Clock Behavior and the Search for an Underlying Mechanism for Relativistic Phenomena

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BIOGRAPHY

Ronald R. Hatch received his Bachelor of Science degree in physics and math in 1962 from Seattle Pacific University. He worked at Johns Hopkins Applied Physics Lab, Boeing and Magnavox before working for a time as a GPS consultant. In 1994 he joined Jim Litton, K.T. Woo, and Jalal Alisobhani in starting what is now NavCom Technology, Inc. He has served a number of roles within the Institute of Navigation (ION), including Chair of the Satellite Division. He is currently finishing a one-year term as President of the ION. Ron has received the Johannes Kepler Award from the Satellite Division and the Colonel Thomas Thurlow Award from the ION. He is also a Fellow of the ION. Relativity theory has been a long time hobby of Ron's. This is the first paper dealing exclusively with relativity theory that he has presented at an ION conference.

ABSTRACT

The Special Relativity Theory (SRT) and the General Relativity Theory (GRT) sometimes exhibit clock effects of equal magnitude which cancel and sometimes exhibit clock effects of equal magnitude which are additive. This cannot be coincidence, yet there is nothing within the two disjoint relativity theories to suggest an underlying mechanism. The effects appear to be related to energy, but the SRT treats energy as relative and the GRT treats an orbiting body as following a force-free trajectory. Thus an alternative to the Einstein theories seems to be required. I have proposed what I call a Modified Lorentz Ether Theory (MLET) which extends the Lorentz ether concepts to cover gravitational phenomena. Following a brief review of MLET concepts, it is contrasted with SRT concepts. Current data available from a number of modern experiments are evaluated with regard to both MLET and SRT. In general, MLET provides a more coherent and consistent explanation of the data. In the last major section of the paper it is shown that in the earth-centered inertial (ECI) frame Global Positioning System (GPS) clocks are not adjusted for the differential effect of the sun's gravitational potential. SRT has no valid explanation for this phenomenon and is thereby refuted. MLET by contrast shows that the differential effect of the sun's gravitational potential is absorbed into the clock bias which converts the Selleri transformation into an apparent Lorentz transformation. This is very strong evidence that some form of Lorentz ether theory is valid and that the Einstein theories are invalid.

INTRODUCTION

Much can be learned from relativistic clock behavior. The Global Positioning System (GPS) has become a primary source for knowledge of relativistic clock behavior. One of the characteristics of clock behavior clearly evident in GPS is that all clocks in the earth-centered inertial (ECI) frame which are at sea level run at the same rate. A clock at sea level on the equator should run slow according to the Special Relativity Theory (SRT) due to its speed in the ECI frame. However, a clock at sea level on the equator should run faster according to the General Relativity Theory (GRT) due to the spin-induced equatorial bulge which causes the clock to be higher in the earth's gravitational potential (i.e. at a less negative potential). These two effects, explained by disjoint theories, are of exactly equal magnitude but opposite sign and precisely cancel each other.

A somewhat similar effect is observed regarding the clocks on board the GPS satellites. When the satellite is near perigee, it has a faster speed; and the SRT indicates that the clocks should run slower than nominal. But near perigee the satellites have a lower (i.e. more negative) potential in the earth's gravitational field which, according to GRT, should also result in a slower clock rate. Again, surprisingly, these effects explained by different theories have precisely the same magnitude—but in this case the sign is the same and the two effects add together.

Why should the magnitude of the clock effects be exactly equal in the two examples above? It is a highly unlikely coincidence. Yet Einstein's two theories, SRT and GRT, have no explanation for the phenomenon. Since clock effects are a function of velocity squared (kinetic energy) and gravitational potential energy, it would seem that the common factor is related to the energy of the particle. But SRT treats kinetic energy as relative and GRT treats gravitation as a geometric effect completely independent of energy considerations. This suggests that we need to search for an underlying mechanism for relativistic phenomena via some other theory. There are a number of other reasons leading to the same conclusion. The alternative which seems to agree best with most of the experimental data is an absolute ether theory.

A MODIFIED LORENTZ ETHER THEORY

In an interesting study, Mansouri and Sexl [1] show that in most respects a Lorentz absolute ether theory with length contraction and clock slowing is equivalent to SRT. After reaching this conclusion, they conclude that SRT is preferable because it preserves the equivalence of all inertial frames. However, there are at least two reasons for seriously questioning this choice. First, the choice of absolute equivalence of all inertial frames requires the non-simultaneity of time while ether theories treat time as it is intuitively understood (i.e. clock rates change but a universal now still exists). But the major reason for choosing an ether theory over SRT is the choice of science over magic. Fundamentally, SRT is a magic theory. The speed of light is magically constant in all inertial frames—no mechanism is given. Having chosen this magic proposition, SRT then derives length contraction and clock (time) slowing as consequences. By contrast, the Modified Lorentz Ether Theory (MLET) models material particles as standing waves. Thus, it automatically predicts a length contraction with motion through the absolute frame due to the lower two-way speed of light relative to the moving particle. Clock slowing also follows because of the effectively lower two-way speed of light relative to the particle. With length contraction and clock slowing, all that is needed to get an apparent equivalence of all inertial frames is to bias the clocks such that the one-way speed of light appears to be isotropic in the moving frames. But most means of synchronizing clocks automatically supply the appropriate bias.

Thus, SRT has it backwards. It assumes the apparent equivalence of inertial frames is real and uses that result, together with the magic of a universal speed of light, to derive length contraction and clock slowing. On the other hand, the ether theories use the length contraction and clock slowing to show that there is an apparent equivalence of all inertial frames and an apparent common universal speed of light.

An extension of the Lorentz Ether Theory has been made to include the gravitational effects. Thus, our Modified Lorentz Ether Theory (MLET) combines into one coherent theory the relativistic phenomena covered under Einstein's two disjoint theories. Because this theory covers the change in measure or gauge of the fundamental parameters of mass, length, and time as a function of speed (SRT type effects) and gravitational potential (GRT type effects), it is also referred to as an Ether Gauge Theory (EGT). A concise review of the theory has been published [2] and is also available at the web site http://www.egtphysics.net

In a nutshell, MLET shows that speed relative to the absolute frame, i.e. kinetic energy, determines a factor, which scales the fundamental units. The scale factor, γ, used in SRT with relative velocities is defined in MLET using absolute velocities. In each case the scale factor is a function of the square of the speed (kinetic energy). The scale factor is:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{1}$$

The rate at which clocks run is divided by the scale factor, i.e. the clock rate decreases. Lengths are divided by the scale factor, i.e. lengths of objects moving with respect to the absolute frame contract in the direction of the velocity. The inertial mass is multiplied by the scale factor, i.e. it increases, and the structural mass, i.e. "rest mass" or gravitational mass, is divided by the scale factor, i.e. it decreases.

Similar effects corresponding to GRT result from the fact that standing waves cause the internal ether density to be decreased, which results in an external increase of the ether density. This ether-density increase decays exponentially with distance and causes changes in the fundamental units as a function of the gravitational potential energy. The MLET gravitational scale factor is slightly different (a second-order effect) from the corresponding GRT scale factor. The GRT scale factor is:

$$s = \sqrt{1 - \frac{2GM}{rc^2}} \approx 1 - \frac{GM}{rc^2} - \frac{G^2M^2}{2r^2c^4} \tag{2}$$

The comparable MLET gravitational scale factor is:

$$s = e^{-\frac{GM}{rc^2}} \approx 1 - \frac{GM}{rc^2} + \frac{G^2M^2}{2r^2c^4} \qquad (3)$$

Clock rates are divided by this scale factor, i.e. they speed up with increased potential. Lengths are divided by the gravitational scale factor, i.e. they expand. The rest mass is multiplied by the scale factor cubed, i.e. it decreases by the third power. The speed of light is increased by the square of the scale factor as the gravitational potential is increased. These kinetic and gravitational-potential effects can be used to account for all the known relativistic phenomena.

COMPARISONS, CONTRASTS, AND CONFUSIONS OF THE ALTERNATE THEORIES

A comparison of the SRT transformation (Lorentz transformation) and the MLET transformation (Selleri transformation) is shown in Figure 1. (The equations for both transformations are given in detail below.) The magic of SRT is also illustrated by the fact that the length contraction and clock slowing are symmetrical. Each frame sees clocks in the other inertial frame running slow and sees lengths contracted. The Selleri Transformation, which is used in the MLET, is reciprocal rather than symmetrical. The observer in the moving frame would see the clocks in the absolute frame run faster and would see lengths expanded. The apparent Lorentz transformation is obtained when the appropriate clock bias is added to the Selleri transformation. It is interesting to note that most standard methods of synchronization of clocks automatically supply the exact clock bias needed to convert the Selleri transformation into a Lorentz transformation.

Though the practical effect of either SRT or MLET involves the Lorentz transformation when one wants to move from one inertial frame to another, the question of when to apply the Lorentz transformation has a dramatically different answer in the two alternate theories. In the MLET there is never any requirement that the Lorentz transformation be employed. One can pick any inertial frame one wants, assume that frame is the absolute frame, and work exclusively in that frame. The apparent Lorentz transformation from the absolute frame to the chosen inertial frame leaves the apparent speed of light isotropic. Thus, in the chosen inertial frame the speed of light is assumed to be isotropic, clocks are assumed to run slow with speed in that frame, and lengths of moving objects are assumed to contract in the direction of their motion. Most important, an observer or sensor moving in that chosen frame will not see an isotropic light speed (i.e. there is no need for a further transformation to cause the observer or sensor to be stationary in his own frame).

However, in SRT, it is clearly taught as part of the theory that the observer's (or sensor's) inertial frame is the correct frame to employ. Thus, in theory, all sources and clocks must be mapped via the Lorentz transformation into the observer's frame at all times. This is most clearly seen in the theoretical development of the Thomas precession.

Thomas Precession

The Thomas precession of the electron as it orbits around the nucleus of an atom is explained in SRT as the result of instantaneous "Lorentz boosts" (infinitesimal Lorentz transformations). Lorentz boosts are required to keep the electron in its own inertial frame. Goldstein [3] explains the process in the following words:

> Consider a particle moving in the laboratory system with a velocity **v** that is not constant. Since the system in which the particle is at rest is accelerated with respect to the laboratory, the two systems should not be connected by a Lorentz transformation. We can circumvent this difficulty by a frequently used strategem (elevated by some to the status of an additional postulate of relativity). We imagine an infinity of inertial systems moving uniformly relative to the laboratory system, one of which instantaneously matches the velocity of the particle. The particle is thus instantaneously at rest in an inertial system that can be connected to the laboratory system by a Lorentz transformation. It is assumed that this Lorentz transformation will also describe the properties of the particle and its true rest system as seen from the laboratory system.

In the SRT model the precession results from the fact that successive Lorentz boosts are not collinear and the result is a rotation of the local reference frame. Magically, this rotation of the local reference frame results in a torque-free precession of an orbiting electron in the laboratory frame.

Instead of magic, the MLET explanation is that a real torque is generated when the force is non-gravitational and when the orbiting object is itself spinning (both apply in the case of an electron). When a spinning object is constrained by a non-gravitational force to follow a curved path, the spin velocity and the orbit velocity add as vectors. This means that the half of the spinning object where the speeds add will become contracted in length and will increase in inertial mass. Conversely, the half of the spinning object in which the spin velocity and orbital velocity combine to decrease the total speed will expand in length and decrease in inertial mass. These length and mass changes combine to cause a movement of the center of mass away from the center of the spinning object.

When the force is non-gravitational and continues to act on the center of the object, a torque will be present which causes the Thomas precession.

The reasoning as to why the Thomas precession does not apply to objects orbiting under gravitational forces is a bit contrived for SRT. Specifically, it is argued that no gravitational force is present. Orbiting objects are assumed to be following a geodesic in space-time. That seems valid enough. But then why is the Lorentz transformation used to explain the aberration of starlight on the earth? These explanations are mutually exclusive. If Lorentz transformations apply, Lorentz boosts apply and Thomas precession would follow.

Twin Paradox

Though entirely theoretical, the solution to the twin or clock paradox also reflects the different application of the Lorentz transformation in the two alternate theories. Part of the problem with addressing the twin paradox of a traveling twin and a stay-at-home twin is that so many different mutually incompatible solutions are offered within SRT. However, as far as I am aware, all the solutions claiming to be consistent with SRT involve changing inertial frames when the traveling twin turns around. The specific solution given by Ohanian [4] seems to be the most consistent with other applications of SRT (particularly with the Thomas precession above). Ohanian says that, when the twin turns around at the middle of his journey, he causes a hyperbolic rotation of the lines of simultaneity around his origin. Again, this involves magic because the position of any light signal in transit must suddenly adjust in both position and time to be consistent with this SRT solution. (This argument has been presented in greater detail in a prior paper [5].)

The solution to the twin paradox in MLET is the soul of simplicity. Pick any inertial frame you want for the twins and treat that frame as the absolute frame. Then stick with that frame as the isotropic-light-speed frame for the entire trip. Never change frames. Simply let each clock run at a rate consistent with its velocity in the chosen frame. The same observed slowing of the clock or decreased aging of the twin who makes the round trip relative to the stay-at-home twin will be observed independent of the chosen isotropic-light-speed frame.

Sagnac effect

Multiple examples exist to show that the "MLET template" is actually what is used in most large-scale experiments. By MLET template we mean that moving observers or sensors do not see an isotropic light speed. Because it is virtually impossible to treat each sensor as existing in a separate frame, the SRT magic does not generally function well in any system with multiple sensors. Unfortunately, even though the MLET template is generally used, SRT is generally called upon for the theoretical explanation of that MLET template. The result is a confusion of theory that provides explanations which are not consistent with either MLET or SRT. The Sagnac effect is a prime example.

Several types of modern gyroscopes function by using the Sagnac effect to measure rotation. Georges Sagnac performed the original experiment in 1913. He split a light beam into two parts, which traveled around the circumference of an area in opposite directions. He then measured the interference fringe effect when the two light beams were brought back together. He found that the fringe shift was a function of the rotational velocity. In other words, the speed of light relative to the rotating sensor was a function of whether the light beam traveled with or against the rotational velocity of the platform. The MLET explanation of the Sagnac effect is again obvious. Simply stated, the motion of the detector (observer) has no effect on the speed of light; and therefore a non-isotropic light speed relative to the moving detector can be expected—which leads to the observed phenomenon.

Explanations for the Sagnac effect within SRT (and GRT) are numerous. However, virtually all of the explanations claim that the speed of light need not be isotropic when rotational phenomena are involved, since rotational phenomena are absolute. But, similar to the situation with the twin paradox, the majority of the explanations are mutually contradictory; and picking out an "official" explanation is a daunting task. However, the most common explanation which I have found in the literature [6], and apparently the one to which Einstein himself subscribed, is that the path around the circumference should be unwrapped into a straight-line path and the Lorentz transformation from the stationary to moving frame applied to this unwrapped moving circumference. This gives the correct fringe shift but directly contradicts the prescription for handling accelerations within SRT which was cited above for the Thomas precession effect.

The situation has become even more controversial with the advent of precise clocks (and/or transponders) placed upon both interplanetary space probes and upon GPS satellites in orbit around the earth. The 1971 JPL document [7] giving the equations used to model round-trip and one-way signals between a space probe and the earth prescribed the use of a sun-centered isotropic-light-speed frame. Clearly, both the probe and the detector (or observer) on the earth are moving in this frame. The equations clearly show that the speed of light was not assumed to be isotropic with respect to the observer. Instead, when a signal was in transit from the probe to the earth, the motion of the earth-observer during the transit time was clearly accounted for. This motion included the earth's spin, the earth's orbital velocity, and even the motion of the earth caused by its orbit around the earth-moon center of gravity. This accounting is precisely that prescribed by the MLET template rather than the SRT template (isotropic light speed relative to the observer or sensor).

In the GPS system a non-rotating earth-centered isotropic-light-speed frame is assumed. Again, the motion of the receiver during the time the signal transits from the satellite to the receiver must be accounted for to obtain precise navigation results. In the GPS context, this effect is referred to as the one-way Sagnac effect and is blamed upon the rotation of the earth. But the receiver must account for its motion during the transit time no matter the source of the motion. It does not matter whether or not it follows a circular trajectory. The critical range which must be determined is the position of the satellite at the time the signal was transmitted and the position of the receiver at the time of its receipt. The path the receiver followed during the time of flight of the signal is completely irrelevant. This is consistent with the argument of Ives [8] that even the original Sagnac experimental results were not specifically due to rotation. Ives suggested an experimental proof designed to show the effect did not require rotation. In a beautiful modification of Ives suggestion, Wang [9] has constructed what he calls a Fiber Optic Conveyer (FOC) which directly verifies that linear motion has the same effect as circular motion.

In the examples above the SRT theoreticians attempt to explain the results by claiming that rotation is involved and that because of the rotation non-isotropic light speed can be explained. The MLET explanation is that any inertial frame can be chosen as the isotropic-light-speed frame. But with that assumption clocks moving within that chosen frame must run slower and receivers or observers moving in that frame will not see an isotropic light speed. This is the MLET template, and its use is widespread though largely unrecognized.

Rotating Mössbauer Experiments

The rotating Mössbauer experiments illustrate the importance of understanding clock behavior before attempting to interpret experimental results. Many texts, e.g. Jackson [10], claim that the rotating Mössbauer experiments conclusively prove that ether drift is not present in the laboratory or on the earth. Thus, it is argued that ether theories such as MLET cannot be correct and that SRT is undoubtedly true. This claim is patently false and illustrates poor science, if not deliberate fraud. The claim is dealt with at length in a prior paper [11], but the essence of the argument is repeated here.

Ruderfer [12] was among the first to argue that an ether drift could be detected via a rotating Mössbauer experiment. He reasoned that, if an ether drift were present, it would affect the transit time of gamma rays crossing a spinning disk. The time derivative of the transit time as a function of path direction would appear as a frequency shift in the gamma ray. The extreme precision of the Mössbauer effect would allow this effect to be measured very precisely. The problem with the proposal is that any reasonable ether theory also proposes that clock speed (or the speed of the gamma ray source or detector) through the ether affects the frequency. Ruderfer in an errata sheet [13], in fact, points out that the transit time effect and the clock effect would cancel each other so that a null result could be expected even in the presence of an ether drift. Yet in spite of this errata sheet (even when it was acknowledged) a number of people [14, 15] performed the experiment and claimed that it proved there was no ether drift. Ironically, Turner and Hill [16] looked for the clock effect, ignoring the transit time effect, and also conclude from the null results that no ether drift is present.

Unbiased analysis of the rotating Mössbauer experiments would have actually led to a conclusion opposite to that reached in each of the above articles. Specifically, there is substantial independent experimental evidence that clock speed always affects the clock frequency and, as the GPS system shows, the spin velocity of the earth clearly affects the clock rate. This being the case, the null result of the rotating Mössbauer experiments actually implies that an ether drift must exist or else the clock effect would not be canceled and a null result would not be present. Thus, the experiments actually favor MLET rather than the SRT, which is completely opposite the account given in virtually all texts on the subject.

THE COUP de GRÂCE

In the prior paper on ether drift referred to above [11], it was shown that the GPS system is very similar to the rotating Mössbauer experiments with two differences. First, rather than measuring frequencies, ranges are measured in the GPS system. Second, the sources (GPS satellites) are rotating independently of the observers (receivers rotating with the earth). But these were dealt with directly, and it was shown that the GPS system worked just as well in the sun-centered inertial frame as it does in the normal earth-centered inertial non-rotating frame. However, upon further reflection, it became apparent that one significant complication with respect to the two frames was not dealt with. Specifically, GPS was compared in the two frames assuming that the earth's orbital velocity was constant. In other words, the instantaneous velocity of the earth in orbit was assumed to be constant; and no provision was made for changing the direction of the orbital velocity. This failure is remedied below. The result clearly shows that neither SRT nor an entrained ether can be correct.

Refer again to the diagrams in Figure 1 of the SRT and MLET transformation process. On the left-hand side we see that the SRT uses the Lorentz transformation when mapping from one frame to another. Because gravity is assumed to be a force-free process in GRT, it is argued that the earth can be treated as an inertial frame even though it is orbiting the sun. If this view is correct, the speed of light will be isotropic in the earth-centered non-rotating frame automatically (by postulate); and clocks will not need to be biased.

The transformation equations from one frame to another are a specification of how coordinate measurements in one frame are to be mapped to another frame. Since the measurements in a given frame are based upon the size of the units in that frame, the mapping of measurements from one frame's units to another are the inverse of the changes in the units. This will be commented upon further below.

The Lorentz transformation from the sun's inertial frame to the earth's inertial frame is specifically:

$$t_e = \gamma t_s - \gamma \frac{v}{c}\frac{x_s}{c} \tag{4}$$

$$x_e = \gamma x_s - \gamma v t_s \tag{5}$$

where: γ is defined by equation (1) and the subscripts e and s refer to the earth's and sun's inertial frames respectively.

The inertial mass unit of measurement is increased on the earth. So measurements of inertial mass in the earth's frame will be decreased when measured in these larger units.

$$m_e = \frac{m_s}{\gamma} \tag{6}$$

The reverse transformation from the earth to the sun is symmetrical. Simply change the subscripts in equations (4) through (6) and change the sign on the velocity terms.

However, on the right-hand side of Figure 1 we see that according to MLET the speed of light is not isotropic on the earth since it is moving through the absolute ether frame (which, for demonstration purposes, we can assume is the sun's frame). The Selleri [17] (or Tangherlini [18]) transformation describes the effects of the earth's motion in the sun's frame mapped to an earth-centered non-rotating frame. Specifically, since clocks run slower in the earth's moving frame, the clock-measurement unit will be larger. This means that the mapped clock readings will be smaller.

$$t_e = \frac{t_s}{\gamma} \tag{7}$$

In like manner, the earth's unit of length is contracted in the velocity direction; and this means that measurements mapped onto these new units will be larger.

$$x_e = \gamma x_s - \gamma v t_s \tag{8}$$

The mapping of inertial-mass measurements is the same as that given in equation (6).

$$m_e = \frac{m_s}{\gamma} \tag{9}$$

The reverse Selleri transformation from the earth to the sun is reciprocal to the above equations and is given by:

$$t_s = \gamma t_e \tag{10}$$

$$x_s = \frac{x_e}{\gamma} + \frac{v_e}{\gamma} t_e \tag{11}$$

$$m_e = \gamma m_e \tag{12}$$

Note that the along-track velocity, as measured in the earth's frame, is different than that measured in the sun's frame. Since the clocks run slower (time unit is larger) and the along-track lengths are contracted in the earth's frame, its velocity is measured in smaller units and a larger numerical velocity is obtained. The inverse mapping of the velocity from the earth's frame to the sun's frame (no subscript) gives a smaller value because the sun's velocity units are larger:

$$v = \frac{v_e}{\gamma^2} \tag{13}$$

Equations (7) through (9) represent, I believe, the reality of the non-isotropic speed of light on the earth. But Poincaré's principle (there is no observable difference between inertial frames) indicates that the one-way speed of light must somehow appear to be isotropic. We can, in fact, make the speed of light appear to be isotropic on the earth, but to do so we must bias the clocks appropriately. Note that the only difference between the Lorentz transformation and the Selleri transformation from the sun to the earth is in the clock mapping given in equations (4) and (7). The amount of clock bias needed to convert the Selleri transformation into the Lorentz transformation is given by equation (4) minus equation (7), or:

$$\Delta t = (\gamma - \frac{1}{\gamma})t_s - \gamma \frac{v}{c}\frac{x_s}{c} \tag{14}$$

This equation makes obvious an often-overlooked fact. The Lorentz transformation achieves a slower running clock by actually increasing the clock rate but then more than counteracting that effect with a clock bias that is a function of position. By contrast, the MLET simply says moving clocks run slower. In any case, we can find the clock bias needed in the earth's frame by substituting into equation (14) the expressions for the sun's time and position given in equations (10) and (11)—being careful to distinguish between v and v_e. This gives:

$$\Delta t = -\frac{v}{c}\frac{x_e}{c} \tag{15}$$

Two important physical processes that relate to this clock bias are developed below. First, we show that any clock motion (no matter how slow) on the earth in the direction of the orbital velocity will automatically generate the clock bias needed to transform the Selleri transformation into the Lorentz transformation if we assume the orbital velocity is constant. Then we show that the changing direction of the orbital velocity is accounted for by the difference between the sun's gravitational potential at the center of the earth and the gravitational potential at any specific clock location. Stated another way, the gradient of the gravitational potential of the sun produces a differential clock-rate effect. This differential clock rate integrates in such a way as to properly maintain the clock bias which is needed to make the velocity of light appear to be isotropic in the earth-centered non-rotating inertial frame. In the GPS system the sun's gravitational potential is indeed ignored. The MLET explanation justifies ignoring the sun's effect upon the clocks by showing its contribution is absorbed into the clock-bias term which converts the Selleri transformation into the apparent Lorentz transformation.

The Product of Velocities

Charles M. Hill reported [19] on comparing earth-bound clocks with the pulses arriving at the earth from the Hulse-Taylor binary pulsar. This pulsar proves to function as a very precise clock which has a stability that rivals that of the very best atomic clocks when an adjustment for its gravitational-radiation damping is performed. The comparison is done in the sun-centered inertial frame. The comparisons clearly fit the MLET template, showing that the reception time of the pulses must be adjusted for the position of the earth in its orbit and the position of the clock on the earth as the earth revolves. In addition, the earth-bound clocks must be adjusted for the earth's changing speed and the sun's changing gravitational potential as the earth moves between perihelion and aphelion and as the earth rotates around its spin axis. Even the movement of the earth around the earth-moon center of gravity must be accounted for both in the changing range from the pulsar and in the effect of that motion upon the speed and gravitational potential in the sun's frame. Thus, we know that the frequency of clocks, on or near the earth, is affected by its speed relative to the sun and by its position in the sun's gravitational potential.

At this point we compute the effect upon a clock of a velocity with respect to the center of the earth combined with the orbital velocity of the clock in the sun's inertial frame. The earth's spin velocity will be considered first. From the effect of speed on frequency and the scale factor of equation (1) we get:

$$f_m = f_f (1 - \frac{(v_o + v_s)^2}{c^2})^{-\frac{1}{2}} \tag{16}$$

where: the subscripts designate the following: m for moving, f for fixed (non-moving), o for orbital, and s for spin. From the above, the approximation for the change in frequency is:

$$\frac{\Delta f}{f_f} \approx -\frac{v_o^2}{2c^2} - \frac{v_o \bullet v_s}{c^2} - \frac{v_s^2}{2c^2} \tag{17}$$

The change in frequency caused by the first term is common to clocks on (or in orbit around) the earth. The change in frequency caused by the last term is completely canceled in the case of the earth's spin by the change in the earth's gravitational potential. Stated another way, the centrifugal force of the spin causes the earth to distort into an oblate sphere, which means that the faster the clocks on the earth are spinning the higher they are in the earth's gravitational potential. This increased gravitational potential exactly cancels the last term in equation (17).

Before addressing the middle term of equation (17) we need to convert the effect on the moving clock into an effect on the reading of the clock time. First, a lower frequency clock, as indicated by the negative sign in equation (17), leads to larger clock-time units. The larger time units mean that the time measured in those larger units will be a smaller value. Thus, considering only the middle term and its effect on the clock readings and expressing the component of the spin velocity in the direction of the orbital velocity as dx/dt gives:

$$\Delta t = -\frac{v_o}{c^2}\int_0^t \frac{dx}{dt}\, dt = -\frac{v_o}{c}\frac{x}{c} \tag{18}$$

Thus, the change in the clock reading caused by the velocity-product term causes the clock reading to be biased according to equation (18) by the exact amount needed to convert the Selleri transformation into the Lorentz transformation according to equation (15). This means that the clock bias produced by the velocity-product term is exactly that needed to make it appear as if the speed of light is isotropic in the earth's frame, i.e. as if the one-way speed of light is equal to c.

Before considering the significance of this result, we can generalize it a bit. If we assume a clock is moved by slow transport on the earth (rather than or in addition to the earth's spin), the same basic equation (17) applies. Only instead of having the gravitational potential cancel the last term, we have made it arbitrarily small by using a very small velocity. This still leaves the middle term and the integral results in the same clock bias. Of course, when the slow transport is done in addition to the earth's spin, a small term, which is a result of the product of the earth-spin velocity and the slow-transport velocity, will result—but this can be accounted for appropriately. If not accounted for, it will make the speed of light appear to be locally isotropic at that point on the earth's surface.

What is the significance of this interim conclusion? We have shown that, assuming the speed of light is isotropic in the sun's frame, the velocity of clocks on the spinning earth will cause them to be biased by just the amount needed to make it appear as if the speed of light is actually isotropic on the earth. This would seem to argue rather strongly in favor of the two-step transformation of MLET given in Figure 1. However, the true believer in SRT can argue that this is simply a coincidence and that it is still the magic of SRT which automatically causes the speed of light to be isotropic on the earth. There is no way to refute his argument in this simplified case where we have assumed that the direction of the orbital velocity vector is constant. But, when the change in the orbital velocity direction is allowed, we get an astonishing result.

Assume the Earth Follows a Circular Orbital Path around the Sun

At this point we want to allow the direction of the orbital velocity vector to change. But it is easiest to assume that it changes by a constant amount, i.e. a circular orbit. This constraint will subsequently be removed.

If we assume MLET is correct and that a clock bias exists for clocks separated along the velocity vector direction, it follows that, for these biases to remain constant as the velocity vector changes, the inertial frame must rotate once per year. But this rotation means that the clocks at a greater distance from the sun than the earth center must travel faster and hence run slower and that clocks closer to the sun than the earth center must travel slower and hence run faster.

From the velocity effects on clocks using the scale factor of equation (1), we get that the change in clock frequency due to the orbital velocity is:

$$\Delta f \approx -f\,\frac{v^2}{2c^2} = -f\,\frac{r^2\dot{\theta}^2}{2c^2} \tag{19}$$

Taking the radial gradient of this gives the relative effect on clocks as a function of their radial distance from the sun caused by rotating the inertial frame once per orbit:

$$\frac{df}{dr} = -f\,\frac{r\dot{\theta}^2}{c^2} \tag{20}$$

But for a circular orbit the angular rotation rate can be expressed as a function of the gravitational potential. This gives:

$$\frac{df}{dr} = -f\,\frac{GM}{r^2c^2} \tag{21}$$

The above result suggests that perhaps the effect of the sun's gravitational potential upon the clocks might counteract the above velocity effect with the result that the proper clock bias could be maintained even without rotation of the inertial frame. From the effect of the gravitational potential on clock rate and the first term of the approximations of either equation (2) or (3) we get:

$$\Delta f \approx -f\,\frac{GM}{rc^2} \tag{22}$$

When we take the radial gradient of this we get:

$$\frac{df}{dr} = f\,\frac{GM}{r^2c^2} \tag{23}$$

Indeed, because equation (23) is identical except for sign with equation (21), it is apparent that the differential effect of the sun's gravitational potential causes the clocks farther from the sun to run faster than clocks closer to the sun. In fact, the effect is exactly such that the proper clock bias needed to convert the MLET Selleri transformation into the Lorentz transformation is maintained as the earth orbits the sun without the need to rotate the earth's frame once per year.

It has been claimed [20] that the effect of the sun's differential gravitational potential on clocks on the earth is canceled by the "centripetal acceleration," i.e. by the differential velocity with respect to the sun. In other words, it is claimed that the inertial frame indeed rotates once per year. However, the GPS clocks clearly show the argument is invalid. The orientation of the GPS orbital planes does not rotate to maintain the same angle with respect to the sun, so there is no differential velocity orthogonal to the orbital plane. And there can be no differential velocity within the plane or else Kepler's laws would be violated. Thus, GPS clocks do not suffer centripetal acceleration. Furthermore, if this argument were correct, the differential gravitational potential would be canceled in the sun's frame as well. The JPL reference document [7] and the Hill pulsar document [19] clearly show that such a cancellation does not occur. But MLET does not have this problem. The clock bias needed to transform the Selleri transformation into the Lorentz transformation does need to change as the earth orbits the sun. This bias term is modified by the sun's differential effect on the clocks so that its value remains correct as the orbital velocity vector changes direction.

The above provides a very powerful means of distinguishing between the MLET and SRT. If MLET is correct, we expect clocks located on the earth (and GPS clocks located in orbit around the earth) to be properly modeled by ignoring the gravitational potential of the sun. The reason for this is, as we have shown above, the differential effect is absorbed into the clock-bias term that converts the Selleri transformation into the Lorentz transformation. By contrast, if SRT is correct, we would expect that the clocks on earth and in the GPS system would require an adjustment for the effect of the sun's differential gravitational potential. Since clocks on earth and in the GPS system function properly by ignoring the effect of the sun's gravitational potential, we must conclude that ***SRT is wrong. MLET explains the phenomenon.*** It is also true that this same phenomenon clearly excludes any ether-drag theory, since an ether-drag theory would also have no reason to exclude the sun's gravitational effect upon the clocks.

Accounting for the eccentricity of the earth's orbit

Before considering the implications of the above result further, we need to generalize it to account for the earth's actual eccentric orbit. This is not difficult. Simply stated, we need to separate the gravitational force (gradient of the gravitational potential) of the sun into the component along the earth's velocity vector and the component orthogonal to the velocity component. The angle γ is generally used to designate the angle between the radius vector and the outward pointing normal to the orbital path. Using this angle we find that the component of force along the velocity vector is given by:

$$F_a = -\frac{GM}{r^2} Sin(\gamma) \tag{24}$$

The force orthogonal to the orbital path is:

$$F_o = -\frac{GM}{r^2} Cos(\gamma) \tag{25}$$

The force represented by equation (24) causes the earth's orbit to slow down and speed up in velocity. This speed variation, together with the associated change in the sun's gravitational potential at the earth's center, causes the rate of all clocks on or near the earth to increase and to slow. Because the change is common to all clocks, it can safely be ignored. The force represented by equation (25) can be substituted for the expression of circular gravitational force in equations (21) and (23). The result is that each equation is simply modified by the Cos γ.

CLOCK BEHAVIOR IN MLET

Though not derived here, it seems logical that the above result can be generalized to all gravitational forces. Specifically, the same spatial gradient of gravitational potential (force) that causes a body to vary from rectilinear motion also affects the clocks in the vicinity of that body in such a way as to automatically adjust the clock bias required to make the speed of light appear to be isotropic. Thus, the variation in the earth's orbit around the sun caused by the motion of the moon can also be ignored. And, indeed, the clocks in the earth-centered inertial frame do ignore the effect of the moon's gravitational potential. ***This also validates MLET and invalidates SRT.***

The tie between gravitational effects on the clock and the gravitational force on an orbiting planet or moon clearly has implications for acceptable isotropic light speed frames. There is a natural hierarchy of acceptable frames depending upon the extent and location of the experiment or system under consideration. In general, it is possible to move up the hierarchy from the natural frame of an experiment to a more general frame. However, it is generally impossible to move down the chain to the more limited frame. As an example, the natural isotropic light speed frame for the GPS system is the earth's frame. It is possible to work the GPS system in the sun's frame but impossible to work the GPS system in a local laboratory frame on the surface of the earth.

The evidence that MLET is correct allows us to describe clock behavior in a new way. Clock rate proves to be independent of the chosen frame. Indeed, two clocks synchronized while collocated and then separated remain synchronized in all frames when adjusted by the appropriate velocity and gravitational potential effects. In a local frame in a lab on the surface of the earth, two clocks moved apart by slow transport will need no adjustment and will measure an isotropic light speed on the surface of the spinning earth. If the same clocks are used in the GPS system, which employs an earth-centered non-rotating frame, the clock rate will need to be adjusted to remove the spin velocity and gravitational potential of the earth (which in general cancel). However, the clock biases will be different in the two cases. In the first case of the local laboratory, slow clock transport will give the transported clock the automatic bias needed to measure an isotropic light speed locally. In the second case the clock bias will need to be adjusted by the computed effect of the spin velocity product with the slow-transport velocity in order to obtain an isotropic light speed in the earth-centered non-rotating frame.

In the earth's frame, when in the vicinity of the earth, the clocks need to be adjusted by the velocity with respect to the earth center and by the earth's gravitational potential but not by the moon's or the sun's gravitational potential. This latter is verified by the clocks in the GPS. The clause "when in the vicinity of" is needed because it is the local gradient of the gravitational potential causing the motion of the frame origin which affects the clocks and causes the clock to be biased to make the local speed of light to appear to be isotropic. When the clocks are far removed from the frame origin, this gravitational gradient is not the same and must be carefully analyzed. Thus, in the earth's frame when in the vicinity of the moon, the moon's gravitational potential clearly creates an effect which cannot be ignored. Similarly, in the sun's frame in the vicinity of the earth, the effect of the earth's gravitational potential must be accounted for. It should also be noted that gravitational tidal effects (gradient of the force) can affect the orbits of satellites and the position of clocks and thereby induce differential clock rate effects which are not automatically canceled.

In the sun's frame, when in the vicinity of the sun, the effect of the planets upon the clocks could be ignored. However, a more practical approach is taken. The sun's frame can be generalized to cover the entire solar system and beyond by using the barycenter (the center of mass) of the solar system as the center of the coordinate system rather than the sun's center. When this is done, we get a procedure valid throughout the solar system. Simply adjust all clocks by the effect of the velocity with respect to the barycenter and by the combined gravitational potential of the sun and all the planets. Even here, though, we ignore the effects of the galactic gravitational potential—because its gradient keeps the clocks biased properly so that we can ignore the changing direction of the sun's orbit around the galaxy.

CONCLUSIONS

In conclusion, in the solar system barycenter frame, as used by JPL in space probe analysis and as used by others to convert the electromagnetic pulses from a pulsar into a precise clock, all clocks are seen to slow as a result of velocity with respect to that frame and all clocks are seen to vary as a function of the sun's and earth's gravitational potential. However, in the earth's frame, when we assume the speed of light is isotropic on the earth, the velocity with respect to the earth and the gravitational potential of the earth affect the clocks as expected. But there is no discernable effect of the sun's gravitational potential. It is easy to understand that there is no discernable effect from the average (at earth's center) of the sun's potential since it affects all clocks in the earth's vicinity equally. But SRT has no valid way of explaining why the clocks do not seem to be affected by the gradient of the sun's gravitational potential. By contrast, MLET and Lorentz ether theories in general can explain the absence of the effect. The effect is still there. It is simply absorbed into the clock bias required to convert the Selleri transformation into an apparent Lorentz transformation.

The requirement that the sun's gravitational potential not be applied to clocks resident or moving in the earth's inertial frame gives very strong support to the MLET theory. But, even more significant, it clearly invalidates the SRT.

The clear invalidation of SRT should have at least one desirable effect. Specifically, it should make the intellectual climate more open to alternative theories. Numerous quotes in the latter half of the 20^{th} century can be cited to show that Einstein has been accorded the status of a "God of Science," and to question his theories has been anathema. I illustrate this with several quotes:

James Gleick [21]: "There will never be another Einstein …Einstein's genius seemed nearly divine in its creative powers. He imagined a certain universe and this universe was born."

Carl Lanczos [22]: "He (Einstein) wrote his name in the annals of science in indelible ink which will not fade as long as men live on the earth. There is a finality about his discoveries which cannot be shaken. Theories come, theories go. Einstein did more than formulate theories. He listened with supreme devotion to the silent voices of the universe and wrote down their message with unfailing certainty…he was never deceived by appearances and his findings had to be acknowledged as irrefutable."

Paul Davies and John Gribben [23]: "All the implications of special relativity…have been confirmed by direct experiments. There are still people who believe it is 'just a theory.' But they are wrong."

Isaac Asimov [24]: "No physicist who is even marginally sane doubts the validity of special relativity."

Clifford Will [25]: "Special relativity is so much a part not only of physics but of everyday life, that it is no longer appropriate to view it as the special "theory" of relativity. It is a fact…"

These quotes show why virtually all main-line magazines will not accept any paper questioning Einstein's theories. The situation needs to change. It is anti-science. Einstein himself was never so pretentious, as the quote from Banesh Hoffman [26] shows: "To Solvine who had written congratulating him on his seventieth birthday, he wrote in reply on 28 March 1949, saying in part: 'You imagine that I look back on my life's work with calm satisfaction. But from nearby it looks quite different. There is not a single concept of which I am convinced it will stand firm,…'"

A second desirable effect is hoped for. A critical experiment could easily be performed to verify or refute MLET. MLET receives strong support from the fact that the effect of the gradient of the sun's gravitational potential is absorbed into the Lorentz transformation clock bias. However, as developed in a prior paper [27], there are very significant implications for all of physics when the concepts of MLET are pursued to their logical conclusion. For example, there is substantial evidence in favor of the MLET gravitational scale factor of equation (3) in place of the GRT scale factor of equation (2).

If equation (3) is correct, we find that the gravitational force deviates from an inverse square law and becomes significantly weaker than the inverse square law would predict near large masses. In fact, because the gravitational force is self-limiting, "Black Holes" are ruled out. This same weaker gravity causes the mass of large stars to be underestimated because the inverse square law is used to measure the mass. This effect can explain the anomalous redshift of type OB stars. The red shift is gravitational. The mass has simply been underestimated. This same underestimation of the mass implies a greater force at long distances. This greater force may explain the excess rotation rate at the edges of galaxies and do so without WIMPS, MACHOS or any other form of strange mass.

A critical refutation or verification of the validity of the MLET force law could be obtained by launching a drag-free spacecraft (a spacecraft which is accelerated to maintain its position relative to a freely orbiting internal test mass) to carefully measure the gravitational force as a function of the distance from the sun.

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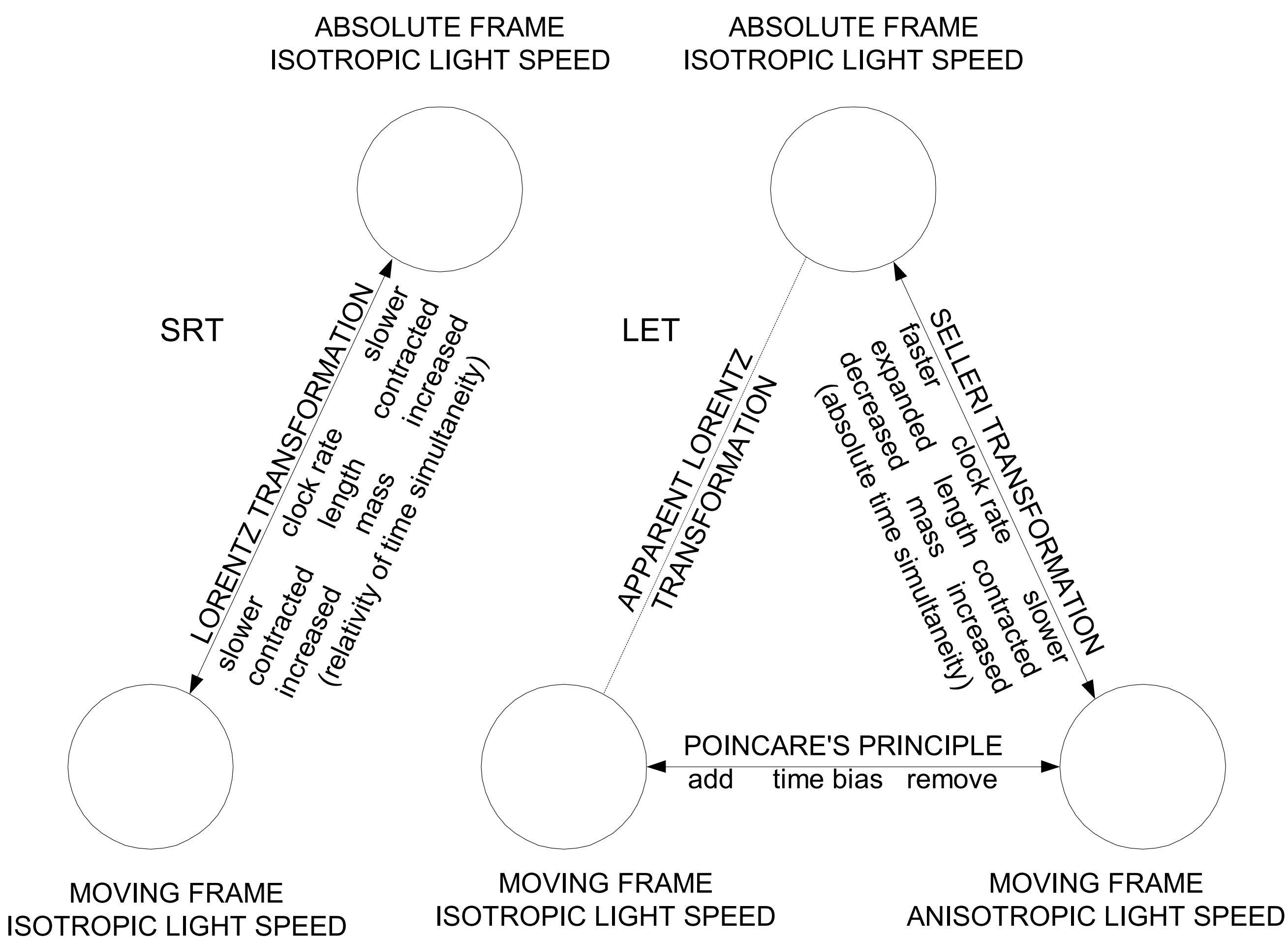

Figure 1 Comparison of SRT and LET transformations