



**HAL**  
open science

# The Geometrodynamics of Space

Shlomo Barak

► **To cite this version:**

| Shlomo Barak. The Geometrodynamics of Space. 2017. hal-01435685v2

**HAL Id: hal-01435685**

**<https://hal.science/hal-01435685v2>**

Preprint submitted on 31 Jan 2017 (v2), last revised 21 Sep 2018 (v4)

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# The Geometrodynamics of Space

Shlomo Barak

Taga Innovations 28 Beit Hillel St. Tel Aviv 670017 Israel

Corresponding author: shlomo@tagapro.com

## Abstract

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

Our “**GeometroDynamic Model** of reality”, the **GDM**, presented here, is this required layer. The GDM reveals the essence of charge, elementary particles, gravitation, and inertia. It also relates to additional fundamental subjects. The GDM provides derivations and accurate calculations of the radii and masses of elementary particles. Its specificities enable us to suggest new experiments of validation or falsification. Some of these subjects have already been addressed in our recently published papers, “On the Essence of Electric Charge”, [1], [2], “On the Essence of Gravitation and Inertia”, [3], [4], “Where is Anti-Matter?” [5], and “The Photon and the Quantum Enigma” [6].

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

# 1 Introduction

## 1.1 The GDM Idea

The elastic and vibrating three-dimensional Space Lattice is all there is.

Elementary particles are Transversal or Longitudinal wavepackets of this vibrating space.

## 1.2 The GDM

The GDM is a model of the physical reality, in which space is all there is.

This expresses the drive to reductionism.

The GDM explains known, but currently unexplained, phenomena.

This expresses the drive to understand.

The GDM predicts new phenomena that can be confirmed experimentally.

This is the requirement for specificity and falsifiability.

The GDM logically infers laws of physics.

No phenomenology and hence no need to ask where the laws come from.

## 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  $[\hbar] = L^5 T^{-1}$

G	Gravitational Constant	$[G]= T^{-2}$
$\alpha$	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  $\alpha$  instead.

In the GDM:  $[v] = LT^{-1}$ ,  $[a] = LT^{-2}$ ,  $[H] = [G] = T^{-2}$ ,  $[Q] = [M] = L^3$ ,  $[E_E] = [E_G] = LT^{-2}$ ,

$[\varphi_E] = [\varphi_G] = L^2T^{-2}$ ,  $[F] = L^4T^{-2}$ ,  $[U] = L^5T^{-2}$ , see [1], [2], [3], and [4].

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

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

## 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

It is interesting to note that 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]. This is **all we can say, and in fact, need to say** about the structure of space.

## 2.2 The Linear Dimension of a Space Cell

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

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

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

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

## 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 [20] 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.

## 4 Space Density

Space density  $\rho$  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  $\rho_0$ .

Let  $dn$  be the number of space cells in a given volume  $dV$ . Since  $dn = \rho_0 dV$  and also  $dn = \rho dV'$  we get:

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

In Appendix A of [1] we prove that the relative volumetric change equals the divergence of the Elastic Displacement Vector  $\mathbf{u}$ :

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

This proof is a corner stone in the GDM electromagnetism.

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

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

### 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 electromagnetic waves are merely elastic transversal waves of space, but not in the classical sense. We 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,  $\mathbf{u}$ , (53.6) in [22], is the **Navier equation**:

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

$\mu$  and  $\lambda$  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  $\epsilon$ . Hence, for space as the elastic media,  $m$  represents the energy density of vibrations:

$$m = \frac{\epsilon}{c^2} \quad (5)$$

To solve equation (4), we adopt the Kelvin [22] method and decompose  $\mathbf{u}$  as follows:

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

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

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

$\varphi$  stands for the scalar potential and  $\mathbf{f}$  for the vectorial potential. This decomposition is true under the boundary condition  $\mathbf{u} \rightarrow 0$  at  $\infty$ . 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  $\mathbf{u}_L$ :

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

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

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

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

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

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

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

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

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 (19<sup>th</sup> century) suggested that  $\lambda + 2\mu = 0$ , see [23] 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:

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

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  $\rho_0$ , 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:

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

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

$$m = \epsilon_s / c_0^2 \quad (8)$$

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

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

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

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

By using (8) we have turned (7), an equation that determines  $c$ , into an equation that determines the ratio  $c/c_0$ . This ratio  $\epsilon/\epsilon_s$  is the ratio between the energy density  $\epsilon$ , in a

specific zone of space, and the energy density  $\epsilon_s$ .

### **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  $\rho_0$ , 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 [24] [25] 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 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 [6].

Measuring time is merely the comparison of the rates of clocks. Time by itself has no fundamental meaning in the GDM.

Our time coordinate, in units of distance, is  $x = ct$ . Relating to our 4D reality as a 3D Space and 1D Time, the following notations are common in the literature;  $x_4 = ct$ ,  $x_4 = ict$  or

$x_4 = -ict$ . It is now clear that we can relate to space density in a broader sense that includes the rates of clocks (time) at each and every point.

## 8 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:

$$\lambda = 0.5818 \mu \quad \text{In this case:}$$

$$k = 1.2485 \mu$$

i.e., the **space bulk modulus is positive**. Taking space “mass” density as  $m = \frac{\epsilon_s}{c^2}$ , where  $\epsilon_s$  is

the energy density of space vibrations (the vacuum state), and substituting this value for  $m$  in (7)

gives  $\mu = \epsilon_s$ . Hence:

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

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

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

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

$$\epsilon/\epsilon_s = - 3.7455 \, dV/V$$

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:

$$\epsilon/\epsilon_s = 3.7455 \, dV/V \quad (13)$$

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  $\rho_0$  of un-perturbed space is determined by its vibrational energy density  $\epsilon_s$ . According to Sakharov [7], space density is  $\rho$  rather than  $\rho_0$  if the energy density is  $\epsilon$ , rather than  $\epsilon_s$ . Note that  $\epsilon > \epsilon_s$  is related to dilation whereas:  $\epsilon < \epsilon_s$  is related to contraction.

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

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  $\epsilon > \epsilon_s$  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  $\epsilon_s$ , see Section 11.2.

## 9 Blackbody Radiation and the Vacuum State – a Reminder

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

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

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:

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

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

Namely, in the limit  $T \rightarrow 0$  the energy  $U \neq 0$  and when  $T = 0$  then  $U = \frac{1}{2}h\nu$ . 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 [26]. In the current paradigm, this concept, which relates to each field separately, is unclear and leads to perplexing results, as presented in [27].

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:

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

which is independent of space density  $\rho$ .

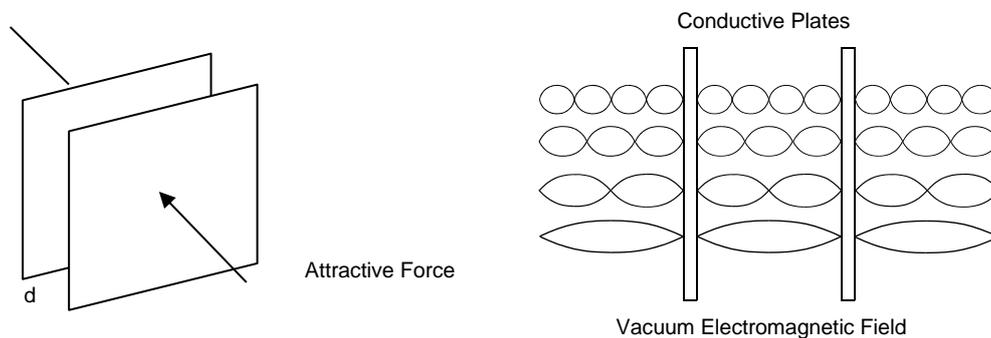
The energy of a single space cell, however, is inversely proportional to  $\rho$ . The proportionality of  $n(\omega)$  to  $\omega^3$  is Lorentz invariant. The vacuum state spectrum is the only one with such invariance. This is, therefore, **the only spectrum that does not enable an observer to detect 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 [28].

## 10 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 [29] or the **Lamb shift**, see [30] 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, therefore, 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.

## 11 Estimates of the Vacuum State Energy Density

### 11.1 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:

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

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

$$\epsilon(\omega) = \int_{\omega_1}^{\omega_2} n(\omega) d\omega = \frac{\hbar}{8\pi^2 c^3} (\omega_2^4 - \omega_1^4) \quad \text{See [30] P.399.} \quad (17)$$

According to [31] P.49, in the range of the visible spectrum, 700 – 400 nm:

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

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

According to [7] P. 1202, for  $L_{\text{cutoff}} = L_{\text{planck}}$ ,  $\omega_2 = \frac{2\pi\lambda_{\text{cutoff}}}{c}$  and  $\omega_1 = 0$ , the energy density for

the whole vacuum state spectrum is:  $\epsilon_s \sim 2.4 \cdot 10^{12} \text{ erg} \cdot \text{cm}^{-3}$ . This perplexing situation is discussed in [27]. In comparison, the energy density of the baryonic matter of the universe is  $\sim 10^{-10} \text{ erg cm}^{-3}$ .

### 11.2 An Estimation of $\epsilon_s$ Based on the Highest Gamma Ray Energy Ever Detected

The H.E.S.S. Gamma ray observatory in the Namibian desert [31] 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  $\omega = 1.6 \cdot 10^{27}$ sec<sup>-1</sup>,  $\lambda = 1.2 \cdot 10^{-16}$ cm.

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

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

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

$$\epsilon_s \sim 10^{112} \text{erg} \cdot \text{cm}^{-3} \quad (18)$$

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

$$\epsilon_s \sim 10^{56} \text{erg} \cdot \text{cm}^{-3} \quad (19)$$

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

## 12 “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<sub>L</sub>. 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<sub>L</sub>, is on a closed track [3]. This orbital movement, Dirac’s Zitterbewegung [32], 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].

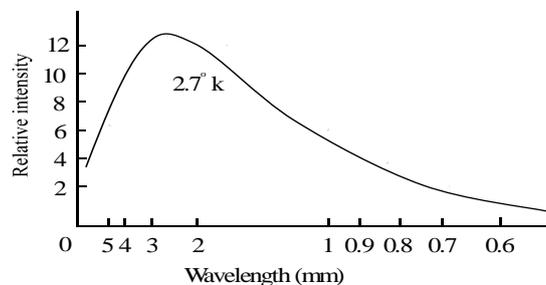
## 13 Space is a Special Frame

Space is a special frame. Velocity and acceleration relative to space are measured by the Cosmic Microwave Background (CMB) Doppler shift. The idea that space is a special frame is encompassed in the Lorentzian interpretation of the Special Theory of Relativity. See Section 14.

### 13.1 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 [33]. In 1989 the CMB was again measured, this time by the Cosmic Background Explorer (COBE) satellite [34], 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**

### 13.2 Velocity Relative to Space

A CMB anisotropy was first observed by Smoot et al [35], and interpreted as the result of the above Doppler shift [36].

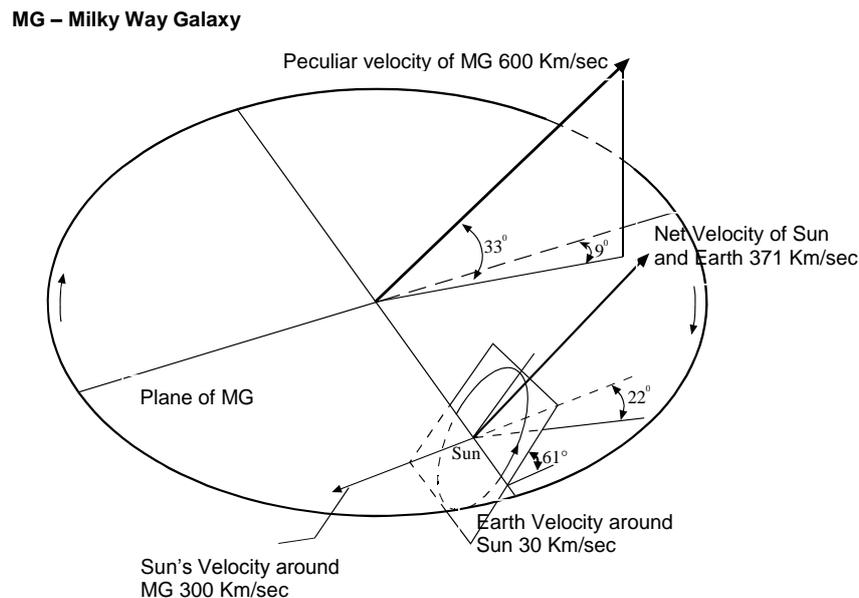
Fig. (3) shows the vector of the velocity of planet Earth relative to the universe [37]. Recently, the velocity of the Earth around the Sun and its rotational velocity have been derived from the Doppler shift.

Earth's velocity relative to space, see Fig. (3), is:  $v = 371.0 \pm 0.5 \text{ km sec}^{-1}$ . This velocity is towards a point whose equatorial coordinates are:  $(\alpha, \delta) = (11.20^{\text{h}} \pm 0.01^{\text{h}}, -7.22^{\circ} \pm 0.08^{\circ})$ , [38]. 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 Space**

Coleman and Glashow [39], [40], also adopted this idea that space is a special frame.

## 14 On Special Relativity (SR)

### 14.1 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  $\gamma$ , 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 in Section 14.2 an alternative.

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.

### 14.2 The GDM Understanding

In the GDM, space is a universal 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 will be 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.

### 14.3 Light Velocity as a Constant of Nature

An observer moves parallel to a light beam, at a velocity  $v$  relative to space. If he moves in the direction of the beam the relative velocity to the beam is  $c - v$ . If he moves in the opposite direction it is  $c + v$ .

In both cases the observer's yardstick is contracted by  $1/\gamma$ , and the rate of his clock is prolonged by  $\gamma$ . These are real changes that give, in both cases the same measured value,  $c$ , for light velocity. This invariance justifies the consideration of  $c$  as **a constant of nature**.

## 15 On General Relativity (GR)

### 15.1 Light Velocity as a Constant of Nature

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, see Section 15.2. This **invariance** is the essence of the concept of a "**constant of nature**".

## 15.2 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  $r > R$ :

$$ds^2 = -g_{00}c^2 dt^2 + 2g_{0r}dr dt + g_{rr} dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (20)$$

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

According to [41], Chapter 10, the line element  $ds^2$  is:

$$ds^2 = -e^{-\frac{2GM}{c^2 r}} c^2 dt^2 + e^{\frac{2GM}{c^2 r}} dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (21)$$

We denote a gravitational scale factor,  $a$ :

$$a = e^{\frac{GM}{c^2 r}} \sim (1 + GM/rc^2) > 1 \quad (22)$$

For the surface of the sun or the edge of our galaxy:  $GM/rc^2 \sim 10^{-6}$  and thus  $GM/rc^2 \ll 1$ .

We rewrite (21) as:

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

We relate to space as a 3D elastic, deformable media, rather than a bent manifold. Thus, 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:

$$dr_0 = adr \quad (24)$$

where  $a > 1$ .

For OB1, a time interval,  $dt$ , 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:

$$dt_0 = a^{-1}dt \quad (25)$$

where  $a > 1$ .

The 4D spacetime interval between two events; the “emission” of a short pulse of light at point A and its “arrival” at point B is  $ds^2 = 0$  [42] p.236. Hence using (23):

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

$$a^{-1}cdt = adr \quad \text{or:}$$

$$dr/dt = a^{-2}c \quad (26)$$

This,  $dr/dt = c'$ , is the light velocity close to the mass M. Light velocity, far away from the mass M, is  $c$  and  $dr/dt = c' < c$ . 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  $dr/dt$  is a **real speed**.

We contend that light velocity is **not** constant; it depends on space density  $\rho$ , but **it is** a constant of nature, as we show:

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

$$dr/dt = a^{-1}dr_0/adt_0 = a^{-2}dr_0/dt_0 = a^{-2}c \quad \text{and hence:}$$

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

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

$$\text{Light velocity in the OB1 zone of space} = \text{Light velocity in the OB2 zone of space} \quad (28)$$

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

## 16 The Elementary Particles of the First Generation in the GDM

Photon  
Photom (Anti-Photom)  
Electron (Positron)  
Neutrino (Anti-Neutrino)

Note that Quarks, in the GDM, are “twisted” Electrons (Positrons).

Photoms are the ground state (vacuum state) particles (quantized vibrations of space) of the electromagnetic field. Photom is a photon at the bottom.

## 17 Subjects that the GDM Already Addressed

On the Essence of Electric Charge Part 1: Charge as Deformed Space hal-01401332 (2016)

On the Essence of Electric Part 2: How Charge Curves Space hal-01402667 (2016)

On the Essence of Gravitation and Inertia Part 1: Inertia and Free Fall of an Elementary Particle hal-01404143 (2016)

On the Essence of Gravitation and Inertia Part 2: The Curving of Space by an Elementary Particle hal-01405460 (2016)

Where is Anti-Matter? hal-01423547 (2016)

The Photon and the Quantum Enigma hal-01423548 (2016)

The papers can be found by inserting *shlomo barak* in the HAL Search:

HAL (<https://hal.archives-ouvertes.fr>)

## 18 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. We are, however, left with the riddle of where space, finite or infinite, comes from, and what role we, as humans, play in it.

## Acknowledgements

We would like to thank Mr. Roger M. Kaye for his linguistic contribution and technical assistance.

## References

- [1] S. Barak: On the Essence of Electric Charge A, Part 1: Charge as Deformed Space  
hal-01401332 (2016)
- [2] S. Barak: On the Essence of Electric Charge B, Part 2: How Charge Curves Space  
hal-01402667 (2016)
- [3] S. Barak: On the Essence of Gravitation and Inertia A, Part 1: Inertia and Free Fall of  
an Elementary Particle hal-01404143 (2016)
- [4] S. Barak: On the Essence of Gravitation and Inertia B, Part 2: The Curving of Space  
by an Elementary Particle hal-01405460 (2016)
- [5] S. Barak: Where is the Anti - Matter? hal-01423547 (2016)
- [6] S.Barak: The Photon and the Quantum Enigma hal-01423548 (2016)
- [7] A. D.Sakharov: Soviet Physics-Doklady, Vol. 12 No. 11, P.1040 (1968)
- [8] Y. B. Zeldovich and I. D NOVIKOV: Stars And Relativity (1971) P. 71
- [9] C. W.Misner, K. S. Thorne,J. A.Wheeler: Gravitation, (1970)P. 426 P. 1202
- [10] J.D. Bekenstein.: Phys. Rev. D 7, p. 2333 (1973)

- [11] L. Smolin: Three Roads to Quantum Gravity (2001)
- [12] S. Chandrasekhar NATURE 344, 285 (1990)
- [13] G. Amelino-Camelia: arXiv: astro-ph/0201047 (4 Jan 2002)
- [14] D. Finkelstein: Quantum time, on the web (2010)
- [15] R. Penrose: The Road to Reality Knopf N.Y. (2005)
- [16] G. t'Hooft: Physics and Our Own View Of The World, P.25, Ed. T. Hilgevoord, Cambridge (1994)
- [17] W. Rindler: Relativity Oxford (2004)
- [18] A.M. Steane: Relativity made relatively easy. Oxford (2013)
- [19] J. J. Callahan: The Geometry of Spacetime Springer (1999)
- [20] B. P. Abbott et al.: Observation of gravitational waves from a binary black hole merger, Phys. Rev. Let. **116**, 061102 (11 Feb 2016)
- [21] A.F. Palacios: The Small Deformation Strain Tensor as a Fundamental Metric Tensor  
Journal of High Energy Physics, Gravitation and Cosmology, 2015, 1, 35-47
- [22] Encyclopedia of Physics, Vol. VI Elasticity and Plasticity, Springer-Verlag (1958)
- [23] A. Sommerfeld: Mechanics of Deformable Bodies, Academic Press Inc. (1950) P.108
- [24] B. I. and B. Bleaney: Electricity and Magnetism. Oxford (1959) p. 239
- [25] J. D. Jackson: Classical Electrodynamics, Wiley (1998)
- [26] M. S. Longair: Theoretical Concepts In Physics, Cambridge University Press (1984)
- [27] J. Baez: Home Page internet (Aug 25 1999).
- [28] T. H. Boyer: Sci. Am. P.56, (Aug 1985)
- [29] L. A. Ballentine: Quantum Mechanics, Prentice Hall (1989)
- [30] P. W. Milonni: The Quantum Vacuum, Academic Press (1994)

- [31] T. C. Weekes: <http://arxiv.org/abs/arXiv:0811.1197>
- [32] W. Heitler: *The Quantum Theory Of Radiation*, Oxford (1954)
- [33] A. A. Penzias and R.W. Wilson: *Astrophysical Journal* Vol.72 P.315 (1967)
- [34] J. C. Mather. et al: *Astrophysical Journal Letters* Vol. 354 P.37-40 (1990)
- [35] G. F. Smoot: *Wrinkles in Time*, Abacus (1993)
- [36] M. Rowan-Robinson: *Ripples In The Cosmos*, W. H. Freeman/Spektrum (1993)
- [37] R. A. Muller: *The Cosmic Background Radiation and the New Aether Drift*, *Sci. Am.* P.64 (May 1977)
- [38] G. F. Smoot and D. Scot: *European Phys. J.* No. 1-4, P. 145-149 (2000)
- [39] S. Coleman and S. L. Glashow: *Phys. Let. B.* 405, 249-252 (1997).
- [40] S. Coleman and S. L. Glashow: *Phys. Rev. D.* 59, 116008 (1999).
- [41] B. F. Schutz: *General Relativity*, Cambridge (2003)
- [42] W. Rindler: *Relativity*, Oxford (2004)