Relativistic Crossroads and the possibility of Variable c Space-Times

E. F. Halerewicz, Jr.*

February 3, 2003

Abstract

By proposing multiple variants for the speed of light an extended relativistic theory is presented where the second relativity postulate $x_i = ct$ applies only to local mediums and not extended frames.

1 Introduction

Undoubtedly one of the greatest achievements in 20^{th} Century physics was the development of the relativistic description of the motion of electrodynamic bodies proposed in 1905 by Albert Einstein [1]. Transforming the established absolute preferred frame or universal reference frame which allowed Newtonian physics to describe mechanics with high precession. The special theory of relativity revealed an entirely new world view in which space and time were unified into a single continuum, as opposed to independent quantities. Its usefulness has been shown by allowing events at great distances to become synchronous even without a universal frame of reference. The relativistic theory of electrodynamic motion was also successful at explaining the apparent non existence of a luminiferous ether. The relativistic theory has been successful in describing perviously unknown dynamics of gravitational fields as well as relativistic quantum fields. There can be no question to the usefulness and significance of the relativistic description of physical systems to the natural sciences.

The theory of general relativity has largely been successful at describing the behavior of many observed astronomical phenomena. Even providing the basic frame work for the evolution of the cosmos at large. It would however be interesting from an empirical perspective to assume no knowledge of relativistic affects when considering cosmology. Do our preconceived notions of relativistic affects dramatically change the interpretation of our view of the universe, or does it act as an aid for our observations as presumed? From that stand point taking astronomical objects such as Blazars whose apparent velocity is observer dependent into consideration we would conclude that there are velocities for light

*halgravity@yahoo.com

greater than what is derived by Maxwell's theory on electromagnetism. However with the many experimental success from relativity theory we know that the previous example is merely an illusion, or is it? Noting such a potential deviation of observation from theory is it unreasonable to ask that our preconception of the 1905 special relativity is stalemating our understating of all the possible dynamics of relativistic fields?

The 1905 theory of special relativity is based on the *special* consideration that speed of light is constant for observers in frames K and k, this consideration requires that the two observers reside in the same medium. When there are frames with varying initial conditions K' and k' we have the general relativistic description of space-time, or covariant reference frames. Any sufficiently localized area of curved space-time reduces to the flat relativistic space-times of special relativity, which has been confirmed by experimental observation. This established description however necessarily neglects the possibility for variable c mediums for the propagation of light, thereby we introduce the following extended reference frames K_0 and k_0. Clearly such a consideration would have a direct impact on both the special and general theories of relativity and possibly relativistic Quantum Field Theories (QFTs) as affective field theories in which to describe the dynamics of space-time. Since the mathematical possibility of variable c propagations are not ruled out in the Maxwellian theory of electromagnetism, is it not unreasonable to consider variable c affects on the relativistic description of space-time? Although for the purpose of discussion it is noted in advanced that while variable c frames may be mathematically feasible it does not necessarily require space-time to be variable c in nature. The purpose of this paper is just to discuss the potential affects of variable c space-times and how there validity may be tested. This paper describes the potential affects of variable c mediums in relativistic frames, in Lorentz frames, and finally within gravitational sources. The special relativistic case implies tachyonic-like states can be momentarily observed, however they obey there own local Lorentz laws. In the general relativistic case c-variable mediums can affect the interactions between gravitating bodies thereby possibly indicating new field dynamics for the behavior of space-time.

2 Variable c reference frames

Boosted and rotated frames of reference are at the heart of the relativistic transformations within space-time. It would thus be wise to look at the affects of variable c Lorentz transformations. Let us consider two reference mediums in respect to our prior assumed c, c' will represent a subluminal medium and c'', will be superluminal as seen from K. When the light paths of reference mediums c and c'' interact the K_0 (the c' reference frame) could be considered a gravitational field in reference to K, thus K_0 would appear to have a contracted light cone as seen from K. If one considers the c'' medium or frame K_1 it would appear as a cosmological expanse that is to have an expanded light cone as seen from K. The interactions between these three mediums can also allow us to open up a natural frame work in which to discus casual and acasual affects, which may yield new insight to the so called grandfather's paradox[1]. On taking frames K_0 and K we put k' (where prime is the 1905 special relativity synch factor for the remote frame) into K_0, so that points A and B_0 in space-time are in different mediums (see figure 1). From K_0 a light signal from a rest particle at A would appear to be blue shifted, while from K a signal from rest particle B_0 would appear red shifted. So that the frame k'_0 appears to doppler shift rest particles A and B_0 to the reference mediums K and K_0. Although both A and B_0 perceive $c = constant$, so if B_0 accelerates to some value B'_0 towards A no doppler shift in acceleration will be perceived from B'_0 as seen from K. As a consequence if B'_0 is moving in the line of sight of K can appear stationary even though its in motion and can therefore appear to jump into frame K, and only then appear to accelerate once in the new frame medium. The jumping of an accelerated particle from one reference medium K_a to another reference medium K_b tends to mimic the description of tachyonic particles. Inversely if B'_0 were to accelerate away from rest particle A it can at some point appear to have negative energy as seen from K, however it is outside the light cone of K and hence cannot be observed . Clearly acausal events can seem to occur when particles accelerate into variable c reference frames, but locally there are no acausal events, as the Lorentz transformation remain intact locally. Thus casuality violations only appear when a particle from K_a crosses into K_b and vise versa, as the laws for Lorentz transformations vary upon the local medium. Casualty violation thus occurs because of a global assertion that $c = constant$ when k'_a appears to be in synch with k'_b. From this consideration frame K_1 as seen from frame K would appear as K does from K_0, thereby resolving apparent 'superluminal' acausal paradoxes, that occurs by assuming 1905 Lorentz transformations are affective globally.

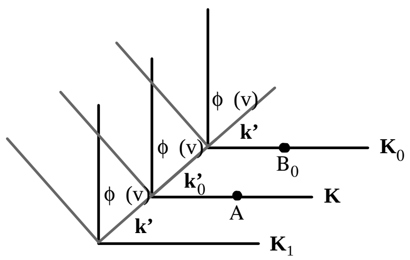

Figure 1: Variable c reference frames. K represent the rest medium for each c-variable frame, while the subscripts represent variable c basis. k' represents the rotation from an extended frame k'_b into a remote observer's frame K_a, and lastly $\phi(v)$ represent the medium shift.

[1]The thought experiment which outlaws time travel because of a logical paradox which can result from travelling backwards through time. For example it is illogical for someone to travel backwards through time and kill their grandfather and still have the ability to exist in the future and travel backwards through time.

postulate 1: Tachyons are particle boosts from c-variable frames K_b into a remote observers's frame in K_a.

postulate 2: Spontaneous doppler shifts can arise in space-time and are the result of Lorentz rotations in c-variable frames k'_b in reference to a local frame K_a.

This idealogy supports dispersion modified versions of Lorentz transformations presented in "Doubly Special Relativity" (DSR) theories [2], [3] inspired in part to explain cosmic energies above the GZK ($10^{19}eV$) cut off [4].

3 The Lorentz ϕ-factor

When considering our variable c approach it becomes helpful to review the early relativistic transformations [1]:

$$t' = \phi(-v)\beta(-v)(\tau + v\xi/ct^2) = \phi(v)\phi(-v)t \tag{1}$$

$$x' = \phi(-v)\beta(-v)(\xi - vt) = \phi(v)\phi(-v)x \tag{2}$$

$$y' = \phi(-v)\beta(-v)\eta = \phi(v)\phi(-v)y \tag{3}$$

$$z' = \phi(-v)\beta(-v)\zeta = \phi(v)\phi(-v)z \tag{4}$$

where

$$\beta = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{5}$$

thus one is left with a transformation of order $\phi(v)$. On examination transformations from k'_b to K_a are required to be light like separated, requiring a transformation corresponding to:

$$\beta(K_a) = \beta(\phi(v_b)c_b t) \tag{6}$$

with $v = c = 1$ the special relativistic solution

$$\phi(v)\phi(-v)t = 1 \tag{7}$$

eq. (6) reduces to eq. (5), and is the likely reason for the variable c loophole for having gone unnoticed in the 1905 special relativity as it would have complicated the description of the so called luminiferous ether. Thus when the light paths between A and B_0 are no longer synchronous caused by a remote shift in $\phi(v)$ tachyonic-like states can spontaneously form in space-time.

4 Variable c in the quasi-general theory

The frame work for general relativity is based on comparing frames Kk to $K'k'$, or in the format of this paper its the comparison between $K_a k_b$ to $K'_a k'_b$, although keeping with the less general notation $K_a k'_b$ and $K'_a k''_b$. So that there are points A and B that make up $K_0 k''$, and $K' k_0''$, with A' and B' to make up $K_0' k''$ and $K' k_0''$. This requires that $K_a k_b$ is in actual sync with $K_a' k_b''$ so that k'' and k_0'' provide an averaging speed for c. Say that there is a test particle at A and that another particle at B has a non trivial mass, one would assume that time would slow near B in reference to A. However since the frames can be given as $B' k_0''$ and Ak', $k_0'' = k'$ thus $A = B$, which indicates that B rotates into A' to require mass as seen from A. So with a variable c, K_0 would slow time for K, from that it can be seen that mass can't be boosted into K_0, as mass would then be required to accelerate into the past light cone of $\phi(v_b)$ which would be non physical.

Theorem 1: Rotational c-variable frames k_b'' *cannot* be boosted into a remote observer's frame K_a, there are **no space-time boosts**.

Theorem 2: Frame extended gravitational fields are past light cone doppler shifts of c-variable rotational frames into future light cones of a remote observer.

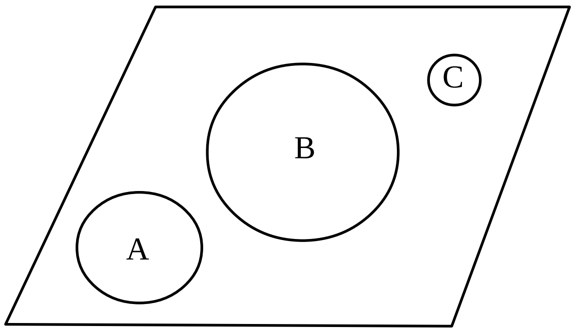

Figure 2: Interaction between gravitational torsion between varying Schwarzchild radii. Both A and C can reduce the mass of B, however B can not affect A and C. Neither A or B can affect the torsion within C, and only C can affect the mass of A. This shows that $\phi(v_a)$ can not affect space-times with higher masses (with future extended light cones), as seen by theorem 1, thereby requiring a rotation of the extended frames, as seen by theorem 2.

5 Polarized Vacuum approach

In the Polarized Vacuum (PV) model of general relativity [5] one has the relation:

$$K = e^{2GM/rc^2} \tag{8}$$

Thus it is not difficult to see that $\phi(v_a)$ transformations take the form

$$\phi(e^{2GM/rc^2})dct^2 \tag{9}$$

if ϕ represents a doppler shift $f'(\phi) = f(\phi(v_b) + v_0)/\phi(v_b)$, it is seen that

$$\phi(e^{2GM/rc^2}) = \frac{2GM_a(M_b + M_a)}{M_b dct^2} = \frac{2GM_a(M_a)}{dct^2} \tag{10}$$

thus

$$\phi \simeq \frac{2M_a r}{dt} \tag{11}$$

so that the gravitational Lorentz transformation is

$$\beta(K_a) \equiv \frac{2M_a r(v_b) c_b t}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{12}$$

finally considering proper time $d\tau = (E/c^2)dt$ one can see that the apparent gain in mass from frame K increases as function of $2Mr$, which is in agreement with the equivalence principle.

Also of significance is the line element of the PV model of general relativity [5]:

$$ds^2 = \frac{1}{K} c^2 dt^2 - K(dx^2 + dy^2 + dz^2) \tag{13}$$

from theorem 1 a remote frame K_b can affect the local frame K_a, but no remote boost should be observed. In metric representation $g_{00} = 1/K_a$ for the local frame and $\hat{g}_{11} = \hat{g}_{22} = \hat{g}33 = K_b$ for the remote frame, thereby K acts as a torsion term on a metric. Thus a stress-energy momentum torsion tensor is likely to take the form

$$\nabla^c T_{\mathbf{ab}} = \rho u_a u_{a'} + P(\hat{\eta}_{bb'} + \hat{u}_b \hat{u}_{b'}) \tag{14}$$

(the bold subscripts represent tensor notation as opposed to frame references) it is clear that the momentum of a system can affect the g_{00}, thereby alluding to energy loss in gravitational fields.

This can be further substantiated by the derivative operate approach by Wald [6]. Presuming linearity $A, B_0 \in \mathcal{F}(k,l)$ and $\alpha, \beta \in R^3$. Our frame description in section (4) agrees with the Leibnitz rule, insuring torsion by commutativity contraction. Thereby torsion affects can be presented as

$$t(f) = t^a \nabla_a f \quad t(f) = t^b \nabla_b f \tag{15}$$

As the Einstein tensor can be written in the form

$$\frac{G_{\mathbf{ab}} 2}{\nabla^c - g_{\mathbf{ab}} T} \equiv \nabla^c T_{\mathbf{ab}} = 0 \tag{16}$$

it is not difficult to show that

$$\frac{1}{\nabla^c g_{\mathbf{ab}}} \equiv \frac{1}{2M_b r} \ . \tag{17}$$

The consequence of this effect is that rotational c-variable frames will appear to lose energy in respect to K_a. This can be seen by comparing a local stress-energy component T_1^{00}, with that of the remote frame T_2^{00}. So that the total interaction for axial momentum states is

$$T^{11}_{total} = T^{22}_{total} = \left[\frac{1}{a_m}\right] T_1^{00} - T_2^{00} \tag{18}$$

where $a_m = GJ/Mc^3$ is the angular momentum of the system. Such that when two gravitational masses $M_1 \equiv M_2$ interact the relative energy shared by the bodies approximates to $T_1^{00} + T_2^{00} = 2Ma_m^2$ for axial rotation. In this context the ρ and P terms of eq. (14) translate to

$$\rho = \frac{T_1^{00}}{dV} \qquad P_{axial} = \left[\frac{1}{a_m}\right] T_2^{00} + \left[\frac{1}{a_m}\right] T_2^{00} + 0 \tag{19}$$

So that as long as $a_m < rc$ the Strong Energy Condition (SEC) is upheld even with substantial gravitational radiation, however there is a violation of $\rho + \sum_i^3 P \geq 0$ $(i = 1, 2, 3)$ for $a_m > rc$. The consequence of these proposed interactions can be verified by observation for they suggest two possible test of the interactions between massive bodies and gravitational radiation[2].

6 Discussion

The possibility of c-variable space-times were presented in order to review the possibility of a neglected possible space-time dynamic with varying vacuum solutions. It was shown that the only modification to special relativity was the presence of variable c boost in frame K_a, which suggest the possibility that tachyonic-like states could be found in space-time, which is roughly analogous to the current arguments for DSR theories. The second artifact was the existence of external (extended) rotational frames which manifest themselves as gravitational fields. It was found that such extended reference frames can induce torsion on the fabric of space-time which can act to generate curvature onto a remote metric. Thus indicating that c-variable vacuums can affect the curvature of space-time and that such potential consequences can be observationally verified. Although c-variable space-times have negligible consequence on lower order fields they may provide useful insights into the dynamics of higher order fields. It will however take further investigation to realize wether or not these high order fields are physical, but there potential affects are significant enough to warrant further investigation into the affects of extended frames.

[2]The first is that two rotating near mass bodies orbiting each other may radiate gravitational energy and reduce there total entropy before there is any physical collision. The second being that if two rotating equal mass bodies where on a collision course but one satisfying the condition $a_m > rc$ they may in affect avoid such a course in contrast to the predictions of classical general relativity.

References

[1] Einstein A. "Zur Elektrodynamik bewegter Körper," *Annalen der Physik* **19** (1905). Lorentz H.A., et. al. The Principle of Relativity. Toronto: Dover, 1952.

[2] Amelino-Camelia G. "Relativity in space-times with short-distance structure governed by an observer-independent (Planckian) length scale." *Int. J. Mod. Phys. D* **11** (2002) gr-qc/0012051

[3] Maguejo J. and Smolin L. "Lorentz invariance with an invariant energy scale." *Phys. Rev. Lett.* **88** (2002) 190403 hep-th/0112090

[4] Amelino-Camelia G. "Kinematical solution of the UHE-cosmic-ray puzzle without a preferred class of inertial observers." astro-ph/0209232

[5] Puthoff H. "Polarizable-Vacuum (PV) representation of general relativity." *Found. Phys.* **32**, 927-943 (2002) gr-qc/9909037

[6] Wald R. General Relativity. Univeristy of Chicago Press, 1984, pg 31.