Concepts and ramifications of a gauge interpretation of relativity

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ABSTRACT. The Theory of General Relativity correctly describes physical phenomena, when observed/measured by electromagnetic radiation. Time can be defined as a property of electromagnetic radiation. Specifically, the propagation process required for light to travel 1cm, can be taken as a unit of time. The behavior of electromagnetic energy propagation (including propagation velocity) depends on the curvature of spacetime. Both gravitation and electromagnetism can be described as manifestations of spacetime curvature. By showing the speed-of-light c to be a function of curvature, one can argue that velocities greater than c do not violate causality. If electromagnetism is the standard of measurement & observation, then physical phenomena manifesting in states at (or in excess of) electromagnetism states, will appear distorted under such measurement. The principles of Einstein's relativity theory are used to derive a generalized relativistic concept, which is not based on electromagnetic signal behavior. Relativity is viewed as a gauge theory, to gain further insight into fundamental cosmology, such as examining if c is an upper bound to possible velocities.

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1. Introduction

Gravitation is a manifestation of spacetime curvature. Curvature is shown by the deviation of geodesics in a given spacetime neighborhood. Electromagnetism is also a manifestation of spacetime curvature. Gravitation & electromagnetism respectively can be viewed as the symmetric and asymmetric parts of the Ricci Tensor [1], [2], [7]. Obviously, curvature is not constant throughout all of spacetime. Thus, spacetime can be viewed as containing regions which can have curvature peculiar to that region. Information is generally defined as electromagnetic energy which radiates/propagates at the speed-of-light (c). With this definition, superluminal propagation could result in causality violation. However, this definition might be *specific*, and *not generically applicable* to the *basic concept* of information transfer. If this is true, issues of paradox, causality violation, etc. might be irrelevant. A reasonable postulate is that any events/phenomena (manifesting in excess of c) would appear distorted or ambiguous if observed via electromagnetic radiation. Further, the additional postulate that c i*s not* a limiting velocity, does not invalidate Special Relativity. It might, however, question Einstein's original interpretation of his theory.

If one considers the above 2 postulates, one concludes that gravitation and electromagnetism are both manifestations of spacetime curvature, and *functionally* equivalent. It follows that the primary constraint on velocity (*in normal spacetime*) is the *curvature* of spacetime. Additionally, since curvature can be different (*in different areas of spacetime*), it is reasonable to consider a *regional-structure of spacetime*. Such a regional-structure could suggest solution to several lingering cosmological questions.

To define a regional structure of spacetime, the concept of an orbifold is useful. The regional structure can be analytically defined, resulting in a tensor-based description for such a structure. Thus, such a regional structure concept is compatible with most cosmological methods

& models (e.g. Relativity, M-Theory, methods of Minkowski, Riemann, etc.), all of which employ tensor analysis methods. Conceptually, any region of spacetime can be defined by a separate (i.e. different) orbifold. Such a region would consist of a set of points identified under some *discrete symmetry group*. The manifold points that are so identified would be disjoint or overlapping subsets of the manifold. The "set of points" depends on the symmetry group selected. Thus, a given regional structure of spacetime depends *analytically* on the symmetry group selected for the different regions of that spacetime. A region of spacetime is defined by a set of points (of the general spacetime manifold) selected under a discrete symmetry group. If the "set of points" contains fixed points, then the region is defined as an orbifold. Each (non-fixed) point of a region can (obviously) be defined by a tensor element $\xi^{ij\ldots}{}_{k\ldots}$ that is an element of the tensor defining that region. Fixed points can also be defined in this manner.

Regions containing fixed points (i.e. orbifold singularities) are now considered. Such regions fail to be manifolds precisely at any respective "fixed points" of said regions. One notes that such "fixed points" might be useful in describing black holes and other cosmic discontinuities or singularities.

If fixed points are defined as;

> Singularities of an infinite curvature type, wherein the curvature of spacetime (at such a "fixed point") is infinite,

Then;

> Such a singularity induces (at that "fixed point"/singularity) a breakdown of General Relativity

By defining a region collapsed around a singularity (i.e. a region containing only a "fixed point", or containing only a set of "fixed points") a method of analysis might be suggested. A starting point, to find such a method, could be the assumption that singularities are a physical reality of spacetime. The next step is to attempt to establish an analytical framework for regional spacetime that accommodates singularities/"fixed points". A possible benefit of such a method (and of the overall concept of a regional structure of spacetime) can be appreciated from the following discussion concerning *gravitation* and *quantum theory* in a regional spacetime structure;

1.1. Spacetime Regions (Some possible ramifications)

If (as a brief aside) one examines a regional structure of spacetime, several factors might follow. The regions of spacetime, if dynamic (in size and/or other properties), could account for several phenomena (both observed and predicted). Considering the curvature parameter, if one examines *regional curvature*, as the regions become smaller;

Let:

W_i = volume of the ith region of spacetime

λ_i = curvature of the ith region of spacetime

$= f(W_i, \cdots)$

$$\partial\lambda_i/\partial W_i = \partial f(W_i, \cdots)\, dq_i/\partial W_i\ ,$$

where q_i is a generalized coordinate

Then:

$$\lim_{W_i \to 0} f(W_i, \cdots) = \lim_{W_i \to 0} \lambda_i \approx K$$

Where K is an approximation of curvature/gravity in a quantum framework?

It is interesting to note that, where W_i approaches the *Planck-Scale* (i.e. micro-regions), neither Relativity nor Quantum Theory accurately predicts the behavior of matter. Micro-regions could be used to describe quantum behavior/properties of curvature. As region size "theoretically" approaches zero, regional size encounters *the Planck-Scale*. Below the Planck-Scale, present knowledge prevents accurate prediction of behavior. Descriptions of curvature/gravity (under a regional structure) might therefore offer a way to incorporate a quantum framework that includes gravity, when micro-regions are considered.

The regions containing "fixed points" can be analytically collapsed into sub-regions that contain only "fixed points". This includes sub-regions that contain only one point (such that said point is a "fixed point"). The regions without "fixed points" are manifolds. Therefore each point of these manifolds can be defined as non-singular. These manifolds/regions can be represented by tensors, the elements of which define points of said manifolds. Sub-manifolds (i.e. sub-regions) could be defined by tensor operations such as *contraction*. Obviously, given a set of properties of a specific region, a particular sub-region might not be a manifold. In this case, considering that spacetime is a Riemann manifold, examining the *neighborhood* (of said sub-region) that has the properties of a manifold is required. Such a *non-manifold* sub-region might contain "fixed points". The micro-region concept can be applied here, such that a micro-region contains only a "fixed point" (i.e. singularity), or only *sets of* "fixed points" (i.e. *sets of* singularities). Theorems & methods for analyzing spacetime singularities are given in [2] and [5]. This is an ongoing research area. Analytically, using micro-regions to contain singularities, the methods of [2] and [5] can be applied to said micro-regions. Tensor representations (such as from [2]) for adjacent singularity-free sub-regions (i.e. manifolds), can then be applied.

In summary, a regional structure of spacetime provides a means to analyze certain cosmological (and perhaps quantum) phenomena. The question of the speed of light c, as a limit to velocities, can be effectively analyzed under a regional structure of spacetime. Although, controversy continues regarding c (and the Special Theory of Relativity), a regional structure of spacetime can be a useful tool. It accommodates most of the prevailing cosmological theories (including M-Theory).

2. Mag-Lev (*Magnetic-Levitation*) Considerations

To illustrate how electromagnetism can affect curvature, one can examine mag-lev technology. This technology neutralizes gravity and thus locally induces a change in spacetime curvature. Please note that **boldface type** indicates a vector quantity, in the remainder of this document; example (***v*** implies the vector quantity v).

The Ricci Tensor is a second order covariant tensor, formed by the contraction of the curvature tensor $ß^{m}_{ikj}$, and usually denoted as R_{ij} . It is used to analytically express the curvature of spacetime, in a specified neighborhood, at a specified time. Dynamic spacetime curvature thus could be viewed as an event in spacetime. If said neighborhood is defined as the immediate vicinity of a vehicle (wherein said vehicle possesses a configuration of electromagnetic devices, such that said devices project an electromagnetic field (i.e. bubble), in/about the neighborhood of said vehicle), the vehicle could move/fall along the geodesic produced by manipulating the curvature of said neighborhood.

The equivalence of gravity and electromagnetism has been established in references [1] and [2]. The process of *mag*netic *lev*itation (mag-lev) is described in [10]. This mag-lev process, where;

M_B ==> strength of base magnet
M_L ==> strength of levitation magnet
(usually attached to a vehicle, such as a mag-lev train)

The force between the base (M_B) and the vehicle (M_L) is referred to as the heave-force ***h***, in mag-lev applications. The heave-force neutralizes gravity *locally*. This is a manifestation of spacetime curvature, and one has the following;

$\boldsymbol{h} = \boldsymbol{h}(M_B , M_L)$

$\boldsymbol{h} \approx$ ***Њ*** , where: ***Њ*** = ***Њ*** (M_B , M_L)

In a generalized mag-lev application, the base-magnet M_B and the lev-magnet M_L are both connected to the vehicle.

2.1. Equations of Motion

The Ricci Tensor (in terms of M_L and M_B) can define the heave-force/induced-curvature of the mag-lev effect resulting from M_L and M_B. From reference [3], (*noting that a vector is a tensor of rank 1*), one has the expression

$$\boldsymbol{h} = \mu_0 \boldsymbol{I}^2 \beta / 2\pi \boldsymbol{z} = \boldsymbol{F_h}$$

where: β = coil length
$\boldsymbol{I}$ = current
μ_0 = a magnetic constant

$\boldsymbol{F_h} = \mu_0 \boldsymbol{I}^2 f(\boldsymbol{D}/\varphi)$ is the heave force description

where: $\boldsymbol{D}$ = a magnet dimension (*electric flux density*)
φ = separation of M_B (base) and M_L (lev-vehicle)

$\boldsymbol{F_g} = q\boldsymbol{E} + (q\boldsymbol{v} \times \boldsymbol{B})$ is the EM/gravity description (Ricci Tensor) for change in q at velocity $\boldsymbol{v}$.

$\boldsymbol{F_h} \equiv \boldsymbol{F_g}$, $\mu_0 \boldsymbol{I}^2 f(\boldsymbol{D}/\varphi) = q\boldsymbol{E} + (q\boldsymbol{v} \times \mu\boldsymbol{H})$

where: $\boldsymbol{H} = \boldsymbol{B}/\mu$
$q\boldsymbol{E} + (q\boldsymbol{v} \times \mu\boldsymbol{H})$ is the Lorentz Force law

Again from reference [10], $\boldsymbol{F}$ is defined as follows;

$\boldsymbol{F} = M_L M_B / \boldsymbol{r}^2$ (where r is the distance between magnets M_L and M_B)

$R_{\mu\nu} = -K\, T_{\mu\nu}$ is the Ricci Tensor, $T_{\mu\nu}$ is the Energy-momentum Tensor, and $\mu\nu$ are *translation* and *rotation* coordinates respectively.

If $\boldsymbol{F}$ and $R_{\mu\nu}$ are both expressions of spacetime curvature, one has the following;

$$M_L M_B / \boldsymbol{r}^2 = -K\, T_{\mu\nu} \tag{2.1}$$

$$= R_{\mu\nu}(M_L, M_B) \tag{2.2}$$

$$= \boldsymbol{Ћ}$$

With an expression for $\boldsymbol{Ћ}$ in terms of M_L and M_B, it is possible to define a set of "*equations-of-motion*" for a particle or vehicle.

Definitions:

$\boldsymbol{Ћ}$ --- the (M_L and M_B induced curvature) geodesic path velocity of a particle/vehicle
$\int \boldsymbol{Ћ}\, dt$ --- position (along the induced curvature) geodesic path
$d\boldsymbol{Ћ}/dt$ --- acceleration (along the induced curvature) geodesic path

The curvature induced by M_L and M_B is equivalent to the heave-force $\boldsymbol{h}$ (i.e. mag-lev effect) induced by M_L and M_B.

2.1.1. Equations-of-Motion Conclusions. Gravitation and Electromagnetism are respectively the symmetric and antisymetric parts of the Ricci Tensor, within a proportionality factor. Gravitation and electromagnetism are both expressions of spacetime curvature. Thus the mag-lev heave-force is also an expression of spacetime curvature, and $\boldsymbol{h}$ and $\boldsymbol{Ћ}$ are arguably equivalent.

Obviously, a more rigorous derivation can lead to a fully comprehensive set of equations-of-motion. The purpose here was to merely illustrate these arguments in an analytical framework.

2.2. Framework of Concept

Gravity is a manifestation of the curvature of spacetime. Due to the equivalence of gravity and electromagnetism (i.e. gravitation and electromagnetism are respectively the symmetric and antisymetric parts of the Ricci Tensor), electromagnetism is also a manifestation of spacetime curvature. Thus, by "*proper use*" of electromagnetism, spacetime curvature can be induced. Mag-lev technology is an example of this. The term, "*proper use*", herein means specific configurations of electromagnetic forces can produce/induce desired curvature of spacetime.

A geodesic is defined in [4], as a curve uniformly "parameterized", as measured in each local "Lorentz frame" along its way. If the geodesic is "timelike", then it is a possible world line for a freely falling body/particle.

As stated in [4], free fall is the neutral state of motion. The path through spacetime, of a free falling body, is independent of the structure and composition of that body. The path/trajectory of a free falling body is a "parameterized" sequence of points (i.e. a curve). The generalized coordinate q_i is used to label/parameterize each point. Generally, q_t refers to time. Thus, each point (i.e. parameterized point) is an "*event*". The set of events (i.e. ordered set of events) is the curve/trajectory of a free falling body. In a curved spacetime, these trajectories are the "straightest" possible curves, and are referred to as "geodesics". The parameter q_t (defining time) is referred to as the "affine parameter".

A Lorentz frame, at an "event" (ε_0) along a geodesic, is a coordinate system, in which

$$g_{\mu\nu}\,(\varepsilon_0) \equiv \eta_{\mu\nu}$$

and $g_{\mu\nu} \approx \eta_{\mu\nu}$ in the neighborhood of ε_0 ,

$$\begin{array}{rcll} \text{where:} \quad \mu & \Rightarrow & \text{translation coordinate} & \\ \nu & \Rightarrow & \text{rotation coordinate} & \\ \eta_{\mu\nu} & \Rightarrow & \text{Minkowski Tensor} \Rightarrow & \begin{cases} 1 \Rightarrow \mu = \nu = 1,2,3 \\ -1 \Rightarrow \mu = \nu = 0 \\ 0 \Rightarrow \mu \neq \nu \end{cases} \\ g_{\mu\nu} & \Rightarrow & \text{metric tensor} & \end{array}$$

The relationship between two points/events can be *spacelike* or *timelike*. The spacetime interval between two events ε_i , ε_j is given by;

$$d\tau^2 = dt^2_i - (1/c^2)d\varepsilon_i^2 = dt^2_j - (1/c^2)\, d\varepsilon_j^2$$

$$d\sigma^2 = d\varepsilon^2_j - c^2\, dt_i^2 = d\varepsilon^2_j - c^2\, dt_j^2$$

Depending on the relative magnitude of dt and $d\,|\varepsilon|/c$, $d\tau$ *or* $d\sigma$ will be real-valued. If $d\tau$ is real, the interval is timelike. If $d\sigma$ is real, the interval is spacelike. The degree of curvature can determine the relationship between points/events along a geodesic, resulting from such curvature. Thus, curvature defines a geodesic. A given curvature of spacetime produces a set of geodesics. A *properly controlled* particle (or vehicle) can "*fall*" along a given geodesic. The velocity vector ***Њ*** (under induced spacetime curvature) is dependent on the "*degree*" of that induced curvature. Thus, ***Њ*** is not constrained by c (the speed of light in normal/our spacetime). The velocity vector ***Њ*** is constrained only by the magnitude and configuration of the sources inducing the spacetime curvature.

3. Relativity as a Gauge Theory

One can define a gauge theory as one in which dynamic variables are specified relative to an arbitrary reference frame. Variables with physical significance are independent of which arbitrary reference frame is chosen. Stated alternatively, physical variables are gauge invariant. If one regards c as an arbitrary reference frame for the Theory of Relativity, then we can choose an arbitrary Φ (where $\Phi > c$) as an arbitrary reference frame. Then, a re-derivation of Relativity using Φ (instead of c) can be examined. Such a "Light Gauge Theory" could be regarded as an extended subset of Relativity. The Lorentz Transformation, using Φ, can be regarded as another gauge type transformation. To examine Einstein's field equations under a gauge framework, and consider the mag-lev example (for the equivalence of gravity and electromagnetism), it is useful to derive a modified Lorentz Transformation. This is done below in the Light Gauge Theory discussion.

Electromagnetic radiation is the basis by which we perceive and measure phenomena. All of our human experiences and observations rely on electromagnetic radiation. Observing experiments and phenomena perturb electromagnetic radiation. Our observations and measurements sense the resulting perturbations in electromagnetic fields. This realization has far reaching ramifications, ranging from our basic perceptions of the universe, to our concepts of space, time, and reality.

As a starting point, the Special Theory of Relativity postulates that the speed-of-light (c), is the maximum velocity achievable in our spacetime continuum. A more correct statement, of this result of Einstein's ingenious theory, is that c is the greatest *observable* velocity (i.e. the maximum velocity that can be observed) in our spacetime. This is because c (the natural propagation speed of electromagnetic radiation) is our *basis of observation*. Phenomena moving at speeds $\geq$ c cannot be *normally* observed using electromagnetic radiation. Objects/matter moving at *trans-light* or *super-light* velocities will *appear distorted* or be *unobservable*, respectively. A brief analytical discussion of these factors is given below, in following sections. This is the *first*, of the two primary principles, exploited in this document.
The *second* principle is that electromagnetism and gravitation are both expressions of spacetime curvature. Stated from the analytical perspective, electromagnetism and gravitation are respectively the antisymetric and symmetric parts of the gravitational Ricci Tensor. Since both the electromagnetic field and the gravitational field are obtained from the Riemann Curvature Tensor, both fields can be viewed as manifestations/expressions of spacetime curvature. This principle is proven in [7], and several other works.

3.1. Some Basic Issues

The above cited (and related) works also raise fundamental issues as to the origin, dynamics, and structure of our spacetime continuum. Our universe appears to be dynamic in several parameters. It is suggested that the results arrived at in this document might shed some small light on a few of said fundamental issues. Theoretically, the maximum achievable velocity is determined by *curvature*. The maximum achievable velocity is not limited by c (the speed-of-light) in normal/unperturbed spacetime.

3.2. Basic Concepts

Trans-light and super-light speeds have long been the domain of the science fiction community. In recent years, serious cosmologists and theoreticians have examined this arena. Below is presented a *generalized view* of the Special Relativity Theory. One starts with a *regional structure* of spacetime.

3.2.1. Regions of Spacetime. It has been suggested (for example in [9], by some string-theorists, etc.) that the “Big Bang” was a local phenomena, and that other “Big Bang” type phenomena events might be observable in distant reaches of our known universe. Additionally, many of the theoretical problems with the “Big Bang theory” (primary among which is causality), can be solved by considering a *regional structure* of spacetime. The, depending on the size of the regions, a “Big Bang” event could be viewed as a local phenomena.

- Below in this document, an arbitrary region of spacetime is examined and equations-of-motion (based on a generalized parameter of said region) are derived, so as to develop a *generalized view* of Special Relativity.

A regional view of spacetime can offer several analytical advantages and some ramifications. For this work, one can consider our known spacetime as a “region” of the universe. Under this framework, certain phenomena encountered by astro-physicists and cosmologists might be accounted for through *boundary conditions* of our spacetime region. Black holes, and the possible *variance* of c, are examples of such phenomena.

Further, if the “Big Bang” is a local phenomena, this reality would suggest that *the universe has always existed*. Coupled with aspects of M-Theory, a *regional structure* of the universe makes it not unreasonable to consider the universe without a specific origin, as one contemplates the definition of *origin* in this context. It is possible that the universe has always existed, [9]. Additionally, observed background radiation could be accounted for as inter-regional energy exchange.

3.3. Velocity

To examine constraints on velocity, it is useful to begin by deriving a generalized view of Special Relativity. An arbitrary *region* λ of spacetime will be examined. This could conceivably be our region/sub-universe/brane of existence. A generalized parameter of this region will also be used. Let this generalized parameter $\boldsymbol{\Phi}$ be defined as the maximum natural velocity (i.e. energy speed of propagation) in this region. Then one can derive the concepts of Special Relativity, based on parameter $\boldsymbol{\Phi}_\lambda$ in *region* λ .

For the purpose of this document (*and to attempt leeward bearing to other naming conventions*) the generalized derivation is referred to as the Light Gauge Theory (LGT). In this context “gauge” is defined as a standard of *measurement*, or a standard of *observation*. Additionally, the speed-of-light c , will also denote the velocity (vector) $\boldsymbol{c}$. Thus, both the speed & velocity-of-light are denoted by c, for notational simplicity in this document.

The term “neighborhood” should be understood as the immediate volume of spacetime surrounding (and containing) the point, particle, or vehicle under discussion, in the context of this document.

4. The Light Gauge Theory

Given:

Two observers a distance x apart in a *region* λ of spacetime. An event happens at observer A's position, at time t, (x_1, x_2, x_3, t). The observer B, at position $(x'_1, x'_2. x'_3, t')$ also observes the event that happens at A's position.

Let:

--- v_λ define the maximum propagation speed of signals in *region* λ

--- $v_\lambda > c$, $v_\lambda > c_\lambda$

This is a counter assumption that c is not necessarily universal, and that c_λ is not the maximum speed a signal can propagate in spacetime *region* λ .

Two viewpoints/arguments are considered:

1. The maximum signal velocity, in a spacetime region, is unbounded (i.e. ∞)
2. The maximum signal velocity, in a spacetime region, cannot exceed some Φ in that spacetime region, (e.g. Φ_λ , for the spacetime *region* λ). One states that $\Phi_\lambda \neq c_\lambda$, can be viewed as the general case.

Argument 1;

This 1st viewpoint would imply instantaneous synchronization, and the *observable* simultaneity of diverse events. Instantaneous propagation is an oxymoron. It does not follow observable (or analytical) analysis.

Argument 2;

This 2nd viewpoint involves deriving a Lorentz transformation for a spacetime region. One then defines an inter-region transformation for observers in different spacetime regions, where the regions are sub-manifolds on the general *Riemann Manifold* of spacetime.

4.1. Modified Lorentz Transformation

For the remainder of this document, I consider the set of spacetime regions that are definable as sub-manifolds on the *Riemann Manifold* of spacetime. The Theory of General Relativity describes physical space (i.e. our spacetime region) as a manifold.

One considers, in spacetime *region/(sub-manifold)* λ, two observers moving relative to each other, at velocity $\boldsymbol{v}$. For notational simplicity, one observer will be in an unprimed coordinate system, (x_i , t_i). The other observer is in a primed coordinate system, (x'_i , t'_i). One "assumes" (as in Special Relativity) that , at the origin of each *reference frame*, $x = 0$, $t = 0$.

Let:

$$x' = \alpha\boldsymbol{x} + \boldsymbol{v}(\beta\boldsymbol{v} \bullet \boldsymbol{x} + \kappa t)$$

$$t' = \zeta\boldsymbol{v} \bullet \boldsymbol{x} + \eta t$$

$\alpha, \beta, \kappa, \zeta, \eta$ fall from the pre-relativistic equations $x' = x + vt$, and $t' = t$

Thus, α, κ, η approximate 1, and β, ζ approximate 0, when $v < \Phi_\lambda$. One defines c_λ as the speed of light in spacetime *region* λ . Let $c_\lambda < \Phi_\lambda$. If one assumes (according to Relativity) that the speed of light is constant, one has $c_\lambda = c < \Phi_\lambda$.

If the primed coordinate system has a velocity $\boldsymbol{v}$, in the unprimed coordinate system, and the unprimed coordinate system has velocity $\boldsymbol{v}$ in the primed coordinate system, one has the following;

If $x' = 0$, then $x = -vt$ and if $x = 0$, then $x' = vt'$

$$\begin{aligned} 0 &= -\alpha\boldsymbol{v}t + \boldsymbol{v}(\beta\boldsymbol{v} \bullet \boldsymbol{v}t + \kappa t) \\ &= -\alpha\boldsymbol{v}t + \kappa\boldsymbol{v}t - \beta\boldsymbol{v}^2 \bullet \boldsymbol{v}t^2 \end{aligned}$$

$$\alpha = \kappa - \beta\boldsymbol{v}^2$$

$$t' = \zeta\boldsymbol{v} \bullet \boldsymbol{x} + \eta t$$

$$t' = -\zeta\boldsymbol{v} \bullet \boldsymbol{v}t + \eta t$$

$$\eta t = \zeta\boldsymbol{v}^2 t \text{ , (where } \eta = \zeta \text{ for proper values of } \boldsymbol{v}^2 \text{)}$$

One can now discuss the maximum signal velocity ($\boldsymbol{\Phi}_\lambda$) , possible in the λ *region* of spacetime. Assume that this maximum is universal, in the λ *region* of spacetime. In other words, ($\boldsymbol{\Phi}_\lambda$) is the maximum attainable signal velocity in the λ *region* of spacetime, irrespective of the observer's coordinate system.

Note;

1. Here, the λ *region* of spacetime is defined as a sub-manifold on the (general spacetime) Riemann Manifold.
2. Assume that $\boldsymbol{\Phi}_\lambda$ is a function of the curvature of spacetime *region* λ.

(In the remainder of this document, *for notational simplicity and confusion avoidance*, Φ_λ will be used interchangeably with $\boldsymbol{\Phi}_\lambda$, to imply the vector $\boldsymbol{\Phi}_\lambda$)

Suppose at time t = 0 , an event occurs at x = 0 , the origin of the unprimed coordinate system in *region* λ . Then at any point in *region* λ (with coordinate x), a signal traveling at maximum velocity will arrive at x by:

$$\Phi^2_\lambda t^2 = x^2 \ , \quad t > 0 \tag{4.1}$$

this is also true for x' , thus $\Phi^2_\lambda t'^2 = x'^2$

$$x = -vt \ , \quad x^2 = v^2 t^2 \qquad (\text{ for } x' = 0 \ )$$

$$t^2 = x^2 / \Phi^2_\lambda$$
$$v^2 = x^2 / t^2$$

$$\alpha = \kappa - (x^2 / t^2)\, \beta \ , \ \kappa = \eta$$
$$= \kappa - v^2 \beta$$

$$x' = \alpha\, \Phi_\lambda t + \boldsymbol{v}(\beta \boldsymbol{v} \bullet \Phi_\lambda t + \kappa t) \tag{4.2}$$
$$t' = \zeta\, \boldsymbol{v} \bullet \Phi_\lambda t + \kappa t$$
$$= (\zeta\, \boldsymbol{v} \bullet \Phi_\lambda + \eta\ ) \tag{4.3}$$

$$\Phi_\lambda t' = \alpha\, \Phi_\lambda t + \boldsymbol{v} t\, (\beta \boldsymbol{v} \bullet \Phi_\lambda + \kappa)$$
$$= (\zeta\, \boldsymbol{v} \bullet \Phi_\lambda t + \eta t)$$
$$= (\zeta\, \boldsymbol{v} \bullet \Phi_\lambda + \kappa) t$$

$$\zeta\, \boldsymbol{v} \bullet \Phi_\lambda t + \kappa t = \alpha\, \Phi_\lambda t + \boldsymbol{v}\, \beta \boldsymbol{v} \bullet \Phi_\lambda - t + \kappa \boldsymbol{v} t)$$
$$= \alpha\, \Phi_\lambda t + \boldsymbol{v} \bullet \Phi_\lambda t\, (\boldsymbol{v}\, \beta - \zeta\ ) + \kappa t\, (\boldsymbol{v} - 1)$$
$$= \alpha + \boldsymbol{v}\, (\boldsymbol{v}\, \beta - \zeta\ ) + (\kappa / \Phi_\lambda)(\boldsymbol{v} - 1)$$
$$= \alpha + \boldsymbol{v}\, (\boldsymbol{v}\, \beta + \kappa / \Phi_\lambda) - \zeta\, \boldsymbol{v} - \kappa / \Phi_\lambda$$
$$= \alpha + \boldsymbol{v}^2\, \beta + (\kappa / \Phi_\lambda)(\boldsymbol{v} - 1) - \zeta\, \boldsymbol{v}$$

Let :

$$\beta = \boldsymbol{v} / \Phi_\lambda$$

then:

$$\zeta\, \boldsymbol{v} \bullet \Phi_\lambda t + \kappa t = \alpha\, \Phi_\lambda t + \boldsymbol{v}\, \boldsymbol{v}^2 t + \kappa \boldsymbol{v} t$$
$$\zeta\, \boldsymbol{v} \bullet \Phi_\lambda + \kappa = \alpha\, \Phi_\lambda + \boldsymbol{v}\, \boldsymbol{v}^2 + \kappa \boldsymbol{v}$$
$$= \alpha + \boldsymbol{v}\, \boldsymbol{v}^2 / \Phi_\lambda + \kappa \boldsymbol{v} / \Phi_\lambda$$
$$(\text{where;} \quad \alpha = \kappa - \boldsymbol{v}^2 \beta$$
$$= \kappa - \boldsymbol{v}^2\, \boldsymbol{v} / \Phi_\lambda \ \}$$

$$\zeta\, \boldsymbol{v} + \kappa / \Phi_\lambda = \alpha + \boldsymbol{v}^2 \beta + \kappa\, \beta$$
$$\zeta\, \boldsymbol{v} + \kappa / \Phi_\lambda - \boldsymbol{v}^2 \beta - \kappa\, \beta = \alpha$$
$$\zeta\, \boldsymbol{v} + \kappa\, ((1 / \Phi_\lambda) - \beta) - \boldsymbol{v}^2 \beta = \alpha$$
$$\zeta\, \boldsymbol{v} + \kappa\, (1 - \Phi_\lambda \beta) - \boldsymbol{v}^2 \beta = \alpha$$
$$\kappa + (\zeta\, \boldsymbol{v} - \Phi_\lambda \beta) - \boldsymbol{v}^2 \beta = \alpha$$
$$\{\text{where;} \quad (\zeta\, \boldsymbol{v} - \kappa \Phi_\lambda\, \beta) = 0 \ , \quad \text{under certain conditions}\}$$

4.1.1. Inter-Region Transformation.

Given:

$$x^2 + y^2 + z^2 - \Phi^2_\lambda\, t^2 = (x'^2 + y'^2 + z'^2 - \Phi'^2_\lambda\, t'^2)f(\boldsymbol{v}) = 0$$

$\{y^2 = y'^2\,,\ z^2 = z'^2 \implies$ no motion$\}$

$$x^2 + y^2 + z^2 - \Phi^2_\lambda\, t^2 = (x'^2 + y'^2 + z'^2 - \Phi'^2_\lambda\, t'^2)f(\boldsymbol{v}) = 0$$

$$x^2 - \Phi^2_\lambda\, t^2 = x'^2 - \Phi'^2_\lambda\, t'^2$$

Let;

λ(n) = 1

$x'(x,t) = kx + \ell t$

$t'(x,t) = mx + nt \implies$ *time* (in one coordinate system) is a function of *position*, in another coordinate system

If x' = 0

$= k(\boldsymbol{v}t) + \ell t$, thus; $k\boldsymbol{v} = -\ell$

$$x' = kx - \ell\boldsymbol{v}t$$
$$t' = mx + nt$$

where $\boldsymbol{v}$ is the *relative velocity* of the unprimed coordinate system, relative to the primed coordinate system

$$x^2 - \Phi^2_\lambda\, t^2 = k^2x^2 - k^2x\boldsymbol{v}t + k^2\boldsymbol{v}^2t^2 - \Phi^2_\lambda\, m^2x^2 - \Phi^2_\lambda\, mnxt - \Phi^2_\lambda\, n^2t$$

$$0 = (k^2 - 1 - \Phi^2_\lambda\, m^2)x^2 - (k^2\boldsymbol{v} + \Phi^2_\lambda\, mn)xt + t^2(k^2\boldsymbol{v}^2 - \Phi^2_\lambda\, n^2 + \Phi^2_\lambda)$$

since x and t are arbitrary

$$k^2 - 1 - \Phi^2_\lambda\, m^2 = 0\,,\quad k^2\boldsymbol{v} + \Phi^2_\lambda\, mn = 0\,,\quad k^2\boldsymbol{v}^2 - \Phi^2_\lambda\, n^2 + \Phi^2_\lambda = 0$$

$$k^2 = 1 + \Phi^2_\lambda\, m^2\,,\qquad \Phi^2_\lambda\, mn = -k^2\boldsymbol{v}$$

$$k^2\boldsymbol{v} + \Phi^2_\lambda\, mn = 0$$

$$\boldsymbol{v} + \boldsymbol{v}\,\Phi^2_\lambda\, m^2 + \Phi^2_\lambda\, mn = 0$$

substituting the expression $(1 + \Phi^2_\lambda\, m^2)$ for k^2 in $(k^2\boldsymbol{v}^2 - \Phi^2_\lambda\, n^2 + \Phi^2_\lambda = 0)$, one has

$$(1 + \Phi^2_\lambda\, m^2)\boldsymbol{v}^2 - \Phi^2_\lambda\, n^2 + \Phi^2_\lambda = 0$$
$$(1 + \Phi^2_\lambda\, m^2)\boldsymbol{v}^2 = \Phi^2_\lambda\, n^2 - \Phi^2_\lambda$$
$$(1 + \Phi^2_\lambda\, m^2) = \Phi^2_\lambda\,(n^2 - 1)/\boldsymbol{v}^2$$
$$m^2 = ((n^2 - 1)/\boldsymbol{v}^2) - 1/\Phi^2_\lambda$$

one now has an initial expression for m ;

$$m = (((n^2 - 1)/\boldsymbol{v}^2) - 1/\Phi^2_\lambda)^{1/2} \tag{4.4}$$

$$\boldsymbol{v}^2 + \boldsymbol{v}^2/\Phi^2_\lambda\, m^2 - \Phi^2_\lambda((\boldsymbol{v} + \boldsymbol{v}\,\Phi^2_\lambda\, m^2)/\Phi^2_\lambda\, m^2) + \Phi^2_\lambda = 0$$
$$\boldsymbol{v}^2/\Phi^2_\lambda\, m^2 + \boldsymbol{v}^2/\Phi^4_\lambda\, m^4 - \boldsymbol{v}^2 - k\,\boldsymbol{v}^2\,\Phi^2_\lambda\, m^2 - \boldsymbol{v}^2/\Phi^4_\lambda\, m^4 + \Phi^2_\lambda\, m^2 = 0$$
$$-\boldsymbol{v}^2 - \boldsymbol{v}^2/\Phi^2_\lambda\, m^2 + \Phi^4_\lambda\, m^2 = 0$$

$$m^2 = \boldsymbol{v}^2/(\Phi^4_\lambda - \boldsymbol{v}^2\,\Phi^2_\lambda) = \boldsymbol{v}^2/(1 - (\boldsymbol{v}^2/\Phi^2_\lambda))$$
$$k^2 = 1 + \boldsymbol{v}^2/(\Phi^2_\lambda - \boldsymbol{v}^2) = \Phi^2_\lambda/(\Phi^2_\lambda - \boldsymbol{v}^2) = 1/(1 - \boldsymbol{v}^2/\Phi^2_\lambda)$$

$$k = 1/(1 - \boldsymbol{v}^2/\Phi^2_\lambda)^{1/2} \tag{4.5}$$
$$m = \boldsymbol{v}/(1 - \boldsymbol{v}^2/\Phi^2_\lambda)^{1/2} \tag{4.6}$$
$$\ell = -\boldsymbol{v}/(1 - \boldsymbol{v}^2/\Phi^2_\lambda)^{1/2} = -m \tag{4.7}$$
$$n = (\boldsymbol{v} + \boldsymbol{v}^2/(\Phi^2_\lambda - \boldsymbol{v}^2))/(\Phi^2_\lambda\,\boldsymbol{v}/\Phi_\lambda\,(\Phi^2_\lambda - \boldsymbol{v})^{1/2})$$
$$= -1/(1 - \boldsymbol{v}^2/\Phi^2_\lambda)^{1/2} \tag{4.8}$$

remembering that: $x' = kx - \ell\boldsymbol{v}t$, $t' = mx + nt$

Letting; $\beta = \boldsymbol{v}/\Phi_\lambda$

then;

$$x' = (x - \boldsymbol{v}t)/(1 - \beta^2)^{1/2} \tag{4.9}$$
$$t' = (\boldsymbol{v}x - \Phi^2_\lambda\, t)/\Phi^2_\lambda\,(1 - \beta^2)^{1/2} \tag{4.10}$$

after algebraic simplification

$$dx'/dt' = \boldsymbol{v}_x' = (dx - \boldsymbol{v}dt)/((\boldsymbol{v}dx/\Phi^2_\lambda) - dt)$$
$$= (\boldsymbol{v}'_x - \boldsymbol{v})/((\boldsymbol{v}x_x/\Phi^2_\lambda) - 1)$$
$$dy'/dt' = \boldsymbol{v}'_y\ ,\ dz'/dt' = \boldsymbol{v}'_z$$
$$dt' = ((\boldsymbol{v}dx/\Phi^2_\lambda) - dt)/(1 - \beta^2)^{1/2} \tag{4.11}$$

4.1.2. Length Contraction.

$$x'_2 - x'_1 = (x_2 - x_1)/(1 - \beta^2)^{1/2} \tag{4.12}$$

thus, an object *measures* shorter in coordinate system ξ', when observed from coordinate system ξ, iff ξ' is in motion relative to ξ.

4.1.3. Time Dilation.

$$t_2 - t_1 = (t'_2 - t'_1)/(1 - \beta^2)^{1/2} \tag{4.13}$$

thus, time Δt measures larger in a frame moving relative to the frame holding the clock.

4.1.4. Modified Lorentz Transformation Conclusions. By the above transformations, where $\beta = \boldsymbol{v}/\Phi_\lambda$, a particle moving at velocity $\boldsymbol{v} \geq \Phi_\lambda$ drives the *transformation equations* to infinity. Thus, in any given spacetime *region λ*, $\boldsymbol{v} \geq \Phi_\lambda$ implies the particle is not observable in *region λ*, when measured by signals propagating (in *region λ*) at velocities $\boldsymbol{v}_\lambda < \Phi_\lambda$. If we let $\Phi_\lambda = c$, we have the (*length contraction* and *time dilation*) observables from Relativity.

4.2. Φ_λ and Curvature

Einstein intuitively chose c (the natural speed of electromagnetic wave propagation in our spacetime region) to be the Φ_λ of his derivations. This was apparently an intuitive choice, since the speed of light is the highest "*natural velocity*" observed in our spacetime region. One can state that c is a special case of the general case Φ_λ. Also, *for the generalized case*, Φ_λ can be greater than c.

For this work, the "*natural speed*" is defined as the velocity of propagation of electromagnetic energy along a geodesic. Since a geodesic curve is the result of spacetime curvature, the "*natural speed*" is arguably dependent on the curvature of spacetime. Thus, given a regional structure of spacetime, the curvature θ_λ of *region* λ determines Φ_λ . Then

$$\theta_\lambda \Longrightarrow \Phi_\lambda(\theta_\lambda) \text{ is a function of curvature.}$$

This implies that the "generalized natural speed" is dependant on the curvature. For any spacetime *region i*, $\Phi_i(\theta_i)$; where θ_i is the curvature of *region i*. Methods for calculating θ_i , *for our region of spacetime*, are found in documents [1] and [2].

4.3. Inter-Region Relative Observations

For each inter-region observation, the related maximum of each region, ($\boldsymbol{\Phi}_i$, $\boldsymbol{\Phi}_j$, $\cdots$), must be derived. Examining motion in one region, while the observer is in another region, requires some additional considerations.

Initially, the thought is to algebraically add the regional maximum velocity vectors, ($\boldsymbol{\Phi}_i$, $\boldsymbol{\Phi}_j$), and treat the observer's region as stationary. The other region's velocity is ($\boldsymbol{\Phi}_i + \boldsymbol{\Phi}_j$), relative to the observer's region. This sum can be regarded as logically equivalent to Einstein's c, for inter-region relative motion.

4.3.1. Notes on Dark Energy (considerations & possibilities). In 1998, physicists discovered that the expansion of the universe is speeding up. They (these astro-physicists) postulate that a new (i.e. as yet undefined) form of energy is causing the galaxies, of the observable/known universe, to fly apart at accelerating speeds. Today, this unknown energy is referred to as "Dark Energy". Scientists theorize that "Dark Energy" comprises approximately ⅔ of the known universe. However, no one *really knows* what "Dark Energy" is.

The accelerated expansion calls into question the "Big Bang Theory", in that expansion should be decelerating (due to gravity) after the (*so called*) "Big Bang" event. "Dark Energy" appears to oppose gravity. To understand what "Dark Energy" might be, one might first examine definitions of gravitation.

Gravitation & electromagnetism are both manifestations of spacetime curvature. These manifestations cause matter & energy to behave in certain ways. Matter & energy behave according to the curvature of spacetime in their (the particular matter or energy) immediate region of spacetime. Since "Dark Energy" appears to oppose gravity, and gravity is a manifestation of spacetime curvature, one could argue that "Dark Energy" is a manifestation of spacetime curvature. Also "Dark Energy" and "Dark Matter" might be equivalent.

The curvature of spacetime (in regions where "Dark Energy" phenomena manifests) is such as to effect matter & energy in a manner different (perhaps opposite) from the curvature of regions in which gravitational phenomena is observed. Stated alternatively; spacetime regions in which "Dark Energy" phenomena are exhibited, will have curvature different/opposite from spacetime regions in which gravitational phenomena are exhibited. This postulate is a further argument for <u>*a regional structure of spacetime*</u>. It could also explain the observed accelerated expansion of galaxies. Additionally, quintessence, a scalar field with equations of state defined as;

$$P_q = \omega \rho_q, \qquad \text{where: } P \rightarrow \text{ pressure },\ \rho \rightarrow \text{density}$$

$$\omega \rightarrow (-⅓),\ q \rightarrow \text{a generalized parameter}$$

$$P = \omega \rho c^2$$

as yet has no concrete evidence of its existence. However, some scientists think that such evidence could come from variations in the fundamental constants of spacetime. A regional structure of spacetime could support such variance.

Quintessence is dynamic, and generally has density and equations of state that vary through spacetime.

5. Summary

The “Light Gauge Theory” defines concepts that remove the speed of light (c) as a constraint on achievable velocities, in normal spacetime. It is also important to note that, if c is a function of regional curvature, then causality is not violated by matter traveling at velocities > c .

It is useful to note that the prevailing modern cosmological theories (including M-Theory) can be accommodated under the “Light Gauge Theory”, and the concept of a regional structure of spacetime. The derivations presented here attempt to maximize clarity, and minimize notational complexity, without sacrificing the necessary rigor. Obviously, a more rigorous derivation can lead to a fully comprehensive set of equations-of-motion.

6. References

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