (by the same means) in a second frame in relative motion to the first.

This would obviously not be the case if the second possibility were adopted. Furthermore, the statement is in **direct contradiction** to the above-mentioned definition regarding the equality of time in the two-way propagation of light. The definition **demands** an equivalent convention for the concept of simultaneity as it is evident through logical extension that it allows synchronization of clocks separated by distance.

By relegating the uniform velocity of light in two-way motion to the status of definition, and compound velocities to that of a "principle", it would seem that we are to **assume** the former, while in reality it is the latter. Unfortunately, this trivializes the first postulate since it is given only the

appearance of being correct, and renders unintelligible the subsequent insistence on reciprocity between frames of reference.

In an attempt to resolve the inconsistencies, we may begin with the observation that there is no reason provided by Dr. Einstein for restricting the method of synchronizing clocks to the use of light waves. The unresolved dual interpretation regarding the speed of light obviously makes this method impractical. The following mechanical methods are to be preferred as they will provide synchronism (although not in any absolute sense,) to any degree of accuracy that could possibly be required:

a. The distance between clocks is marked on a rigid rod which is then caused to move along the same axis as the clocks. As the marks reach the respective clocks, they are set. (The rod may also be moved perpendicular to the clocks' axes, thereby eliminating any presumed relativistic contraction.)

b. The clocks are synchronized at one end of the fixed rod. One clock is then transported to the other end. (This is the well-known "slow clock" transport method.)

The motion of the rod or clock can be made arbitrarily small so that presumed relativistic effects within that frame of reference become inconsequential. That is to say, it is only necessary to exceed the requirements of any subsequent velocity experiment by an appropriate magnitude.

Synchronism between moving frames requires only that one clock be set in each. Others may then be synchronized using the above methods. Any presumed cumulative dilation of time in this case, would apply to all because of the first postulate.

4. RELATIVISM OF SPACE

With the elimination of the luminiferous ether, no a priori basis is established for the phenomenon of contraction in the Special Theory. As Minkowski stated [3] -

"This hypothesis sounds extremely fantastical, for the contraction is not to be looked upon as a consequence of resistances in the ether, or anything of that kind, but simply as a gift from above, - as an accompanying circumstance of the circumstance of motion."

There is no reason given for an object to contract, and as Kennedy and Thorndike observed [4] , there is no necessity for the contraction to be in the direction of motion. Also noteworthy is the fact that the transformation equations of relativity are not volume or area-preserving. This is rather curious since no physical restrictions are placed on dimensions perpendicular to the direction of motion.

These, and other questions regarding the spatial dimensions of objects are effectively resolved as follows:

As unambiguous methods for synchronizing clocks have been established above, they may be used to determine relative lengths. Reference is made to the standard thought experiment [5] whereby it is shown that measurements along the perpendicular Y and Z axes of two systems in relative motion show no relativistic contractions. It is held that since either frame can be considered in motion, a comparison of lengths would involve a contradiction if one or the other was found to be shorter. The following demonstrates in a simple manner that the same argument applies to measurements along the X coordinate.

Assume two rigid rods of equal length [l] if measured in a fixed frame of reference. They are considered in relative motion along the X axis with left end-points marked A' and A and right end-points marked B' and B respectively. From the perspective of AB, the motion of A'B' is to the right. Clocks and observers are stationed at the end-points of each rod. The clocks are synchronized independently in each frame in the above prescribed manner. The distance perpendicular to the direction of motion which separates the lengths is assumed to be negligible and a mechanical device that can make physical contact with the opposing length is attached to point A' and B.

According to Special Relativity, if A'B' is assumed to be in motion by observers in AB, its length will be contracted. But then end A' will make contact with A prior to end B' with B. According to the first postulate, motion can be equally attributed to AB by observers **in** AB. In this case, the length AB would be contracted in comparison to A'B' and end B will make contact with B' prior to end A with A'. Contact at A'A cannot be both before and after contact at B'B, therefore the contacts are simultaneous and the lengths must be equal. **If prior contact is established at either end, a preferred reference frame is indicated and the first postulate is nullified.**

This is implicit in the results of the Michelson-Morley experiment. By eliminating the implausible assumption that the earth is at absolute rest, a physical time and/or space modification **must** be assumed in order to maintain a universal value for the speed of light since (l/c-v)+(l/c+v) does not equal 2l/c. According to the first postulate, a similar modification would obviously apply to any frame of reference in relative motion to the earth, thereby rendering it undetectable. This conclusion has always been glaringly evident in the standard relativistic equations for length contraction (where [l] and [l'] are the lengths of fixed and moving rods and [ß]= $(1-v^2/c^2)^{-1/2}$.

$l = l'ß$ (1)

and

$l' = lß$ (2)

therefore,

$l/l'=l'/l$, and $l=l'$ (3)

This relationship also applies to time.

The equations are fundamental to relativity theory and are tautological. Subsequent derivations must also be tautological.

5. COMPARISON OF RELATIVE TIMES

An independent comparison is now made of time between the two frames of reference as indicated above. It is assumed that clocks at A and B are synchronous. The clock at A' is synchronized with A and compared at point A'B.

Relativity theory requires that the clock at A' display an earlier time than that of B to an observer in B and the clock at B must display an earlier time than that of A' to an observer in A'. Since the observers may assume themselves to be in motion, this would require that each clock simultaneously display a time in advance of, and behind the one viewed. This obviously entails a logical

contradiction. Therefore, the clocks must be synchronous.

Some commentators on the Special Theory insist that the clocks operate at different rates because one has been subjected to an acceleration. If this is the case, there is no justification for introducing the paraphernalia of relativity since we are not dealing with equivalent inertial frames. Also, time dilation would not be cumulative unless further assumptions were introduced.

While the above demonstrations are simple, they are by no means trivial since the transformation equations of the Special Theory reduce to Galilean and the experimentally determined mass modifications must be attributed to causes other than those indicated. To say the dilation-contraction effects are merely observed and not real is to deny physical reality to any derived (dynamic) results.

6. DIMENSIONAL CONSIDERATIONS IN RELATIVITY THEORY

Relativistic effects were introduced to explain the null result of the Michelson-Morley experiment; a two-dimensional configuration. The purpose of this experiment was to determine the frame of reference (the ether,) in which light maintained a constant speed [c] in accordance with Maxwell's equations. If we assume this speed to be a "universal" constant, we must at the same time concede that it is a one-dimensional phenomenon.

Space-time modifications cannot simultaneously satisfy the requirements of the above-mentioned experiment and observation or measurement of one-dimensional motion without the introduction of asynchronous times. Even a cursory examination of the Einstein-Lorentz transformation equations will confirm that the Galilean "addition of velocities" has been replaced by the "addition of times", and **then effectively denied reality under the guise of a presumed absence of synchronism.** This is evident in the standard derivation of the equations [6] :

We assume a frame of reference S' moving relative to S at [v] in the positive [x] direction. At [t'=t=0], all axes coincide and a spherical light wave is emitted from origin which, according to theory, propagates at [c] in both frames. At a given time, the wave front will have travelled a distance of [x=ct] according to an observer in S and the coordinates of any point on the wave front would be,

$$x^2+y^2+z^2=c^2t^2 \quad (4)$$

Similarly in S', the wave has travelled a distance of [x'=ct'] and the coordinates become,

$$x'^2+y'^2+z'^2=c^2t'^2 \quad (5)$$

The transformation equations may be derived directly from (4) and (5) by assuming the following:

$$x'=ß(x-vt) \quad y'=y \quad z'=z \quad (6)$$

$$t'=ß(t+a) \quad (7)$$

where [ß] involves relative velocity, [a] involves time and is added to account for asynchronous clocks. By substituting the variables in (6 and 7) for those in (5), we have,

$$ß^2(x^2-2vxt+v^2t^2)+y^2+z^2=ß^2c^2(t^2+2at+a^2) \quad (8)$$

As (8) must reduce to equation (4) which does not explicitly contain [xt] or [vt] terms, we find,

$-ß^2 2vxt = ß^2 c^2 2at$ (9)

therefore

$a=-vx/c^2$ (10)

but also, $x = ct$ (11)

therefore

$a=-vt/c$ (12)

Note that equation (12) is never made explicit in any literature on the subject.
After evaluating the [a] and [a^2] terms in (8) and solving for [$ß^2$] we find that,

$ß=(1-v^2/c^2)^{-1/2}$ (13)

The values for [a] and [ß] may be inserted in (7) to obtain the standard forms of the transformation equations. Here, we are interested only in those involving time.

$t'=(t-vx/c^2)/(1-v^2/c^2)^{1/2}$ (14)

and in accordance with the usual formalism,

$t =(t'+vx'/c^2)/(1-v^2/c^2)^{1/2}$ (15)

The denominators may be eliminated as they are common to both frames of reference and proven in sections 4. and 5. to be redundant. By now substituting [ct] for [x] in (14) and [ct'] for [x'] in (15), they reduce to,

$t'=t(c-v)/c$ (16)

and,

$t=t'(c+v)/c$ (17)

Since t = t' according to section 5, equations (16) and (17) reduce to Galilean distances. The Lorentz transformation equations implicitly contain **compound times**!

Excerpt from http://wbabin.net/babin/transform.pdf:
It is difficult to understand why equations (14) and (15) were not reduced to their simplest form unless it was to obscure this fact. In any event, this anomaly was overcome in relativity theory by claiming an inability to determine synchronism of events with clocks separated by distances. The more obvious explanation is that the transformation equations apply specifically to the wavelengths and frequencies of light, where the space and time between pulses vary inversely with speed.

By emphasizing constant (absolute) light speed, the treatment excluded reference or comparison to

classical transformations. In this way, the formulas were separated from common usage and given a somewhat mystical aspect. This in all probability added to their appeal.

Re-arranging equation (17) and comparing with (16) shows,

t' = t(c - v) / c
t' = tc / (c + v)
t' **does not equal** t' (18)

Obviously, lengths are subject to the same disparity if based on time. In this demonstration of logical flexibility, one begins to understand the appeal of relativity theory. One can always find support for diverse and even opposing arguments.

Inverting the equations in (18), it is immediately obvious that they represent classical light frequencies,

f' = fc/(c [+/-] v) (19)

where the observer is at rest relative to a medium and the source is in motion, and

f' = f(c [+/-] v) / c (20)

where the source is at rest relative to a medium and the observer is in motion. (Sign changes in (19) and (20) depend on the direction of motion).

Although relativity theory does not distinguish differences with respect to motion of source or observer, they are obviously required! Furthermore in relativity, we have the formula,

f' = f [(c + v)/(c - v)]1/2 (21)

if the source and observer are moving toward each other, and a reversal of signs in the opposite direction. **This is the root of the classical Doppler expression for a fixed medium where both source and observer are in motion.**

Mathematically, this allows treating source and observer equally but does profound violence to each since they are physically required to take on the role and observations of both - to move and not move simultaneously! [End of Excerpt]

In order to maintain universality for the speed of light and also constancy within each inertial frame, (as an experimental "null" result infers,) an object travelling at [v] in the same direction as the beam of light must contract by the factor [(c-v)/c]. The reciprocal aspect of contraction and dilation in Special Relativity is negated since an equivalent object (when observed or measured from the "moving" frame,) would appear to be travelling in the **opposite** direction and would necessarily exhibit an **expansion** factor of [(c+v)/c].

There is no logical argument available which would circumvent this asymmetry. If the speed of light is assumed to be a universal constant, then one-dimensional modifications of space and/or time must be introduced to disguise it. However, the derived physical effects, (momentum, energy,) would vary significantly from the predictions of the theory and of experiment. To state it more

succinctly -

If we affirm the universality of the speed of light and the ability to measure it in one dimension, it then becomes possible to determine, absolutely, the state of motion of a system moving relative to it. This is specifically forbidden by the first postulate. If we, for some reason, assume that reality must of necessity be expressed in a minimum of two dimensions, the Special Theory would be merely tautological since no conceivable difference between frames in relative motion can be demonstrated.

7. OBSERVED EFFECTS AT RELATIVISTIC VELOCITIES

Dr. Einstein has given no details on the mechanics by which observations are made. They appear to require the instantaneous transmission of light images. On the other hand, the paper by J. Terrell [7] assumes a physical contraction. In the following assessment, lengths are considered equal and times synchronous in both frames of reference as proven in the preceding analysis. All observations are along the X axis at a negligible angle.

In order to view the two points (A'B') of a rigid rod in motion at [v] on the X axis, it is assumed that light waves propagate at [c] in the observer's frame (AB) and are emitted at different times from each point in the primed frame to arrive simultaneously at B. Time in the primed system is determined by an observer at B by assuming point A' emits a pulse of light which illuminates its clock face at regular intervals.

As the two points approach B it is obvious that the length [l] will be viewed by B as dilated by a factor of [c/c-v] (disregarding the angle of observation). Conversely, as the two points recede from B, the length will be viewed as contracted by the factor, [c/c+v].

The clock at A' as viewed by B will be retarded by the amount of time required for light to traverse the distance between them. This amount becomes progressively less as the distance is reduced. When A' is directly opposite B, the two clocks are synchronous. As clock A' recedes, it again trails the clock at B by progressively greater amounts. Since the rod is in motion, the time between pulses (as viewed by B) would be contracted by the factor [(c-v)/c)] as A' approaches B, and its velocity would appear to be greater by the same factor. The time between pulses would be dilated by [(c+v)/c)] as it recedes, and its velocity reduced in kind.

It is obvious from the foregoing that the velocity of light will be calculated (not seen,) by B to be constant at [c] in the A'B' reference frame. Time and space merely appear to expand and contract because of the constancy of light in the observer's frame. No assumptions are required to satisfy the two postulates since clocks function (physically) at the same rate and lengths are equal.

8. SUMMARY

It has been demonstrated that the concept of a universal frame of reference (whether abstract or real,) defined by the speed of light, cannot be supported in conjunction with the first postulate. It has also been demonstrated that synchronism is achievable both theoretically and practically, and that presumed two dimensional time-space modifications would be reciprocal and obviously undetectable. Essential one-dimensional considerations are totally ignored in the theory. The kinematic hypotheses of Special Relativity are therefore nullified and cannot serve as the basis for any subsequent dynamic theory.

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[1] W. Perrett and G.B. Jeffery, "On the Electrodynamics of Moving Bodies", (translation) The Principle of Relativity, Dover Publications, New York, N.Y. P38 (1952).

[2] Newton "Principia", Definitions, University of California Press, 1962, pp. 9

[3] " Space and Time, The Principle of Relativity". Dover Publications, New York, NY, (1952), pp. 81

[4] Kennedy, Thorndike "Experimental Establishment of the Relativity of Time", Physical Review, Nov. 1, 1932.

[5] N. Ashby, S. Miller, "Principles of Modern Physics", Holden-Day Inc., San Francisco, CA, (1970), pp.60

[6] R. Eisberg and R. Resnick "Quantum Physics", Appendix A, , John Wiley & Sons, New York, NY (1985). Also, X-Rays in Theory and Experiment, A.H. Compton, D. Van Nostrand Co. Inc., 1940.

[7] J. Terrell, Physical Review, 116, 1041, 1959.

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