Special and General Relativity are Modified to Assure Their Isomorphism to Reality

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Abstract

The current paradigm, despite the successes of the excellent theories that construct it, is facing many obstacles. Many principles remain unproven, attributes of elementary particles cannot be derived and calculated, and mysteries are un-resolved. This situation results from the lack of a deeper underlying theoretical layer that explores the geometrodynamics of space.

Our **G**eometro**D**ynamic **M**odel of reality - the **GDM**, presented here, is this required layer. **This GDM incorporates a modified version of both Special and General Relativity, in order to assure their isomorphism to reality.**

The GDM reveals the essence of charge, elementary particles, gravitation, and inertia (mass). It also relates to additional fundamental subjects. The GDM provides derivations and accurate calculations of the radii and masses of elementary particles, which in the current paradigm are wrongly considered constants of nature. Its specificities enable us to suggest new experiments of "validation" or falsification. These and additional subjects have already been addressed in our recently published papers, for example: "On the Essence of Electric Charge", [1], [2], "On the Essence of Gravitation and Inertia", [3], [4], "Where is Anti-Matter?" [5], and more….

Key Words: Space, Electric charge, Gravitation, Inertia, Elementary Particles

1 Introduction

The GDM appears in the HAL journal, Optica Open, ResearchGate and other journals as 38 separate papers and books, submitted from Nov 2016 to April 2024.

THE CURRENT PARADIGM

The current paradigm, despite its excellent theories, faces many obstacles. Many principles remain unproven, attributes of elementary particles cannot be derived and calculated, and mysteries are un-resolved. This situation results from the lack of a deeper theoretical layer.

THE GDM

The missing theoretical layer is the GeometroDynamic Model of Reality (GDM). The GDM provides answers as to what are: **charge, elementary particles, inertia (mass), gravitation**, and relates to additional fundamental subjects. The GDM does not, at large, contradict the paradigm; it simply serves as a realistic and tangible deeper theoretical layer.

1.1 The GDM Basics

A. The sole GDM **postulate** is:

The three-dimensional elastic space Lattice is all there is.

Necessarily:

The deformation of space is described by a metric.

Space vibrates longitudinally and transversally with only two corresponding velocities.

There is no rest - only motion at the waves' velocities.

Elementary particles at "rest" are circularly rotating wavepackets. Their virtual geometric centers are at rest. When they move the wavepackets describe spirals.

The only one field is the tension in space, due to a gradient in space density, see **G**.

B. In contrast to the conventional scientific **inductive method** the GDM is a *freely invented* (Einstein's expression) idea. With this idea alone we can infer logically the laws of physics and construct a physical theory isomorphic to the entire physical reality. The GDM is thus a non-phenomenological theory.

The GDM specificity is also expressed by new suggested experiments and observations, which enable its "validation" or falsification.

C. In the past, space was considered a reference frame, which is meaningless without the presence of material bodies. Today, space is considered a kind of elastic foam or elastic fluid with nonlinear properties.

D. In the GDM **nothing is alien to space**. Space, not yet clearly modeled is, however, the **one and only one** basic physical entity that is needed to construct known physics and beyond.

E. The goal in physics is much humbler than finding the truth - what is truth? In physics we just build tentative models for different aspects of the Reality or for the entire Reality.

F. **A model** is: A collection of mathematical equations and a geometrical, or other, description that relates to variables and constants.

G. In the GDM there is **only one variable**, which is **space density ρ**. And only two dimensions: L length (cm) and T time (sec).

Space Density ρ **at a point within a singular space cell** is the inverse of the volume of this particular cell, $[\rho] = L^{-3}$.

Space Density ρ at a point on the boundary between cells is the inverse of the average volume of the cells that share this boundary, $[\rho] = L^{-3}$.

For physicists, that consider the linear dimension of a space cell to be the **Planck Length** **$1.6 \cdot 10^{-33}$** cm, **Space Density,** is approximately the **number of space cells per unit volume**.

The un-deformed (not contracted or dilated) space density is notated ρ_0.

Examples are:

Electric Charge density, as we show, is: $q = 1/4\pi \cdot (\rho - \rho_0)/\rho$ $[q] = 1$.

Charge bivalency is clearly noticed.

Deformation (Curvature) of a deformed space is: $K = c\,\frac{4\pi}{45}\left(\frac{\nabla\rho}{\rho}\right)^2$ $[K] = L^{-2}$

H. The purpose of a model is:

To create a compact language to describe phenomena – Reductionism

To describe causal relationships - Understanding

To predict phenomena that have not yet been observed – Specificity and Test of "Validity"

The GDM is the Ultimate Reductionism.

I. English is our language. Tensor analysis and our Deformation geometry [6] (**1.2** below) are our mathematical tools. Limitations of language and mathematics are also the limitations of a model, the GDM included.

J. Physical models are **tentative**. Even a single fact that does not comply with the model falsifies it.

1.2 The Geometry of Deformed Space Lattices

Euclidian geometry is the geometry of homogenous and isotropic continuous spaces. Riemannian geometry is the geometry of n dimensional homogenous and continuous but non-isotropic curved manifolds in more than n dimensional hyper-spaces. The GDM geometry, is the geometry of n dimensional Space Lattices that are non-homogenous and non-isotropic namely **Deformed**. This kind of space, according to General Relativity-GR, is isomorphic to the real space. Our geometry enables a realistic understanding of GR, its solutions and the resolution of long-standing issues like the flatness of the universe and the nature of dark matter. In this geometry we use the terms and concepts of Differential Geometry.

1.3 The Units of the GDM

In the GDM all units are expressed by the unit of length L (**cm**) and the unit of time T (**sec)** only. A conversion from the **cgs system** of units to the **GDM system** enables calculations of known phenomena and of new, GDM-predicted, phenomena.

1.4 The Constants of Nature

$c_T = c$	Velocity of transversal Space vibrations (EM waves)	$[c_T]=LT^{-1}$
$[c_L$	Velocity of longitudinal Space vibrations ($c_L > c_T$)	$[c_L]=LT^{-1}]$
$\hbar$	Planck Constant	$[\hbar]=L^5T^{-1}$
G	Gravitational Constant	$[G]= T^{-2}$
α	Fine Structure Constant	$[\alpha]=1$

Since $c_L/c = \pi/2\cdot(1+ \pi\ \alpha)$, see (25) in [2], we exclude c_L from the list and choose α instead.

In the GDM the elastic space vibrates both transversely and longitudinally. Gravitational waves are transversal space waves that recently have been detected. We have shown, that the known electromagnetic waves are also transversal space waves. Longitudinal electromagnetic waves have recently been detected, see Section 7.

A **Constant of Nature** is a physical quantity that, measured locally by observers anywhere in space, and with any relative velocity with respect to each other and space, results in the same value (invariance).

Note, however, that a Constant of Nature is not necessarily a constant like π. This fact is often overlooked. Our discussions on light velocity, in GR, will clarify this statement.

1.5 Dimensionality see [1], [2], [3], and [4]

esu	GDM
$[M] = M$	$[M] = L^3$
$[Q] = Q$	$[Q] = L^3$
$[H] = 1$	$[H] = T^{-2}$
$[G] = M^{-1}L^3T^{-2}$	$[G] = T^{-2}$
$[V] = LT^{-1}$	$[V] = LT^{-1}$
$[a] = LT^{-2}$	$[a] = LT^{-2}$
$[F] = MLT^{-2}$	$[F] = L^4T^{-2}$
$[\varphi_E] = QL^{-1}$	$[\varphi_E] = L^2$
$[\varphi_G] = L^2T^{-2}$	$[\varphi_G] = L^2$
$[E_E] = QL^{-2}$	$[E_E] = LT^{-2}$
$[E_G] = LT^{-2}$	$[E_G] = LT^{-2}$
$[U_M] = ML^2T^{-2}$	$[U_M] = L^5T^{-2}$
$[U_E] = Q^2L^{-1}$	$[U_E] = L^5T^{-2}$
	$[\in] = L^2\,T^{-2}$

1.6 Some GDM Results

Some results, out of many published in the Barak papers, are presented here. The current foundations of physics, including the Standard Model and String Theory **fail** to provide such results.

Masses of The Elementary Particles (See [2], cgs units)

Electron/Positron Mass

$M_e = \frac{s^2\sqrt{2}}{\pi(1+\pi\,\alpha)} \cdot \sqrt{G^{-1}\alpha\hbar c^{-3}}$

For the electron/positron charge, which is a white/black hole, s = 1 ($[s^2] = L^2T^{-2}$) is light velocity at the event horizon, as the far-away observer measures.

M_e (calculated) = $0.91036 \cdot 10^{-27}$gr

M_e (measured) = $0.910938356(11) \cdot 10^{-27}$gr

A dimensionality check: $[G^{-1}] = ML^{-3}T^2$, $[\alpha] = 1$, $[\hbar] = ML^2T^{-1}$, $[c^{-3}] = L^{-3}T^3$ Thus:

$M = [s^2\sqrt{G^{-1}\alpha\hbar c^{-3}}\ ] = L^2T^{-2}(ML^{-3}T^2 \cdot ML^2T^{-1} \cdot L^{-3}T^3)^{1/2} = L^2T^{-2}(M^2L^{-4}T^4)^{-1/2} = L^2T^{-2}ML^{-2}T^2 = M$

Muon/Anti-Muon Mass

M_μ (calculated) = 112.5 Mev/c^2

M_μ (experimental) = 105.8 Mev/c^2

Quarks/Anti- quarks Masses

M_d (calculated) = $9M_e$ = 4.5 M_eV/c^2

M_d (measured) = 4.8 ± 0.5 M_eV/c^2

$M_{\tilde{u}}$ (calculated) = $4.5M_e$ = 2.25 M_eV/c^2

$M_{\tilde{u}}$ (measured) = 2.3 ± 0.8 M_eV/c^2

Proton/Anti-Proton Charge Radius

r_p (calculated) = $0.8774 \cdot 10^{-13}$cm

r_p (measured) = $0.8768(69) \cdot 10^{-13}$cm

The Extended GR Equation (See [4], cgs units)

Exploring the essence of electric charge, we found that by defining charge as nothing but curved space we are able to derive the entire Maxwellian Electromagnetic theory, without any phenomenology. This result enables us to extend Einstein's equation of General Relativity (GR) to become an equation that incorporates not only the energy/momentum tensor ($T_m^{\mu\nu}$), but also the charge/current tensor ($T_q^{\mu\nu}$).

$$R^{\mu\nu}-1/2Rg^{\mu\nu} = 8\pi G/c^4 \cdot T_m^{\mu\nu} + 4\pi G^{1/2}/s^2 \cdot T_q^{\mu\nu}$$

where S = 1 and [S] = LT^{-1}

This equation becomes a macroscopic/microscopic equation of the entire physical reality. Charge and angular momentum are quantized and thus we predict that the curvature of spacetime is also quantized.

1.7 The GDM Unification of Gravitation and Electromagnetism (See [4], [5])

The GDM **approach** to the issue of unification is as follows: **Instead** of adding spatial dimensions, which we consider a formal, even artificial, way of unification, we have explored the possibility that **all phenomena** have a common denominator. This common denominator turns out to be the **geometrodynamics of space,** since in the GDM **space is all there is**. Thus, our geometry of deformed spaces rather than the Rimemaniann geometry of bent manifolds [6], becomes our mathematical tool to explore the reality.

2 Space

2.1 Space as a Lattice

By attributing a cellular structure to space we can explain its expansion, its elasticity and can introduce a cut-off in the wavelength of the vacuum state spectrum of vibrations. Without this limitation on the wavelength, infinite energy densities arise. The need for a cut-off is addressed by Sakharov [7], Misner et al [8], and by Zeldovich [9]. The Bekenstein Bound sets a limit to the information available about the other side of the horizon of a black hole [10]. Smolin [11] argues that:

> *There is no way to reconcile this with the view that space is continuous for that implies that each finite volume can contain an infinite amount of information*

Riemann, quoted by Chandrasekhar in Nature [12], was of the opinion that space is a lattice. Relevant review introductions appear in papers [13] [14] and [15].

2.2 The Linear Dimension of a Space Cell

Let L_{cell} be the linear dimension of a unit cell of space. If we consider L_{cell} as **Planck's length**, then:

$$L_{cell} = L_{planck} = \left(\frac{\hbar G}{c^3}\right)^{\frac{1}{2}} \sim 1.6 \cdot 10^{-33} \text{cm}$$

The cut-off wavelength is: $\lambda_{cut\text{-}off} = 2L$, and the cut-off wavenumber is: $k_{cut-off} = \dfrac{1}{\lambda_{cut-off}}$

t'Hooft [16] explains the meaning of L_{planck}. The GDM, however, **does not** use the value of $\lambda_{cut\text{-}off}$, L_{planck} or L_{cell} in any calculation. In the GDM the elasticity of space means a flexible L_{cell}.

3 The Elastic Space

3.1 Deformed Spaces versus Bent Manifolds

We relate to space not as a passive static arena for fields and particles but as an active elastic entity, which is the, one and only, entity that exists. Physicists have different, sometimes conflicting, ideas about the physical meaning of the mathematical objects of their models. The mathematical objects of General Relativity, as an example, are n-dimensional manifolds in hyper-spaces with more dimensions than n. These are not necessarily the physical objects that

General Relativity accounts for, and n-dimensional manifolds can be equivalent to n-dimensional elastic spaces. Rindler [17] uses this equivalence to visualize bent manifolds, whereas Steane [18] considers this equivalence to be a real option for a presentation of reality. Callahan [19], being very clear about this equivalence, declares: "…in physics we associate curvature with stretching rather than bending". After all, in General Relativity gravitational waves are space waves and the attribution of elasticity to a 3D space is thus a must. The deformation of space is the change in size, of its cells. The terms positive deformation and negative deformation, around a point in space, are used to indicate that space cells grow or shrink, respectively, from this point outwards. Positive deformation is equivalent to positive curving and negative deformation to negative curving [20].

4 Space Density

Space density ρ is defined as the number of space cells per unit volume. Space density in a zone of space without deformations (far away from masses and charges) is denoted ρ_0.

Let dn be the number of space cells in a given volume dV. Since dn = ρ_0dV and also dn=ρdV' we get:

$$dV = \frac{dn}{\rho_0} \qquad dV' = \frac{dn}{\rho} \qquad \text{Hence:} \quad \frac{dV' - dV}{dV} = \frac{\rho_0 - \rho}{\rho}$$

In Appendix A of [1] we prove that the relative volumetric change equals the divergence of the Elastic Displacement Vector **u**:

$$\nabla \cdot \mathbf{u} = \frac{dV' - dV}{dV} \qquad \text{Thus:} \qquad \nabla \cdot \mathbf{u} = \frac{\rho_0 - \rho}{\rho}$$

This proof is a corner stone in the GDM electromagnetism.

It is based on the **strain tensor** u_{ik} , which is defined as:

$$u_{ik} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_k} + \frac{\partial u_k}{\partial x_i} + \frac{\partial u_l \partial u_l}{\partial x_i \partial x_k}\right)$$

4.1 The Small Deformation Strain Tensor as a Fundamental Metric Tensor

The authors of [21], see also [1], conclude:

"……. **the small deformation strain tensor could be used as a fundamental metric tensor, instead of the usual fundamental metric tensor.**"

Note, however, that space deformation is **a local feature of curvature**, whereas a manifold curvature can also be a global feature of curvature (like that of a closed spherical surface).

5 The Vibrating Space

In the GDM the elastic space vibrates both transversely and longitudinally. Gravitational waves are transversal space waves [22] that recently have been detected [23]. We have shown, that the known electromagnetic waves are also transversal space waves [1], [2] and [24].

The current wrong understanding, however, is that longitudinal electromagnetic space waves have never been detected.

In Section 7 we relate to theoretical and experimental evidence for the existence of longitudinal electromagnetic space waves.

We also show that, by giving up the concept of inertial mass as a fundamental attribute [3], we arrive at the **quantization** of these **elastic vibrations of space** [6].

5.1 Elastic Waves – a Reminder

The equation of equilibrium in an elastic media, with displacement vector, **u**, (53.6) in [25], is the **Navier equation**:

$$(\lambda + 2\mu)\Delta \mathbf{u} - \mu \nabla \times (\nabla \times \mathbf{u}) - m\frac{\partial^2 \mathbf{u}}{\partial t^2} = 0 \tag{4}$$

μ and λ are the **elastic Lamé coefficients**, and m is the media mass density.

Mass in the GDM is only a **practical** attribute [3]. The relevant fundamental attribute is energy U or energy density $\in$. Hence, for space as the elastic media, m represents the energy density of vibrations:

$$m = \frac{\in}{c^2} \tag{5}$$

To solve equation (4), we adopt the Kelvin [25] method and decompose **u** as follows:

$\mathbf{u} = \mathbf{u}_L + \mathbf{u}_T$ Where:

$\nabla \times \mathbf{u}_L = 0 \qquad \nabla \cdot \mathbf{u}_T = 0$ Therefore:

$\mathbf{u}_L = -\nabla\varphi \qquad \mathbf{u}_T = \nabla \times f$

φ stands for the scalar potential and **f** for the vectorial potential. This decomposition is true under the boundary condition $\mathbf{u} \to 0$ at ∞. The known equations for $\mathbf{u}_L$ and $\mathbf{u}_T$ are obtained by substituting $\mathbf{u} = \mathbf{u}_L + \mathbf{u}_T$ in (4).

For $\mathbf{u}_L$:

$$(\lambda + 2\mu)\nabla^2\mathbf{u}_L - m\frac{\partial^2\mathbf{u}_L}{\partial t^2} = 0 \qquad \text{or:} \qquad \nabla^2\mathbf{u}_L - \frac{1}{c_L^2}\frac{\partial^2\mathbf{u}_L}{\partial t^2} = 0$$

which is the vector wave equation for waves which move at a speed c_L, where:

$$c_L = \left(\frac{\lambda + 2\mu}{m}\right)^{\frac{1}{2}} \tag{6}$$

Since $\nabla \times \mathbf{u}_L = 0$ this is the contractional /dilational, **longitudinal wave**.

For $\mathbf{u}_T$: $\mu\nabla^2\mathbf{u}_T - m\dfrac{\partial^2\mathbf{u}_T}{\partial t^2} = 0$ or:

$$\nabla^2\mathbf{u}_T - \frac{1}{c_T^2}\frac{\partial^2\mathbf{u}_T}{\partial t^2} = 0$$

This is again a vector wave equation for waves with speed c_T, where:

$$c_T = \left(\frac{\mu}{m}\right)^{\frac{1}{2}} \tag{7}$$

Since $\nabla\cdot\mathbf{u}_T = 0$, $\mathbf{u}_T$ and c_T, correspond to the shear, **transverse wave**.

5.2 On the Transversal and Longitudinal Wave Velocities

Historically, to account for the absence of electromagnetic longitudinal waves, Cauchy (19th century) suggested that $\lambda + 2\mu = 0$, see [26] P.108. Hence $\lambda = -2\mu$, but the **bulk modulus** is $k = \lambda + \frac{2}{3}\mu$ and since $\mu > 0$ a negative **compressibility** (1/k) of the aether was required.

In the GDM, material (non-zero rest energy) elementary particles are circulating longitudinal wavepackets [2]. This circulation is complex [2] and its basic motion is at the longitudinal velocity

$c_L > c_T = c$. Hence we require:

$\lambda+2\mu > \mu$ or $\lambda+\mu > 0$ see (6) and (7).

In [2] we show that:

$c_L = 1.6068\ c$

Hence $(\lambda+2\mu)/\mu = 1.6068^2 = 2.5818$ and: $\lambda = 0.5818\ \mu$

6 On the Transversal Wave Velocity - Light Velocity

For a homogeneous and isotropic space density ρ_0, far away from masses and charges, light velocity c is notated c_0. In a deformed/curved zone of space, close to a mass, for example, a distance from us where $\rho > \rho_0$, light velocity c is not c_0. This contention seems, on the face of it, to contradict the understanding that light velocity is a constant of nature. It does not - light velocity is indeed a constant of nature, but it is not a constant. To understand this statement the reader is referred to Sections 12 and 13, where we clarify the term “constant of nature”.

The GDM considers the space lattice to be an elastic media and its vibrations EM waves [1]. The Navier equation governs elastic media. Its solution for elastic transversal waves gives the expression (7) for light velocity:

$$c = \sqrt{(\mu/m)} \tag{7}$$

where μ is a Lamé coefficient and m is the mass density of the media. Since space is massless we take m as:

$$m = \epsilon_s / c_0^2 \tag{8}$$

where ϵ_s is the standard space energy density as faraway observers measure, and c_0 is the relevant light velocity. Inserting (8) into (7) gives:

$$c = c_0\sqrt{(\mu/\epsilon_s)} \tag{9}$$

Thus $[\mu] = [\epsilon_s]$, and we can rename the numerator and use ϵ instead of μ. Thus (9) becomes:

$$c = c_0\sqrt{(\epsilon/\epsilon_s)} \tag{10}$$

By using (8) we have turned (7), an equation that determines c, into an equation that determines the ratio c/c_0 . This ratio ϵ/ϵ_s is the ratio between the energy density ϵ, in a specific zone of space, and the energy density ϵ_s.

Light velocity in a Euclidian zone of space where $\epsilon < \epsilon_s$

In the space zone between Casimir plates (Section 10) $\epsilon < \epsilon_s$. Hence we expect the experimental result for c, in this zone, to be $c < c_0$.

Light velocity in a curved zone of space

Space density ρ_0, far away from charges and masses, is homogenous and isotropic, but around a mass space is contracted [3] and $\rho > \rho_0$. As a result, the energy density per space cell, in this contracted zone of space, is smaller than at a distance. This reduced energy affects the space cell by lowering the tension on its structure. A lower tension means a higher permittivity and permeability [27] [28] and hence a lower space vibrational velocity – light velocity. This is the GDM understanding of the GR result for light velocity obtained by the Schwarzschild metric, see [3] and Section 15. For a local observer, in the contracted zone, where $\rho > \rho_0$, necessarily himself and his yardstick are shorter.

In other words, light velocity is a variable depending on the reference frame of the observer. However, GR shows that this dependence is such that **every observer** in a deformed or non-deformed space will get, by taking measurements, the same local result for light velocity. This invariance is the essence of the concept of a "constant of nature", see Section 15.2.

7 On Electromagnetic Longitudinal Waves and their Velocity

7.1 Theoretical Considerations

The abstract of a theoretical paper by Vlaenderen (2016) [29], titled "General Classical Electrodynamics", presents the present situation with classical electrodynamics (MCED). The author suggests a generalization of the theory (GCED) that yields the possible existence of longitudinal waves.

Maxwell's Classical Electrodynamics (MCED) suffers several inconsistencies: (1) the Lorentz force law of MCED violates Newton's Third Law of Motion (N3LM) in case of stationary and divergent or convergent current distributions; (2) the general Jefimenko electric field solution of MCED shows two longitudinal far fields that are not waves; (3) the ratio of the *electrodynamic energy-momentum of a charged sphere in uniform motion has an incorrect factor of $4/3$. A consistent General Classical Electrodynamics (GCED) is presented that is based on Whittaker's reciprocal force law that satisfies N3LM. The Whittaker force is expressed as a scalar magnetic field force, added to the Lorentz force. GCED is consistent only if it is assumed that the electric potential velocity in vacuum, 'a', is much greater than 'c' ($a >> c$); GCED reduces to MCED, in case we assume $a = c$. Longitudinal electromagnetic waves and superluminal longitudinal electric potential waves are predicted. This theory has been verified by seemingly unrelated experiments, such as the detection of superluminal Coulomb fields and longitudinal Amp`ere forces, and has a wide range of electrical engineering applications.*

7.2 Experimental Evidence

In this Section we bring the abstracts of several papers, published in **peer reviewed** journals, which describe experimental evidence for the **existence** of longitudinal waves.

Wang et al [30]in-**nature photon** (2008): "Creation of a needle of longitudinally polarized light in vacuum using binary optics"

Recently many ideas have been proposed for the use of a longitudinal field for particle acceleration, fluorescent imaging, second-harmonic generation and Raman spectroscopy. A few methods to enhance the longitudinal field component have been suggested, but all have insufficient optical efficiency and non-uniform axial field strength. Here we report a new method that permits the combination of very unusual properties of light in the focal region, permitting the creation of a 'pure' longitudinal light beam with sub-diffraction beam size (0.43λ). This beam is non-diffracting; that is, it propagates without divergence over a long distance (of about 4λ) in free space. This is achieved by focusing a radially polarized Bessel-Gaussian beam with a combination of a binary-phase optical element and a high-numerical-

aperture lens. This binary optics works as a special polarization filter enhancing the longitudinal component.

M. J. Cliffe et al [31]: Generation of longitudinally polarized terahertz pulses with field amplitudes exceeding 2 kV/c, published in **Appl. Phys. Lett.** (2014); *We demonstrate the generation of near-single cycle longitudinally polarized terahertz radiation using a large-area radially biased photoconductive antenna with a longitudinal field amplitude in excess of 2 kV/cm.*

Monstein and Wesley [32]; Observation of scalar longitudinal electrodynamic waves, published in **Europhysics Letters** 2002

Theoretically scalar potential Φ waves with a longitudinal electric field _E in the

direction of propagation must exist. A centrally fed ball antenna, 6 cm diameter, producing a pulsating 433.59MHz spherical source charge, generated such a wave, that was detected by an identical ball antenna. The longitudinally of _E was demonstrated by intervening a cubic array of 9 half-wavelength wires, that absorbed the wave when the wires were parallel (but not when perpendicular) to the direction of propagation. The signal from the ball antenna source, placed 4.0m above ground and receiver 4.4m above ground, was measured as a function of distance, yielding satisfactory agreement with theory, including 2 expected interference minima produced by an image source induced in the Earth. Only waves can yield such an interference and can be reflected from the Earth's surface and vary as the inverse square of distance.

Winnerl et al [33]: Universal phase relation between longitudinal and transverse fields observed in focused terahertz beams, published in **New Journal of Physics** (2012)

We directly observe longitudinal electromagnetic fields in focused *freely propagating terahertz (THz) beams of radial and linear polarization. Employing electro-optic detection, which is phase sensitive, allows one to selectively detect longitudinal and transverse field components. A phase shift of $\pi/2$ between the transverse and longitudinal field components is revealed. This phase shift is of universal nature, as it does not depend on the mode, frequency and focusing conditions. We show that the universal phase relation is a direct consequence of the divergence-free nature of electromagnetic waves in vacuum. In the experiments, we observe the phase shift of $\pi/2$ for all frequency components of single-cycle THz radiation pulses of both radial and linear polarization. Additionally, we show that the longitudinal field of a radially polarized THz beam has a smaller spot size as compared with the transverse field of a linearly polarized beam that is focused under the same conditions. For field-sensitive measurements this property can be exploited even for moderate focusing conditions. Furthermore, the phase-sensitive detection of longitudinal electromagnetic fields open up new possibilities to study their interaction with electronic excitations in semiconductor nanostructures.*

Evans [34]: The Experimentally Observed Optical Cotton–Mouton Effect: Evidence For The Photon's Longitudinal Magnetic Field, $B^{(3)}$ **Mod. Phys. Lett. B, (**1993).

The recent experimental observation of the optical Cotton–Mouton effect is consistent with the induction of magnetization by the longitudinal component of the photon's magnetic field, whose classical counterpart is the equivalent flux density $\boldsymbol{B}^{(3)}$. In the optical Cotton–Mouton effect observed by Zon et al.,[16] the field $\boldsymbol{B}^{(3)}$ acts at second order and is independent of the polarization of the inducing laser beam propagating parallel to a permanent magnetic field. The optical Cotton–Mouton effect is therefore proportional to the laser intensity as observed.[16]

8 On the Possible Existence of Gravitational Longitudinal Waves

Corda [35] in is paper: A longitudinal component in massive gravitational waves arising from a bimetric theory of gravity writes: *After a brief review of the work of de Paula, Miranda and Marinho on massive gravitational waves arising from a bimetric theory of gravity, in this paper it is shown that the presence of the mass generates a longitudinal component in a particular polarization of the wave. The effect of this polarization on test masses is performed using the geodesic deviation. At the end of this paper the detectability of this particular polarization is also discussed, showing that its angular dependence could, in principle, discriminate such polarization with respect the two ones of general relativity, if present or future detectors will achieve a high sensitivity.*

9 A Remark on Time

We do not know what time is. All we know is that the rate of a clock can be used to define a unit of time. A local clock can be a box with two opposite ideal mirrors that reflect a beam of light back and forth. The time of flight back and forth is our unit of time. This unit of time, according to the Lorentz transformation, becomes longer if the box moves parallel to the beam, and/or if it is placed in a gravitational field where light velocity is slower. Measuring time is merely the comparison of the rates of clocks. Time by itself has no fundamental meaning in the GDM, [59]. We further refer to this subject in following sections.

10 The Bulk Modulus of Space

The **Bulk Modulus** is:

$$k = \lambda + \frac{2}{3}\mu$$

In [2] we show that $c_L = 1.6068\ c$ hence $(\lambda+2\mu)/\ \mu = 1.6068^2 = 2.5818$ and:

$\lambda = 0.5818\ \mu$ in this case:

$k = 1.2485\ \mu$

i.e., the **space bulk modulus is positive**. Taking space "mass" density as $m = \frac{\in_S}{c^2}$, where $\in_S$ is the energy density of space vibrations (the vacuum state), and substituting this value for m in (7) gives $\mu = \in_S$. Hence:

$$k = 1.2485 \in_S \tag{11}$$

The **bulk modulus,** is defined as:

$$k = \text{stress/strain} = -\,dp/(dV/\,V) \tag{12}$$

Relating to dp, the increment of pressure, as $1/3 \in$ and using (11) gives:

$$\in / \in_S = -\,3.7455\ dV/V$$

The minus sign relates to pressure from outside of the volume V, and on the volume V, whereas we are interested in the internal pressure. Hence for us:

$$\in / \in_S = 3.7455\ dV/V \tag{13}$$

Thus, vibrational energy added to a zone of space dilates it, and if subtracted - contracts it.

Sakharov [7] was the first to suggest that the elasticity of space is determined by the vacuum state energy density, see also [8] and [9]. Thus, the density ρ_0 of un-perturbed space is determined by its vibrational energy density $\in$s. According to Sakharov [7], space density is ρ rather than ρ_0 if the energy density is $\in$, rather than $\in$s. Note that $\in > \in$s is related to dilation whereas: $\in < \in$s is related to contraction.

Note that in the GDM: $[\in s] = [k] = L^2$.

And again: a lower vibrational energy density of space results in contraction (a larger space density), whereas a higher energy density results in dilation (a smaller space density). An example for a case, in which $\in > \in_s$ is the focal zone of an energetic pulsed laser. Space, in this case, is dilated momentarily and acts like a diverging lens. To calculate the amount of this dilation and optical divergence it creates, we have to know $\in_S$, see Section 11.2.

11 Blackbody Radiation and the Vacuum State – a Reminder

By 1900, Planck had derived the equation for the spectrum of **blackbody radiation:**

$\rho(\nu) = \frac{8\pi h\nu^3}{e^{\frac{h\nu}{kT}} - 1}$ using the average energy per radiator: $U = \frac{\varepsilon}{e^{\frac{\varepsilon}{kT}} - 1}$, the relation $\varepsilon = h\nu$, and

the number of modes of vibration per unit volume, $\frac{8\pi\nu^2}{c^3}$.

In 1912, Planck returned to the subject and published his "Second Theory", in which he explicitly assumed that all energies between the level (n-1) $h\nu$ and n $h\nu$ are, on average:

$\frac{1}{2}[n + (n-1)]h\nu = nh\nu - \frac{1}{2}h\nu$ Hence the average energy per radiator is:

$$U = \frac{h\nu}{e^{\frac{h\nu}{kT}} - 1} + \frac{1}{2}h\nu \tag{14}$$

Namely, in the limit $T \to 0$ the energy $U \neq 0$ and when T = 0 then U = ½hν. Thus, the concept of **Zero Point Energy (ZPE)**, **Zero Point Fluctuation (ZPF)** or **Vacuum State Energy,** was born.

In 1914 Planck thought that the ZPF had no experimental significance. For further references to these issues, see [36]. In the current paradigm, this concept, which relates to each field separately, is unclear and leads to perplexing results, as presented in [37].

The spectral and energy density of the vacuum state is therefore: $n(\nu)=\frac{1}{2}h\nu\cdot\frac{8\pi\nu^2}{c^3}=\frac{4\pi h\nu^3}{c^3}$,

which is (Average energy of a mode) x (Number of modes per unit volume). Or:

$$n(\omega)=\frac{\hbar\omega^3}{2\pi^2c^3} \tag{15}$$

which is independent of space density ρ.

The energy of a single space cell, however, is inversely proportional to ρ. The proportionality of $n(\omega)$ to ω^3 is Lorentz invariant. The vacuum state spectrum is the only one with such invariance. This is, therefore, **the only spectrum that does not enable an observer to detect their motion**. This spectrum, therefore, appears in all inertial systems as homogeneous and isotropic. The issue of an observer, accelerated with respect to the vacuum state, is discussed in [38].

12 Experimental Evidence for the Existence of the Vacuum State

We can learn about the vacuum state only indirectly, from effects like the **Casimir effect**, see [39] or the **Lamb shift**, see [40] P. 405.

Two metal plates in a vacuum chamber are mounted parallel to each other and a small distance, d, apart, Fig. (1). The plates conduct, therefor, they reflect EM waves. For a wave to be reflected there must be a node of the electric field – a point of zero electric amplitude – at the surface of the plate.

The maximum wavelength permissible between the plates (perpendicularly) is twice the distance, d, between them. The energy density outside the plates is therefore larger than inside, thus creating an attractive force between the plates (energy density is equivalent to pressure).

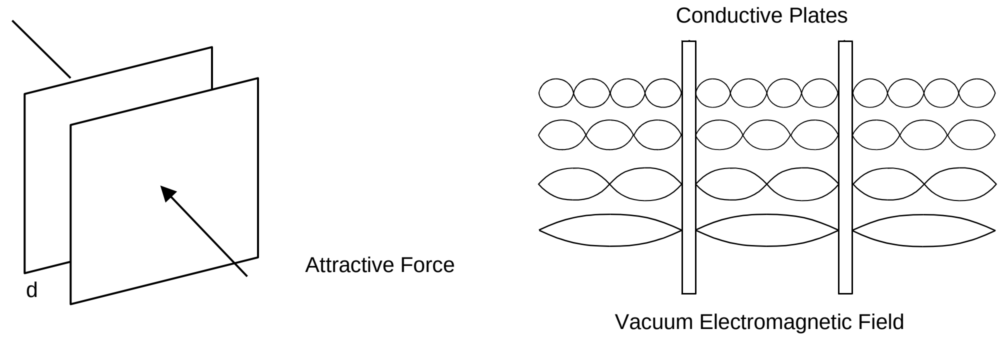

Fig. (1) The Casimir Effect

The force observed in the **Casimir** experiment has two components. At high temperature, thermal radiation gives rise to a force directly proportional to the temperature and inversely proportional to d^3. This force disappears at absolute zero, as does the thermal radiation itself. The force associated with the vacuum state "radiation" is independent of temperature and inversely proportional to d^4. Note that the energy flows out when the plates are being attracted and energy conservation is thus maintained.

13 Estimates of the Vacuum State Energy Density

13.1 Space Vacuum State Energy Density - the QM Calculation

Calculating the number of modes of vibration per unit volume in a three-dimensional space, and taking into account both directions of polarization, yields the vacuum state spectral energy density per unit volume:

$$n(\omega) = \frac{\hbar\omega^3}{2\pi^2 c^3} \tag{16}$$

The energy density contained in a given spectral range is given by:

$$\in(\omega) = \int_{\omega_1}^{\omega_2} n(\omega)d\omega = \frac{\hbar}{8\pi^2 c^3}\left(\omega_2^4 - \omega_1^4\right) \qquad \text{See [40] P.399.} \tag{17}$$

According to [41] P.49, in the range of the visible spectrum, 700 – 400 nm:

$\in \sim 220\,\mathrm{erg}\cdot\mathrm{cm}^{-3}$ While the energy density one meter from a 100 Watt lamp is:

$\in \sim 270\cdot 10^{-9}\,\mathrm{erg}\cdot\mathrm{cm}^{-3}$ a difference of nine orders of magnitude.

According to [7] P. 1202, for $L_{cutoff} = L_{planck}$, $\omega_2 = \frac{2\pi\lambda_{cutoff}}{c}$ and $\omega_1 = 0$, the energy density for the whole vacuum state spectrum is: $\in_S \sim 2.4\cdot 10^{112}\,\mathrm{erg}\cdot\mathrm{cm}^{-3}$. This perplexing situation is discussed in [37]. In comparison, the energy density of the baryonic matter of the universe is $\sim 10^{-10}$ erg cm^{-3}.

13.2 An Estimation of $\in_S$ Based on the Highest Gamma Ray Energy Ever Detected

The H.E.S.S. Gamma ray observatory in the Namibian desert [41] is able to detect (via Cherenkov radiation) rare, high energy, gamma rays.

Gamma rays with energies of up to 100 TeV are routinely detected. However, gamma rays with higher energies have not been found.

1Tev = $1\cdot 10^{12}$ev = 1.602erg. This energy corresponds to $\omega = 1.6\cdot 10^{27}\mathrm{sec}^{-1}$, $\lambda = 1.2\cdot 10^{-16}$cm.

For a possible 500 TeV gamma ray (higher than the above 100 TeV rays) we would get:

$\omega = 8\cdot 10^{29}\mathrm{sec}^{-1}$, $\lambda = 2.04\cdot 10^{-19}$cm, whereas $\lambda_{Planck} = 2L_{Planck} = 3.2\cdot 10^{-33}$cm.

The highest gamma ray energy detected might be an indication of the linear dimension of a space cell, i.e., the λ cut-off. In this case, the energy density of space is $(\lambda/\lambda_{Planck})^4 \sim 10^{56}$ smaller than the known:

$$\in_S \sim 10^{112}\,\mathrm{erg}\cdot\mathrm{cm}^{-3} \tag{18}$$

A possible new estimation for the energy density of space is thus:

$$\in_S \sim 10^{56}\,\mathrm{erg}\cdot\mathrm{cm}^{-3} \tag{19}$$

In comparison: a 100 joule laser pulse, in a focal zone with a waist radius ~ 10^{-3}cm and a similar length dz, creates an energy density, $\epsilon \sim 10^{18}$erg cm^{-3}. Note that the length dz of the zone (on the line of propagation) is dependent on the pulse duration dt: dz = c·dt.

14 "Rest" and Motion

Matter is not alien to space; material elementary particles (non-zero rest energy) are longitudinal wavepackets of contracted, or dilated, space, which are the bivalent elementary electric charges. Their fields are strains in space, expressed by the Elastic Displacement Vector. Every disturbance in space must move at the velocity of its elastic waves, c or c_L. As a consequence, there is no state of rest. "Rest" is defined, therefore, as a situation in which a disturbance, although moving at velocity c or c_L, is on a closed track [3]. This orbital movement, Dirac's Zitterbewegung [42], is the spin of elementary particles [3]. A "translational" motion at a constant velocity v, relative to space, is motion on a spiral. An accelerated motion is that on a spiral, with an ongoing contraction of its radius [3].

15 The Global Space is a Special Frame

The Global Space is a special frame. Velocity and acceleration relative to space are measured by the Cosmic Microwave Background (CMB) Doppler shift. The idea that the global space is a special frame is encompassed in the Lorentzian interpretation of the Special Theory of Relativity. See Section 14. In Sections 16 to 21 we will see that beside the global frame there are local special frames attached to each star, due to confined space inside these stars.

15.1 The Cosmic Microwave Background (CMB)

At large, the CMB is isotropic and homogenous blackbody radiation, with a peak temperature of 2.7°k. The CMB was predicted theoretically by Gamow and discovered accidentally by Penzias and Wilson [43]. In 1989 the CMB was again measured, this time by the Cosmic Background Explorer (COBE) satellite [44], see Fig. (2).

An observer's motion relative to the background radiation is accompanied by a Doppler shift. This shift enables the measurement of the observer's velocity relative to the radiation bath (i.e., space's vibrations) "attached" to space.

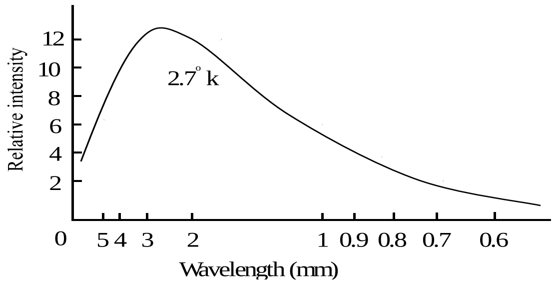

Fig. (2) The Cosmic Background

15.2 Velocity Relative to the Global Space

A CMB anisotropy was first observed by Smoot et al [45], and interpreted as the result of the above Doppler shift [46].

Fig. (3) shows the vector of the velocity of planet Earth relative to the universe [47]. Recently, the velocity of the Earth around the Sun and its rotational velocity have been derived from the Doppler shift.

Earth's velocity relative to space, see Fig. (3), is: $v = 371.0 \pm 0.5$ km sec^{-1}. This velocity is towards a point whose equatorial coordinates are: $(\alpha,\delta) = (11.20^h \pm 0.01^h,\ -7.22^0 \pm 0.08^0)$, [48]. This direction points, approximately, from the cluster of galaxies, Aquarius, towards the cluster Leo-Virgo.

Say the peak of the background radiation is green. An observer, seeing green in all directions, knows they are at rest relative to space. An observer, seeing blue in one direction, red in the opposite direction, and green on the sides, knows they are moving in the direction of the blue.

Similarly, we can also make a distinction regarding acceleration.

An observer moving in a circle notices that tangentially to the circle there is no symmetry, the horizon in one direction looks red, and in the other, blue.

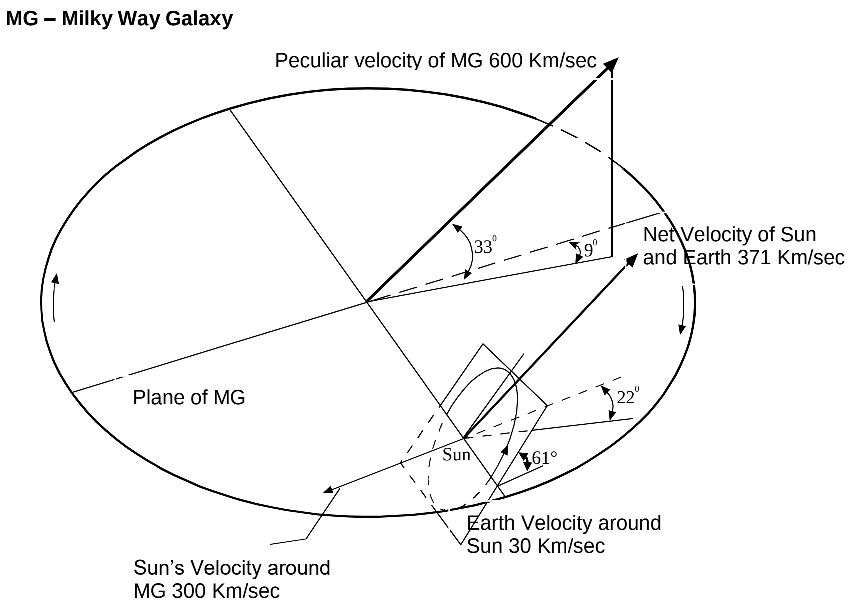

Fig. (3) Earth Velocity Relative to the Global Space

Coleman and Glashow [49], [50], also adopted this idea that space is a special frame. Experiments to reveal the Earth Velocity Relative to the Global Space by measurements of light velocity in and opposite the Earth velocity vector direction failed. The full isotropy obtained is explained in the following sections.

16 On Special Relativity (SR)

16.1 History and Status

Lorentz (1904) explained the constant light velocity in the **two-way** measurement by Michelson-Morley (1887) as the result of **real** length contraction and time dilation.

Einstein (1905), however, postulated **one-way** constant light velocity (and necessarily also two-way) as a law of nature. The result was **virtual** length contraction and time dilation. Thus, the Lorentz cause and effect were reversed; length contraction and time dilation became virtual instead real.

Einstein showed (1939) non-explicitly, that the constant light velocity might be the result of space (and hence the electromagnetic “medium”) being carried by the Earth and by other stars. In this case instruments on the Earth, for measuring light velocity, are **at rest** relative to the Earth’s local space. This carrying of space, while maintaining space continuity, is only possible if space is an elastic **fluid** – Einstein’s *compressible fluid.*

Recent measurements of **one-way** light velocity showed that it is constant (full isotropy). These results, however, **cannot** be explained by length contraction and time dilation – real or virtual. Hence Einstein’s consideration of space as an elastic fluid becomes more realistic.

This led us to suggest a modification of textbook Special Relativity.

16.2 One-Way Light Velocity Measurements

Few are this type of measurement, and not all are reliable. Recent measurements by Ahmed, et al, [51] (2013), and by Gurzadyan and Margaryan, [52] (2018), yielded the constancy of light velocity i.e., full isotropy.

Note that a **one-way** velocity experiment is (v/c) and not $(v/c)^2$ dependent. Hence it is justified to ignore, in the calculations, both length contraction and time dilation, which are $(v/c)^2$ dependent.

16.3 Is Space Kind of an Elastic Fluid?

We consider electromagnetic waves, like gravitational waves, to be space waves. The current understanding, however, is that electromagnetic waves have their own unidentified “medium”, which follows, according to General Relativity (GR), the topology of space.

To explain this isotropy, we conclude that our instruments are stationary relative to space. Thus space, and hence the “medium”, must be confined locally by the Earth and carried along by its linear and rotational motions. This should also be the case for other planets and stars. Thus, to maintain continuity, space must be an **elastic fluid**.

Carrying of space by the Earth is accompanied by both rotational and linear Frame Dragging. Frame Dragging has been confirmed experimentally.

16.4 Our Logic of Argumentation

In **one-way** light velocity experiments, there are two possible results and *terzum non datur*:

Anisotropy

Anisotropy could be the result of the Earth, stars, and material bodies in general, sliding through space. This is possible if, for example, elementary particles, and hence material bodies, are space wavepackets. The entire global space can serve as a special frame that coincides with the Cosmological Microwave Background (CMB) frame. In this case, we can consider space to be an elastic **foam**.

For this frame, Relative velocity is considered Real velocity that yields a CMB Doppler shift. This Real velocity should yield a real Lorentz length contraction and Larmor time dilation.

Isotropy

Isotropy could be the result of space (and hence the electromagnetic "medium") being carried by the Earth and by other stars, but **not** necessarily by "small" bodies. In this case, instruments for measuring times of flight on the Earth must be **at rest** relative to the Earth's local space.

This carrying of space, while maintaining space continuity, is only possible if space is an elastic **fluid** – Einstein's *compressible fluid.*

These confined zones of space are individual special frames. Relative velocity of a "small" body to one of these frames, if it is within the space zone of this frame, should yield a real Lorentz length contraction and Larmor time dilation.

Note that, in the case of anisotropy, we have one special frame, whereas in the case of isotropy there are many special frames.

17 Electromagnetic (EM) Waves are Space Waves

This contention is based on the following:

In [1] we define electric charge density, with **space density** as its single parameter. This definition alone, without any phenomenology, yields the theory of Electrostatics. In [2] we derive the attributes of electric charge and elementary particles. The Lorentz Transformation (LT), is derived in [3], based on our model of the elementary particle. Our Electrostatics together with the LT, and neglecting the field contribution to charge density, yield the entire Maxwell Electromagnetic theory [24]. Considering the field contribution to charge density, as in gravitation, yields a full nonlinear electromagnetic theory that resembles QED.

The confidence in our EM theory is based on the following:

The essence of electric charge and its field has been a mystery. So far, no theory has been able to derive the attributes of electric charge, which are: bivalency, stability, quantization, equality of the absolute values of the bivalent charges, the electric field it creates and the radii of the bivalent charges. Our model of the electric charge and its field [1] enables us [2], for the first time, to derive simple equations for the radii and masses of the electron/positron muon/anti-muon and quarks/anti-quarks. These equations contain only the constants G, c, $\hbar$ and α (the fine structure constant). The calculated results based on these equations comply accurately with the experimental data of CODATA 2014.

Note that the Standard Model of elementary particles, despite its successes, and String Theory fail to derive and calculate the radii and masses of the elementary particles, and fail to explain what charge is.

Note also that our argumentation, in this paper, is independent of the specific understanding of whether Electromagnetic waves are space vibrations or the vibrations of their own “medium” that follows, as GR requires, the topology of space.

18 Einstein's "Stationary" System

18.1 History

Einstein was bothered by his (1905) "constancy of light velocity" postulate, since, on the face of it, it did not comply with the common understanding of the behavior of waves in different media. Hence, he was very careful in the way he phrased the second postulate of Special Relativity (SR), (see below). Only thirty-four years later (1939) he came up with a non-explicit explanation as to why the second postulate of SR is correct and how it complies with the common behavior of waves. We have adopted this explanation, since the **one-way** light velocity constancy narrows the options left for explanations.

18.2 Einstein's SR Second Postulate

The original second postulate of SR, [53] p41 (1905), is:

Any ray of light moves in the "stationary" system of co-ordinates with the determined velocity *c, whether the ray is emitted by a stationary or by a moving body.*

The *"stationary" system*, as we understand it, is simply the medium system whose vibrations are the electromagnetic waves.

In text books, however, the second postulate is expressed in a **different** manner:

The speed of light in vacuum has the same value in all directions and in all inertial reference frames.

Or:

The speed of light in free space is the same for all observers in inertial reference frames.

18.3 Einstein's "Stationary System" and Space as a Fluid

To reveal and clarify the term "stationary system" Einstein (1939) constructed a system of many gravitating masses [54], each moving along a geodesic circular orbit about the center of the system, under the influence of the gravitational field of all the masses. This system, referred to in the literature as an "Einstein cluster", has spherical symmetry.

Einstein, regarding the EM medium, concluded that: … *it would be necessary, therefore, to introduce* ***a compressible liquid …***

This medium is not identified **explicitly**, but logically it is the gravitational field, which is simply, according to GR, space.

Papers on Space as a fluid, discussing theory and possible experiments, are [55] and [56].

19 On Frame Dragging

19.1 Frame Dragging

Frame Dragging is the deformation of the Schwarzschild metric due to rotation or linear motion. These phenomena have been detected. A book on the subject is [57], and a report on the measurement of the Earth's dragging of inertial frames is [58].

20 SR in Textbooks

In textbook SR, all inertial systems are equivalent, length contraction and time dilation are **not real**, and simultaneity is **relative**. In SR, neither space nor time is objective.

Only **spacetime,** (which we consider a legitimate and useful mathematical "trick") **is objective and absolute**, since the interval ΔS^2 is invariant under the Lorentz Transformation.

21 Our Modified Special Relativity – MSR

21.1 MSR

The first SR postulate is turned into a definition of a Law of Nature.

Definition: A physical law is a law of nature if it appears the same in all inertial systems.

Instead of SR **postulates**, MSR presents **laws:**

First Law: Rays of light move in a “stationary” system with velocity c, relative to this system, whether the rays are emitted by a stationary or by a moving body.

Note that all stars are “stationary” systems. But **it is not clear** how small a material system can be and still serve as a “stationary” system.

Second Law: Real velocity of an inertial system (velocity relative to the “stationary” system in which the inertial system resides) is accompanied by a real Lorentz contraction and a real Larmor slowing-down of clocks in this system.

21.2 Conclusions

21.2.1 Two Systems

Two inertial material systems, moving at the same **v**, cannot be considered as one combined inertial system, since space between them is not affected [59]. This is argued by J. Bell, see Ref. [14] in [59].

21.2.2 On Global and Local Spaces

Space between galaxies is subjected to the Hubble flow, whereas the space inside galaxies is not (no cosmological redshift). The CMB resides in the **global** space in and around galaxies and its frame defines real velocity relative to the global space.

A **local** “stationary” space is that of any star, the Earth included.

21.2.3 On Relative and Real Velocities

Relative velocity is the velocity between any two inertial systems.

Real velocity is the velocity of an inertial system relative to a "stationary" system - global or local.

Real velocity is accompanied by real length contraction and time dilation (slowing of clocks).

For relative velocities only, length contraction and time dilation are **not real**, Born [60] p254.

21.2.4 On Lorentz Length Contraction and Larmor Time Dilation

Lorentz length contraction is related to material bodies, and might also relate to local spaces.. It is determined by real velocity as suggested by Lorentz (1904) [61], and by us [59].

Larmor time dilation is the slowing rate of clocks, and is determined by real velocity (Note that we do **not** consider time to be fundamental [59]).

We can infer real velocities of inertial frames by measuring our own real velocity, and our relative velocities to the other frames. Thus, internal observers of all frames will agree whether events occur at the same time or not, despite the fact that their clock rates might differ. **Simultaneity is thus absolute**, in contrast to textbook SR in which it is relative.

Note that in Section 3 [3] the Lorentz transformation appears as a result of the elementary particle model presented.

Note that **not** every inertial system is a "stationary system" and hence **not** all inertial systems are equivalent.

Note also that the velocity of highly-accelerated particles in Labs on Earth is their real velocity.

21.3 The Common Understanding

Two inertial frames, S1 and S2, move with a relative velocity v to each other. Two observers, Ob1 in S1 and Ob2 in S2, have a **subjective,** but symmetric, perception about the reality. Ob1 finds that a standard yardstick in S2 appears shorter by $1/\gamma$ and a standard unit of time appears longer by γ, where $\gamma = (1+v^2/c^2)^{-1/2}$. Ob2 finds that this is exactly what happens in S1; indeed a symmetric situation. Therefore, we do not anticipate any real change in the yardstick length or the unit of time in S1 or S2. After all, S1 and S2 are inertial systems, and there is no force to induce a change. The common understanding of this situation is that the perception of space and time is **subjective** – that each observer relates a contracted space and a prolonged time to the other observer. The GDM opposes this understanding and suggests an alternative below.

Note that, in the Minkowski **4D spacetime**, the line element $ds^2 = -c^2dt^2+dx^2+dy^2+dz^2$ is invariant to the Lorentz Transformation (LT). Hence both Ob1 and Ob2 observe the same ds^2 and necessarily agree on the same **objective** reality.

21.4 The GDM Understanding

In the GDM, space is a special frame, and there is meaning to "rest" and motion with respect to this frame, see our model of the elementary particle in [3]. According to this model the radii of the electron/positron: $R = 1/\gamma \cdot R_0$ and $r = 1/\gamma \cdot r_0$ and its energy $U = \gamma U_0$, (zero subscript denotes - at "rest"), are dependent on the relative velocity to space. This change, of the radii and energy of the electron, is **a real Lorentzian change**, which also occurs as the contraction in length of macroscopic bodies, (this issue is addressed elsewhere). Thus S1 and S2 are not identical **if** their respective velocities relative to space are not identical, i.e., the above features, radii and energy of the electron, are not the same in S1 and S2.

Note that in the GDM, far from masses and charges, spacetime is the same for all observers. Thus, observers of both S1 and S2 can observe each other's length of a yardstick and rate of a clock, to be dependent on their relative velocity. But they can also derive and calculate the **real** length of their yardsticks and the **real** rate of their clocks, by measuring the CMB Doppler-shifts, which give their velocities relative to space. To the question; is it possible to distinguish experimentally between the common understanding of SR and that of the GDM, the answer is affirmative, but out of the scope of this paper.

22 On General Relativity (GR)

22.1 History

It was Einstein, in his Theory of General Relativity, who made a very significant step towards the understanding of gravity. First of all, he realized that it would make sense to suppose that the bodies were in a real, **non-empty medium**, and that it was this medium that transferred the force of Gravity. Moreover, the speed of the spread of force in the medium is the same as the speed of waves in it. This medium, he determined, is **space**. This is a revolutionary determination. Instead of an empty space without any attributes, that serves as a reference frame only, we now have a non-empty space and can study its properties.

In order to learn about the features of space **Einstein** conducted a **thought experiment** (in the human brain rather than in practice) as described in Fig. (4). This figure shows identical four carriages in which the following things occur:

In A, in a carriage positioned on the Earth's surface, a stone falls from a top shelf with the acceleration of free fall on to the floor of the carriage. At B the carriage accelerates upward with the same acceleration as free fall. A stone also falls from a top shelf, which is at the same height. The fall time must be the same (and it is indeed), since an observer, watching from inside has no way to know whether it is on the ground or someone is pulling it up with a rope. From this thought experiment, Einstein determined that the response of a mass to gravitation was equivalent to its response to acceleration (inertia). From here (historically I am not precise), we derive the **Equivalence Principle**, the **equivalence of gravitational and inertial mass.** This law has been confirmed to a very high level of accuracy in many experiments. But it has not yet been proven theoretically, in spite of more than a century that has passed since its discovery. However, we have presented an article that proves that not only are gravitational and inertial mass equivalent, but they are **identical.**

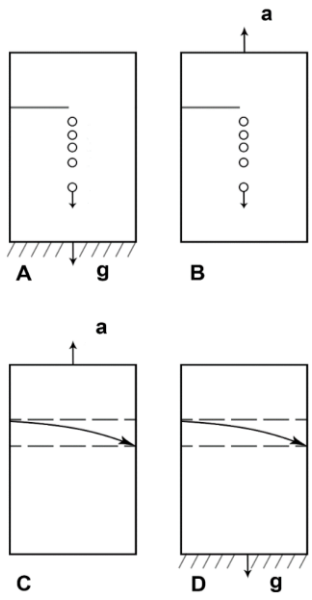

Fig. (4) A Light Beam in a Gravitational Field

In C, a light beam is sent from the shelf toward the right wall and parallel to the ceiling. If the carriage is at rest (or in constant motion in a straight line) the beam will hit the wall right in front of it. Both the beam's exit point and contact point are at the same height below the ceiling. If, however, the carriage is accelerated upwards, as the figure shows, the beam will hit the opposite side at a lower point. All this because of the final speed of the beam and the fact that while it is moving to the right the right wall moves upwards. In practice, this experiment is almost impossible because of the enormous speed of light.

From this thought experiment Einstein came in three steps to an amazing conclusion.

Cases A and B show that we cannot know what acceleration we are undergoing, that is, normal acceleration or the acceleration of free fall as the result of gravitation (Einstein, in his day, could not have thought otherwise. See Note at the end of this section). Therefore, of necessity, in case D where the carriage is not accelerated but is positioned on the Earth, it should get the same downward shift.

Eddington exploited a solar eclipse (1919) and demonstrated that a light beam from a distant star was bent as it passed the Sun.

Space is the medium in which a beam of light travels, ostensibly in a straight line. If it bends, it means that the Sun's mass is distorting space - bending it.

As a result of his thought experiment, Einstein concluded that gravity is nothing but bent space. This bending dictates the energy and motion of masses and light beams.

Here is Einstein's equation that expresses this idea:

$$\mathbf{R^{\mu\nu} - 1/2Rg^{\mu\nu} = 8\pi G/C^4 \cdot T_m^{\mu\nu}}$$

The right-hand side of the equation represents energy and mass (which today is considered energy and nothing more), while the left-hand side represents bent space.

Einstein asked his friend **Marcel Grossman** to find a way to express the bending of space. His recommendation was the only suitable geometry at the time – **Riemannian geometry.**

Since then, many have tried to turn the equation into a general expression that applies to all the existing fields, not just the Gravitational field – the **Unified Field Formula** – as it is known.

The **first successful attempt**, by us, (note the addition of a new term in the right wing), is shown below:

$$\mathbf{R^{\mu\nu} - 1/2Rg^{\mu\nu} = 8\pi G/C^4 \cdot T_m^{\mu\nu} + 4\pi G^{1/2}/s^2 \cdot T_q^{\mu\nu}}$$

Where $S = 1$ and $[S] = LT^{-1}$

So how did it come about, after more than a hundred years, that I now have a **Unified Equation** of gravity and electromagnetism?

22.2 On the Unification of Gravity and Electromagnetism

The Theory of General Relativity relies on Riemannian Geometry which deals with bent (curved) surfaces (manifolds) and not with deformed spaces. The surface of a ball is, for example, a curved surface. A surface like this is two-dimensional, its curving is in the three-dimensional space, and its geometry is not Euclidean. On the other hand, our new geometry –

The Geometry of Deformed space Lattices [6] – deals with a deformed three-dimensional space. This Geometry serves the General Theory of relativity better than Riemannian. It shows that a star does not bend space around it, as is believed today even though it is impossible to imagine it, but rather contracts space around it.

In addition, we show that the electrical charge and its field are deformed space, and therefore electromagnetism and gravitation have a common denominator. From here the road to a Unified Field Formula (of gravitation and electromagnetism) is long but paved.

By adopting the new geometry, whereas the Riemannian "formalism" remains the same as it was, our perception and understanding of general relativity has changed.

Referring to charge and its field as a spatial deformation creates a common denominator that enables the construction of the Unified Field Formula.

In other words, this provides proof that the gravitational and electromagnetic forces are expressions of a single force, the mechanical stretching and contracting (like a spring) of space.

Unification of all forces is **the proof that they are nothing but the tension of space**

So far, we have considered only the union between gravity and electromagnetism, but there are two more forces, the weak force and strong force. we look at these forces, which appear to be nothing but electrical in nature, elsewhere. We show that all four forces are expressions the elasticity of space. This reinforces our determination that there is nothing other than space and the only force is its elasticity.

Thus, the above extended equation becomes the equation of all forces, an equation of the macroscopic and microscopic worlds.

22.3 The New Meaning of Gravity in Our General Relativity

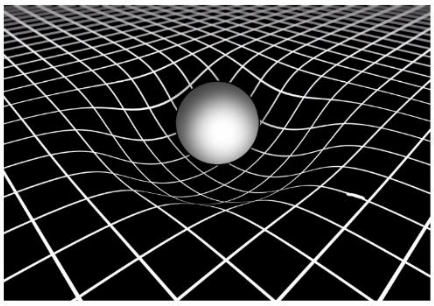

Fig. (5) The Curving of Space by a Stellar Mass

Fig. (5) is a typical illustration. This is how curvature by a mass is presented in all books. It is **meaningless** as we cannot imagine a curved three-dimensional space manifold bent in a four-dimensional hyperspace.

Fig. (6) shows the true deformation of space by a mass, which is merely **space contraction**. Fig. (7) shows, again, the true deformation of space by a mass at point P - a deformation which is nothing but a contraction of space around P, the reduction in space cell's sizes - a positive "curvature".

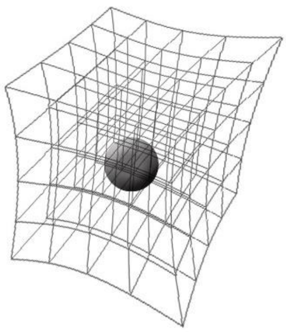

Fig. (6) The True Deformation of Space by a Mass

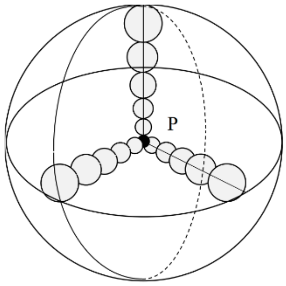

Fig. (7) The True Deformation of Space by a Mass at Point P

From the above, we conclude that gravity is a contraction of space!

This understanding finally allows us to answer questions in science that have been open for hundreds of years:

- Why does a ray of light curve when passing near a mass?
- How does mass contract space?
- How does another mass feel this contraction and move accordingly?
- How to build a Unified Field Formula (the Physicists' yearning)?

Why does a ray of light curve when passing near a mass?

The usual explanation is this:

Mass curves space. A ray of light should, therefore, move on a geodesic line, which means to curve. Although this is a valid explanation, it does not satisfy me.

My explanation:

A mass contracts space around it. In its vicinity, space is dense but its density, from the mass outwards, falls. Space is analogous to glass, in that its refractive index is large near the mass but decreases with the distance from it.

Space, close to a mass, is also analogous to compressed air, high density near the mass falls with increasing distance from it.

The study of optics tells us that a ray of light passing through a medium with a variable index of refraction is curved.

These examples are a good analogy. The explanation is simpler. Space is the medium whose waves are light waves with their speed dependent on the density of space (as we explain, this does not contradict the fact that the speed of the light is a constant of nature).

When a ray of light passes through a media with a variable density the upper part of the ray (at a relatively large distance from the center of the mass) moves faster than the lower part (at a relatively smaller distance from the center of the mass). Of necessity the wave front is tilted, and the ray is curved.

This explanation is from our virtual point of view as observers out of the universe (**far observers**). For spectators in the media, in space, both their yardstick and their clock vary with the density of space and will, therefore, always give the same value for the speed of light.

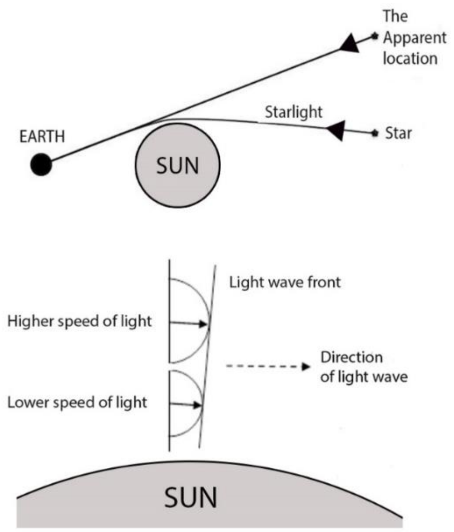

Fig. (8) Deflection of a light beam

22.4 Remarks on Distance Time and More on Light Velocity

Distance

Consider the linear dimension of a space cell as the local observer's yardstick. Hence, in a space lattice the distance between two points is simply the number of space cells on a line between them. The line is straight in Euclidian space and geodesic in curved (deformed) space.

We consider **a standard unit of length** as a yardstick with **the same number** of space cells along its length, anywhere in space. A standard yardstick contains the same number of space cells anywhere, but the linear dimensions of these cells might vary in different zones of space. Hence, a standard yardstick's length, as seen by observers in other than their own zones of space, may also vary.

Time

We consider a **standard unit of time** as the time for a light beam to cross a standard yardstick. If the yardstick moves with respect to space, a unit of time is the time for the beam to move back and forth. The time for this back-and-forth movement is affected by the yardstick's Lorentz contraction. This contraction nullifies the difference between the times of flight in the stationary and non-stationary cases. This device is our **standard clock**.

More on time see [59].

Light Velocity

We clarify the fact that observers in all zones of space, regardless of their space densities, will claim to get the same result measuring light velocity with their standard yardsticks and clocks. Hence, we relate to Light Velocity as a **constant of nature.** However, each and every far-away observer finds that according to his measurements and understanding light velocity elsewhere, where local-observers reside, might vary according to space density in their locality. This is the result of light velocity dependence on the permittivity and permeability of space. But the permittivity and permeability of space depend on the density of space. Hence, we should not consider light velocity as a constant but relate to the **coordinate speed of light** of GR [62] as a real speed.

In GR light velocity is a **variable** depending on the observer's reference frame, and at the same time it is a **"constant of nature"**. GR shows that this dependence, on the frame, is such that **every observer** in a deformed or non-deformed space will get, by taking measurements, the same local result for light velocity, because the yardstick is deformed and so is also the unit of time. This **invariance** is the essence of the concept of a **"constant of nature"**.

22.5 The Metric and Light Velocity

Schwarzschild, in 1916, was the first to find a solution to Einstein's field equation - a general spacetime metric - for the exterior of a spherically-symmetric star of radius R, i.e., for $r > R$:

$$ds^2 = -g_{00}c^2dt^2 + 2g_{0r}dr\,dt + g_{rr}dr^2 + r^2\left(d\theta^2 + \sin^2\theta\, d\varphi^2\right)$$

where the metric elements g_{00}, g_{0r} and g_{rr} are functions of r and t.

According to [63], Chapter 10, the line element ds^2 is:

$$ds^2 = -e^{-\frac{2GM}{c^2r}}c^2dt^2 + e^{\frac{2GM}{c^2r}}dr^2 + r^2\left(d\theta^2 + \sin^2\theta\, d\varphi^2\right) \tag{20}$$

We denote a gravitational scale factor, a:

$$a = e^{-\frac{2GM}{c^2r}} \tag{21}$$

For the surface of the sun or the edge of our galaxy: $GM/rc^2 \sim 10^{-6}$ and thus $GM/rc^2 << 1$. For $GM/rc^2 << 1$ equation (21) is approximated as:

$$a = (1 - GM/rc^2) \qquad a < 1 \qquad r \to \infty \qquad a \to 1 \tag{22}$$

We rewrite (20) as:

$$ds^2 = -a^{-2}c^2dt^2 + a^2dr^2 + r^2\left(d\theta^2 + \sin^2\theta\, d\varphi^2\right) \quad (23)$$

We relate to space as a 3D elastic, deformable lattice, rather than a bent manifold [44].

And we understand that **a standard yardstick** has **the same number** of space cells along its length, anywhere in space.

The metric in equation (23) is derived by a faraway observer OB1– far away from the center of a mass, M, that serves as the origin of his co-ordinates.

For OB1, a radial distance interval, dl, close to a mass, contains a smaller number of his yardstick units, dr, than dr_0, the number of the local observer OB2 yardstick units that dl contains. This is the result of the OB2 yardstick contraction, which is also the contraction of his local space. Hence:

$$dr_0 = a^{-1}dr \qquad a > 1 \quad (24)$$

From the **synchronization of clocks**, [17] Rindler arrives (p. 184) at:

For OB1, a time interval, dτ, contains a larger number of time units, dt, than the number of time units, dt_0, for OB2. And indeed, from the synchronization of clocks, Rindler [42] p.184 arrives at the conclusion, that:

$$dt_0 = adt \qquad a < 1 \quad (25)$$

Thus, for OB1, a time interval, dτ, contains a larger number of time units, dt, than the number of time units, dt_0, for OB2.

The 4D **spacetime interval** between two events [17] p.236; the “emission” of a short pulse of light at point A and the “arrival” of this pulse at point B is:

$ds^2 = 0$.

Hence using (23):

$-a^2c^2dt^2 + a^{-2}dr^2 = 0$ or:

$acdt = a^{-1}dr$ or:

$$dr/dt = a^2c \qquad (26)$$

This, dr/dt = c', for OB1, is the light velocity close to the mass M. Light velocity, for OB1, far away from the M, is c (standard light velocity), whereas dr/dt = c'< c.

This, dr/dt = c', is a local real and slower light velocity since, according to (22), a < 1.

Note that in the literature dr/dt in equation (26) is called **coordinate speed of light.** This is a misleading name, since dr/dt should be considered a **real speed**.

Note that light velocity is **not constant**; it is, however, **a constant of nature,** since Local Observers measuring light velocity in their own zones of space arrive at the same result:

Substituting (24) and (25) in (26) gives:

$dr/dt = adr_0/a^{-1}dt_0 = a^2dr_0/dt_0 = a^2c$ and hence:

$$dr_0/dt_0 = c \qquad (27)$$

We thus conclude that OB1 and OB2 measuring light velocity locally in their own zones of space will arrive at the same result. However:

$$c' = a^2c \qquad (28)$$

This invariance attributes the title "**a constant of nature**" to light velocity, despite the fact that in different zones of space it behaves differently.

This new understanding enables the resolution of the long-standing issue of Dark Matter [66].

23 The Elementary Particles of the First Generation in the GDM

Photon [64]

Photom (Anti-Photom) [64]

Electron (Positron) [1], [2]

Neutrino (Anti-Neutrino) – Not yet modeled

Graviton [65]

Note that Quarks, in the GDM, are "twisted" Electrons (Positrons) [5].

Photoms are the ground state (vacuum state) particles (quantized vibrations of space) of the electromagnetic field. A photom is a photon at the bottom. This is **also** the ground state (vacuum state) of the Gravitons.

24 Summary

The GDM infers the laws of physics logically from the attributes of the elastic space lattice (no phenomenology). Thus, there is no need to ask where these laws of physics come from. Our modification of Einstein's theories is turning them to become realistic rather than relativistic. We know that space is all there is, but we are left with the riddle of where space, finite or infinite, comes from, and what role we, as humans, play in it.

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