Chapter One

Introduction

1.1 Electromagnetic Theory

An electromagnetic field is defined as a field which possesses magnetic an electrical properties and surrounds objects with electrical charge.

In 1873 Professor James Clerk Maxwell assembled the laws of Ampere, Faraday and Gauss, for electric and magnetic field into a set of four equations (MEs) [1].These equations are used to describe the behavior of electric and magnetic fields. Maxwell's that treats light as electromagnetic waves is one of greatest achievement of the 19th century [1-5]. M.Es are physical laws which unity electric and magnetic phenomena [1-3]. The importance of these equations relies in their wide-spread applications in our day life and modern technology.

. Some uses include scattering, wave guides, antennas and radiation. In recent years these applications have expanded to include modularization of digital electronic circuits, wireless communication, land mine detection, design of microwave integrated circuits and nonlinear optical devices.

Also it known that the mode of operation of telecommunication system depends on M.Es [3-4].

M.Es describe how electric charges and electric current acts as a source for the electric and magnetic field. Further, it describes how a time varying electric field generates a time varying magnetic field and vice versa.

Of the four equation two of them, Gauss law for electricity and Gauss law for magnetism describe how the field emanate from changes (for the magnetic fields lines neither begins nor end anywhere). The other two equations describes field circulates around their respective source .The magnetic field circulate around electric currents and the time varying magnetic field in Faraday's law.

1.2 Photon Concepts

The idea that light consist of rapidly moving particles can be traced from of ancient to Descartes and Riverton. The wave theory of light was put forward by Huygens and was later decisively proved to be correct through discovery of interferences and diffraction by young and Fresnel

Maxwell's theory of light as electromagnetic waves one of the greatest achievements of the 19^{th} century.

The history of the photon in the 20^{th} century started in 1901 with formula by blank for radiation of a black body and introduction of what was called later the quantum of action [8].

In 1902 Lenard discovered that energy of electrons in photo effect does not depend on the intensity of light, but depend on the wave length of the latter [9].

In his fundamental article " on an heuristic point of view concerning the production and transformation of light" published in 1905 Einstein's point out that the discovery of Lenard meant that the energy of light distributed in space not uniformly, but in a form of localized light quanta [8].

He explained that all experiments related to the black body radiation photoluminescence and production of cathode rays by ultraviolet light can be explained by the quanta of light.

The proof that Einstein's light quanta behave as particles, carrying not only energy, but also momentum, was given in 1923 in the experiment by Compton on scattering of X-ray on electrons [10].

The term photon for particles of light was coined by Lewis in 1926 in article "the conservation of photon" [11]. His notion of a photon was different from the notion we used today. He considered photon to be "atoms" of light, which analogously to the ordinary atoms are conserved.

A photon is an elementary particle. The quantum if light and all other forms of electromagnetic radiation, and the force carrier for the electromagnetic force, the effect of this force are observable at both macroscopic and microscopic level.

The great success of Maxwellian electrodynamics and quantum electrodynamics is based on the hypothesis that the photon should be a particle with zero mass, which has led to almost total acceptance of the mass less photon concept. The possibility of non zero mass has been studied by De Broglie, Vigier, Bass and Schrodinger [12], [13], [14] as well as Okun [15], [16] and others. The photon mass can be estimated using the uncertainty principle, to be in the range ~ 10^{-66} gram.

With the knowledge that the age of the universe is approximately 10^{10} years. Many laboratory experiments and astrophysical observation have been performed using many methods to check directly or indirectly whether the photon has mass. The particle data group lists the mass of the mass to be $< 10 \times 10^{-17}$ev or $M_{ph} \leq 1 \times 10^{-49}$gram [12].

There are many consequences of non zero mass photon, the speed of light would depend on its frequency, the usual Coulomb potential would become a Yukawa potential, Maxwell's equations would be replaced by Proca equations, the black body radiation formula would take on a new form, and many other theories would be affected.

In addition it seems that non zero photon mass would have impact on the special theory of relatives, because the photon mass would affect the universe constant C.

1.2 Special Theory of Relativity for Massive Photons

The great success of Maxwellian electrodynamics and QED is based on the hypothesis that the photon should be a particle with zero mass, which has led to an almost total acceptance of the mass less photon concept. The possibility of a nonzero photon mass has been studied by De Broglie, Vigier, Bass and

Schrödinger [2][3][4] as well as Okun [13] [14] and others. The photon mass can be estimated using the uncertainty principle [10]

$$m_\gamma \sim \frac{\hbar}{(\Delta t)C^2} \sim 10^{-66}\text{Gram}$$

.Many laboratory experiments and astrophysical observations have been performed, using many methods, to check directly or indirectly whether the photon has mass. The Particle Data Group lists the mass of the photon to be $< 6 \times 10^{-17}$ eV or $m_\gamma \leq 1 \times 10^{-49}$ gram [11].

There are many consequences of nonzero photon mass: the speed of light would depend on its frequency, the usual Coulomb potential would become a Yukawa potential, Maxwell's equations would be replaced by Proca's equations, the black-body radiation formula would take on a new form, and many other theories would also be affected.

In addition, it seems that a nonzero photon mass would have an impact on the special theory of relativity, because the photon mass would affect the universal constant C. In fact, however, this is not necessarily true. We could simply consider that the velocity that is the key quantity in special relativity is not the velocity of light but rather a constant of nature, which is the maximum speed that any object could theoretically attain in space-time. Although the mass of the photon is very small, any nonzero photon mass would have many consequences at a theoretical level. In this study, we will attempt to derive a dynamical relativistic energy equation for the photon as a particle. We then will see how Lorentz transformations can demonstrate, remarkably, that under certain special conditions, length expansion is also possible. All of these results together provide us with a bizarre new picture of the photon behavior.

1.3 Research Problem:

Some recent works shows existence of E.M. Yukawa potential which be associated with photon mass.

A massive photon would have other effect, Coulomb's law would be modified and the electromagnetic field would have an extra physical degree of freedom, these effect yield more sensitive experimental probes of the photon mass than the frequency dependence.

A tiny photon mass would have important consequences for theory and experiments let's list a few of them

A) While there is still a special speed it would no longer be speed light travel.

B) Electrical force binding atoms together would have a characteristic length scale determined by photon mass large photon mass means the force acts only over short range (distance) while small mass would lead to influences over large distance.

C) Massive photon could be unstable decaying in other particles [if the half life of a photon is large enough, their decay might not be noticeable over lifetime of the universe].

1.4 Aim of the Work:

This work is concerned with construction new electromagnetic equations which can predict existence of short range electromagnetic force.

1.5 Research Methodology:

a) Using Lagrange and other formalism to derive E.M equations.

b) Construction of E.M equation obtained to find short range force.

c) Solution of E.M equation obtained to find short range force.

d) Comparison the results with experimental and previous studies.

1.6 Presentation of the Research:

This thesis contains four chapters, chapter one introduction, chapter two General Theory of Massive Photon, chapter three The Literature Review and Chapter four different formalism Used to derive Short Range Gravity Potential self Energy and Nonlinear Potential dependent Lorentz transformation also deducing pressure potential dependent Lorentz transformation.

Chapter Two

General Theory of Massive Photon Effect on Maxwell Equations and Lorentz Transformation

2.1 Introduction:

Because classical Maxwellian electromagnetism has been one of the cornerstones of physics during the past century, experimental tests of its foundations are always of considerable interest. Within that context, one of the most important efforts of this type has historically been the search for a rest mass of the photon. The effects of a nonzero photon rest mass can be incorporated into electromagnetic straightforwardly through the Proca equations, which are the simplest relativistic generalization of Maxwell's equations. Using them, it is possible to consider some far-reaching implications of a massive photon, such as variation of the speed of light, deviations in the behavior of static electromagnetic fields, longitudinal electromagnetic radiation and even questions of gravitational deflection. All of these have been studied carefully using a number of different approaches over the past several decades. This review attempts to assess the status of our current knowledge and understanding of the photon rest mass, with particular emphasis on a discussion of the various experimental methods that have been used to set upper limits on it. All such tests can be most easily categorized in terms of terrestrial and extraterrestrial approaches, and the review classifies them as such. Up to now, there has been no conclusive evidence of a finite mass for the photon, with the results instead yielding ever more stringent upper bounds on the size of it, thus confirming the related aspects of Maxwellian electromagnetism with concomitant precision. Of course, failure to find a finite photon mass in any one experiment or class of experiments is not proof that it is identically zero and, even as the experimental limits move more closely towards the fundamental bounds of measurement uncertainty, new conceptual approaches to the task continue to appear. The intrinsic importance of the question and the lure of what might be revealed by attaining the next decimal place are as strong a draw on this question as they are in any other aspect of precise tests of physical laws [18].

Maxwell’s Equations are four of the most influential equations in science: Gauss’s law for electric fields, Gauss’s law for magnetic fields, Faraday’s law, and the Ampere – Maxwell law.

In Maxwell’s Equations, you’ll encounter two kinds of electric field: the electrostatic field produced by electric charge and the induced electric field which produced by a changing magnetic field. Gauss’s law for electric fields deals with the electrostatic field, and you’ll find this law to be a powerful tool because it relates the spatial behavior of the electrostatic field to the charge distribution that produces it [19].

The most important applications of Maxwell equation found on radio, television, radar, wireless Internet access, and Bluetooth technology are a few Examples of contemporary technology rooted in electromagnetic field theory.

In Maxwell equation the photon mass is ordinarily assumed to be exactly zero. However, this is merely a theoretical assumption; there is no experimental evidence to indicate that the photon mass is identically zero. In contrast, there are various experimental methods that have been used to set upper limits on the photon mass. If there is any deviation from zero, it must be very small. Nevertheless, even a small nonzero value would have many consequences in many theories in modern physics. It would mean that we could treat the photon as a particle that is approximately analogous to an electron. Photon mass would imply that the famous C is not a universal constant but instead depends on the photon energy, just as in the case of other particles within nonzero mass. In a related problem, we will study the Lorentz contraction of a rod using the Lorentz transformation equations. We will see how Lorentz transformations can demonstrate, remarkably, that under certain special conditions, length expansion is also possible! The aim of this study is combine all of these components –

photon mass, length variation, and Doppler Effect – to develop a complete special theory of relativity for the photon as a particle.

(2.2) Maxwell equations

The Maxwell equations for $\vec{\boldsymbol{E}}$, $\vec{\boldsymbol{D}}$, $\vec{\boldsymbol{H}}$ and $\vec{\boldsymbol{B}}$ are::

$$\frac{\partial \vec{B}}{\partial t} + \nabla \times \vec{E} = 0 \qquad \text{(Faraday's law)} \qquad (2.2.1)$$

$$\frac{\partial \vec{D}}{\partial t} - \nabla \times \vec{H} = -\vec{J} \qquad \text{(Ampere's law)} \qquad (2.2.2)$$

Coupled with Gauss's law

$$\nabla \cdot \vec{B} = 0 \qquad (2.2.3)$$

$$\nabla \cdot \vec{D} = \rho \qquad (2.2.4)$$

Where $\vec{J}$ *is* the electric current density vector and ρ is the electric charge density. It can be shown that the time derivative of Gauss' law is a consequence of Faraday's

And Ampere's law, *when* $\frac{\partial \rho}{\partial t} + \nabla \cdot \vec{J} = 0$

For linear, homogeneous, isotropic materials (i.e. materials having field-independent, direction-independent and frequency independent electric and magnetic properties) we can relate the magnetic flux density vector $\vec{B}$ to the magnetic field vector $\vec{H}$ and the electric flux density vector $\vec{D}$ to the electric field vector $\vec{E}$ using:

$$\vec{B} = \mu \vec{H} \quad , \quad \vec{D} = \varepsilon \vec{E} \qquad (2.2.5)$$

And also relate the electric current density vector $\vec{J}$ to the electric field vector $\vec{E}$ using the Ohm's law:

$$\vec{J} = \sigma \vec{E} \qquad (2.2.6)$$

We assume σ, ε and μ are given scalar functions of space (in general case they can be also time-dependent). Often one can neglect the conductivity σ and set $\vec{J} = 0$. Such media are called loss-free. A special loss-free medium is free space. ε Is the Dielectric permittivity and μ is the magnetic permeability. Both of these quantities are positive and describe dielectric and magnetic characteristics of the material. In most cases ε and μ are constant within each body. We set $\varepsilon = \varepsilon_0\varepsilon_r$ and $\mu = \mu_0\mu_r$,

where $\mu_0 = 4\pi \cdot 10^{-7}\frac{H}{m}$ and $\varepsilon_0 = \frac{1}{C^2\mu_0}\frac{F}{m}$ are the free space permeability and permittivity respectively (c = 3X10^8 m/sec is a speed of light).

The relative permittivity $\varepsilon_r$and relative permeability $\mu_r$are frequency dependent. However, in this thesis we simplify this and assume that the materials do not have such a dependence, the so-called simple materials. The magnetic permeability μ_r is equal to one for almost all simple materials except magnetic materials which can be considered as perfect electric conductors (PEC). The dielectric permittivity satisfies $\varepsilon_r > 1$. It is discontinuous at the interface between materials and these changes frequently cause significant difficulties for numerical simulations.

(2.2.1) Maxwell equations in various coordinate systems

(2.2.1.1) Cartesian coordinates

$$\varepsilon\frac{\partial E_x}{\partial t} = \frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z} \qquad \mu\frac{\partial H_x}{\partial t} = -\frac{\partial E_z}{\partial y} + \frac{\partial E_y}{\partial z}$$

$$\varepsilon\frac{\partial E_y}{\partial t} = \frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x} \qquad \mu\frac{\partial H_y}{\partial t} = -\frac{\partial E_x}{\partial z} + \frac{\partial E_z}{\partial x} \qquad (2.2.1.1)$$

$$\varepsilon\frac{\partial E_z}{\partial t} = \frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} \qquad \mu\frac{\partial H_z}{\partial t} = -\frac{\partial E_y}{\partial x} + \frac{\partial E_x}{\partial y}$$

For this goal we shall discuss in more detail the one-dimensional Maxwell equations. Then (2.2.1) reduces to

$$\varepsilon\frac{\partial E_z}{\partial t} = \frac{\partial H_y}{\partial x} \qquad \mu\frac{\partial H_y}{\partial t} = \frac{\partial E_z}{\partial x} \qquad (2.2.1.2)$$

(2.2.1.2) Cylindrical coordinates

Maxwell equations in cylindrical coordinates $(\rho, \emptyset, z)$ are given by:

$$\varepsilon\frac{\partial E_\rho}{\partial t} = \frac{1}{\rho}\frac{\partial H_z}{\partial \emptyset} - \frac{\partial H_\emptyset}{\partial z} \qquad \mu\frac{\partial H_\rho}{\partial t} = \frac{\partial E_\emptyset}{\partial z} - \frac{1}{\rho}\frac{\partial E_z}{\partial \emptyset}$$

$$\varepsilon\frac{\partial E_{\emptyset}}{\partial t}=\frac{\partial H_{\rho}}{\partial z}-\frac{\partial H_{z}}{\partial \rho}\qquad \mu\frac{\partial H_{\emptyset}}{\partial t}=\frac{\partial E_{z}}{\partial \rho}-\frac{\partial E_{\rho}}{\partial z}\qquad (2.2.1.2.1)$$

$$\varepsilon\frac{\partial E_{z}}{\partial t}=\frac{1}{\rho}\frac{\partial(\rho H_{z})}{\partial \rho}-\frac{1}{\rho}\frac{\partial H_{\rho}}{\partial \emptyset}\qquad \mu\frac{\partial H_{z}}{\partial t}=\frac{1}{\rho}\frac{\partial E_{\rho}}{\partial \emptyset}-\frac{1}{\rho}\frac{\partial(\rho E_{\emptyset})}{\partial \rho}$$

(2.2.1.3) Spherical coordinates

We write the system of Maxwell equations in spherical coordinates (r,θ,φ):

$$\varepsilon\frac{\partial E_{r}}{\partial t}=\frac{1}{r\sin\theta}\left[\frac{\partial(\sin\theta H_{\varphi})}{\partial\theta}-\frac{\partial H_{\theta}}{\partial\varphi}\right]\qquad \mu\frac{\partial H_{r}}{\partial t}=-\frac{1}{r\sin\theta}\left[\frac{\partial(\sin\theta E_{\varphi})}{\partial\theta}-\frac{\partial E_{\theta}}{\partial\varphi}\right]$$

$$\varepsilon\frac{\partial E_{\theta}}{\partial t}=\frac{1}{r\sin\theta}\left[\frac{\partial(H_{r})}{\partial\varphi}-\frac{1}{r}\frac{\partial(rH_{\varphi})}{\partial r}\right]\qquad \mu\frac{\partial H_{\theta}}{\partial t}=-\frac{1}{r\sin\theta}\frac{\partial E_{r}}{\partial\varphi}+\frac{1}{r}\frac{\partial(rE_{\varphi})}{\partial r}$$

$$\varepsilon\frac{\partial E_{\varphi}}{\partial t}=\frac{1}{r}\left[\frac{\partial(rH_{\theta})}{\partial r}-\frac{\partial H_{r}}{\partial\theta}\right]\qquad \mu\frac{\partial H_{\varphi}}{\partial t}=-\frac{1}{r}\left[\frac{\partial(rE_{\theta})}{\partial r}-\frac{\partial E_{r}}{\partial\theta}\right]\qquad (2.2.1.3.1)$$

In addition to the time dependent Maxwell equations we have Gauss' law, i.e. in the absence of sources both the divergence of $\vec{E}$ and $\vec{H}$ are zero.

$$\mathrm{div}\vec{E}=\frac{1}{r}\frac{\partial(r^{2}E_{r})}{\partial r}+\frac{1}{r\sin\theta}\frac{\partial(\sin\theta\, E_{\theta})}{\partial\theta}+\frac{1}{r\sin\theta}\frac{\partial E_{\varphi}}{\partial\varphi}=0$$

$$\mathrm{div}\vec{H}=\frac{1}{r}\frac{\partial(r^{2}H_{r})}{\partial r}+\frac{1}{r\sin\theta}\frac{\partial(\sin\theta H_{\theta})}{\partial\theta}+\frac{1}{r\sin\theta}\frac{\partial H_{\varphi}}{\partial\varphi}=0\qquad (2.2.1.3.2)$$

(2.2.2) Solutions of Maxwell equations in spherical coordinates system

The general solution can be obtained by separation of variables in the case of azimuthally symmetry. Boundary conditions are easier to apply to these solutions, and their forms highlight the similarities and differences between electric and magnetic cases in both time- independent and time –dependent situations [19].

The Maxwell equations for the electromagnetic field vector, expressed in international system of units (SI) are:

$$\nabla.\boldsymbol{D}=\rho\qquad \nabla\times\boldsymbol{E}=-\frac{\partial\boldsymbol{B}}{\partial t}$$

$$\nabla.\boldsymbol{B}=0\qquad \nabla\times\boldsymbol{H}=J+\frac{\partial\boldsymbol{D}}{\partial t}\qquad (2.2.2.1)$$

Where the source term ρ *and* J describe the densities of electric charge and current, respectively. For a linear isotropic medium D and H are connected with basic field **E** and **B** by the constitutive relations:

$$\boldsymbol{D} = \varepsilon \boldsymbol{E} \qquad \boldsymbol{H} = \frac{\boldsymbol{B}}{\mu} \tag{2.2.2.2}$$

Where ε *and* μ are the permittivity and permeability of the medium respectively.

The boundary conditions for fields at a boundary surface between two different media are:

$$n.(\boldsymbol{D_1} - \boldsymbol{D_2}) = \rho_s \ , \quad n \times (\boldsymbol{E_1} - \boldsymbol{E_2}) = 0$$

$$n.(\boldsymbol{B_1} - \boldsymbol{B_2}) = 0 \ , \quad n \times (\boldsymbol{H_1} - \boldsymbol{H_2}) = \boldsymbol{J_s} \tag{2.2.2.3}$$

Where $\rho_{s,}$ *and* J_s denote charge and current densities, respectively, and the normal unit vector n is drawn from the normal into first region. The interior and exterior fields satisfy the homogeneous vector wave equations:

$$\nabla^2 \boldsymbol{E} - \varepsilon\mu \frac{\partial^2 \boldsymbol{E}}{\partial t^2} = 0$$

$$\nabla^2 \boldsymbol{B} - \varepsilon\mu \frac{\partial^2 \boldsymbol{B}}{\partial t^2} = 0, \tag{2.2.2.4}$$

Which are obtained from equations (2.2.2.1) and (2.2.2.4) for regions free of charge and current by combining the two curl equations and making use of the divergence equation together with this vector identity.

$$\nabla^2(\ \ ) = \nabla(\nabla.) - \nabla \times (\nabla \times \ \ ). \tag{2.2.2.5}$$

Changes in the electromagnetic fields propagate with speed $v = \frac{1}{\sqrt{\varepsilon\mu}}$

Without any loss of generality, we may consider only harmonic time dependence for sources and fields:

$$\rho(r,t) = \rho(r)e^{-iwt} \qquad J(r,t) = J(r)e^{-iwt}$$

$$E(r,t) = E(r)e^{-iwt} \qquad B(r,t) = B(r)e^{-iwt} \tag{2.2.2.6}$$

Where the real part of each expressions is implied. Equation (2.2.2.4) then becomes time independent.

$$\nabla^2 \boldsymbol{E} + K^2 \boldsymbol{E} = 0, \qquad \nabla^2 \boldsymbol{B} + K^2 \boldsymbol{B} = 0, \qquad (2.2.2.7)$$

Where $K^2 = \varepsilon\mu\omega^2$ .these are vector Helmholtz equations for transverse fields having zero divergence

Actually, the usual technique for solving boundary value problems introduces the electromagnetic potentials as intermediary field quantities. These are defined by equation (2.2.2.5):

$$\boldsymbol{B} = \nabla \times \boldsymbol{A}, \qquad \boldsymbol{E} = -\nabla\emptyset - \frac{\partial \boldsymbol{A}}{\partial t} \qquad (2.2.2.8)$$

With subsidiary Lorentz conditions

$$\nabla . \boldsymbol{A} + \varepsilon\mu \frac{\partial \emptyset}{\partial t} = 0 \qquad (2.2.2.9)$$

It is then found that these potentials satisfy the inhomogeneous wave +equations:

$$\nabla^2 \emptyset - \varepsilon\mu \frac{\partial^2 \emptyset}{\partial t^2} = \frac{\rho}{\varepsilon}$$

$$\nabla^2 \boldsymbol{A} - \varepsilon\mu \frac{\partial^2 \boldsymbol{A}}{\partial t^2} = -\mu J \qquad (2.2.2.10)$$

Which together with the Lorentz condition form a set of equations equivalent to the Maxwell equations. The boundary conditions for the potentials may be deduced from equation (2.2.2.3).

For fields that vary with an angular frequency ω,

$$\emptyset(x,t) = \emptyset(x)e^{-i\omega t}, \boldsymbol{A}(x,t) = \boldsymbol{A}(x)e^{-i\omega t}, \qquad (2.2.2.11)$$

We get equations that do not depend on time in regions free of charge and current:

$$\nabla^2 \emptyset + K^2 \emptyset = 0, \qquad \nabla^2 \boldsymbol{A} + K^2 \boldsymbol{A} = 0, \qquad (2.2.2.12)$$

The purpose of this work is to get general solutions of the electromagnetic vector equations in spherical coordinates with azimuthally symmetry using separation of variables in spite of having equations that mix field components.

The work is organized as follows in section 2 we describe the method for the static case showing how the mathematical complications of solving the vector field equations are easily overcome by means of separation of variables. In section 3 we extend the method to discuss the case of time –varying fields and concluding remark are given in sec 4.

(2.2.2.1) Static fields

For steady – state electric and magnetic phenomena, the fields outside sources satisfy the vector Laplace equations

$$\nabla^2 \boldsymbol{E} = 0, \qquad \nabla^2 \boldsymbol{B} = 0 \qquad (2.2.2.1.1)$$

Where only transverse components with zero divergence are involved. Supposing all the charge and current are on the boundary surfaces, solutions in different regions can be connected through the boundary conditions indicated in equation3. To demonstrate the features of treatment, we first consider boundary value problems with azimuthally symmetry in electrostatics. The solution of stationary current problems in magneto statics is mathematically identical

Combining the expression for $\nabla \times (\nabla \times \boldsymbol{E})$=0 and $\nabla . \boldsymbol{E} = 0$ is spherical coordinates and assuming no $\emptyset$ dependence, we find using eq. (5) that the components of the electric field E_r and E_θ satisfy the equations

$$(\nabla^2 \boldsymbol{E})r = \frac{1}{r^2}\frac{\partial^2}{\partial r^2}(r^2 E_r) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta \frac{\partial E_r}{\partial \theta}\right) = 0 \qquad (2.2.2.1.2)$$

$$(\nabla^2 E)\theta = \frac{1}{r}\frac{\partial^2}{\partial r^2}(rE_\theta) - \frac{1}{r}\frac{\partial^2 (E_r)}{\partial r \partial \theta} = 0 \qquad (2.2.2.1.3)$$

Equation $(2.2.2.1.2)$is for E_r alone, whereas eq. $(2.2.2.1.3)$. Which is involves both components. There is also a separated equation forE_φ:

$$(\nabla^2 \mathrm{E})\varphi = \frac{1}{\mathrm{r}}\frac{\partial^2}{\partial \mathrm{r}^2}(\mathrm{rE_r}) + \frac{1}{\mathrm{r}^2 \sin\theta}\frac{\partial}{\partial\theta} \times \left(\sin\theta \frac{\partial \mathrm{E}_\varphi}{\partial\theta}\right) - \left(\frac{1}{\mathrm{r}^2 \sin\theta}\mathrm{E}_\varphi\right) = 0 \qquad (2.2.2.1.4)$$

Using the transverse condition

$$\nabla . \mathbf{E} = \frac{1}{\mathrm{r}^2}\frac{\partial}{\partial \mathrm{r}}(\mathrm{r}^2 \mathrm{E_r}) + \frac{1}{\mathrm{r}\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\, \mathrm{E}_\theta) = 0 \qquad (2.2.2.1.5)$$

Where the azimuthally symmetry is assumed in Eqs.$(2.2.2.1.5)$ To be implies:

$$\frac{\partial}{\partial r}(rE_\theta) - \frac{\partial E_r}{\partial \theta} = 0 \qquad (2.2.2.1.6)$$

Thus, to obtain E_θ from E_r we can consider either eq. (2.2.2.1.5) Or Eqs (2.2.2.1.6).

Now, in order to solve eq. (2.2.2.1.1) For E_r ,we refer to the method of separation of variables and write the product form

$$E_r(r,\theta) = \frac{u(r)}{r^2}P(\theta), \qquad (2.2.2.1.7)$$

This leads to the following separated differential equations

$$\frac{d^2u}{dr^2} - \frac{n(n+1)}{r^2}u = 0 \qquad (2.2.2.1.8)$$

$$\frac{1}{\sin\theta}\frac{d}{d\theta}\left(\sin\theta\frac{dP}{d\theta}\right) + n(n+1)P = 0 \qquad (2.2.2.1.9)$$

Where n(n+1) is separation constant. The solution of Eqs. (2.2.2.1.7)) is:

$$u(r) = ar^{n+1} + \frac{b}{r^n} \qquad (2.2.2.1.10)$$

Where a and b are arbitrary constant. Equations (2.2.2.1.9) is the Legendre equation of order n and the only solution which is single valued, finite and continuous over whole interval corresponds to Legendre polynomial $P_n(\cos\theta)$, n being restricted to positive integer values.

Thus the general solution for E_r is

$$E_r(r,\theta) = \sum_{n=0}^{\infty}\left(a_n r^{n-1} + \frac{b_n}{r^{n+2}}\right)P_n(\cos\theta). \qquad (2.2.2.1.11)$$

The simplest way of solving Equation(2.2.2.1.2)for E_θ is to use the series expansion

$$E_\theta(r,\theta) = \sum_{n=0}^{\infty} v_n(r)\frac{d}{d\theta}P_n(\cos\theta) \qquad (2.2.2.1.12)$$

Where $v_n(r)$ are functions to be determined. By substituting Equation (2.2.2.1.11), (2.2.2.1.12) into Equation (2.2.2.1.2). It is formed that.

$$v_n(r) = \frac{a_n}{n}r^{n-1} - \frac{b_n}{n+1}\frac{1}{r^{n+2}} \qquad (2.2.2.1.13)$$

For n≥ 1 $a_0 = 0$ this null factor in Eqs.(2.2.2.1.11) . Means the absence of static field terms of the $\frac{1}{r}$ type which are in reality typical of radiative fields. Clearly the solution gives in Eqs(2.2.2.1.11)),((2.2.2.1.12)) and (2.2.2.1.13)satisfy Eq(2.2.2.1.6)). The coefficients a_n *and* b_n are to be determined from the boundary condition.

For completeness we include here the well-behaved general solution of Eqs.(2.2.2.1.13):

$$E_\varphi(r,\theta) = \sum_{n=0}^{\infty}\left(c_n r^n + \frac{d_n}{r^{n+2}}\right)\frac{d}{d\theta}P_n(\cos\theta) \qquad (2.2.21.14)$$

Thus Eqs. (2.2.2.1.11)(2.2.2.1.14) give all three components of the electric field. The same type of equations applies in magneto static. However, the boundary conditions of Eqs.(2.2.2.1.3) will make the difference, implying in particular that $b_{n=0}$ in the series expansion of Eq,s(2.2.2.1.11)in magneto static , this being primarily related to the absence of magnetic monopole.

(2.2.2.2) time-varying fields

By using Eqs. (2.2.2.1.1),(2.2.2.1.2) and (2.2.2.1.6)it is seen that outside sources the fields are related by

$$\boldsymbol{E} = \frac{i\omega}{K^2}\nabla\times\boldsymbol{B} \qquad (2.2.2.2.1)$$

So that we only need to solve Eq.(2.2..1.7) for **B**. alternatively, we can solve for **E** and obtain **B** through the expression

$$\boldsymbol{B} = -\frac{i}{\omega}\nabla\times\boldsymbol{E} \qquad (2.2.2.2.2)$$

In the following, we choose to deal with the Helmholtz equations for the magnetic induction field. the reason to exhibit similarities and difference with the static case treated in sec(2.2.2.1.1).

In the case of spherical boundary surfaces with azimuthally symmetry, the $\boldsymbol{B_r}$ and $\boldsymbol{B_\theta}$ components of the magnetic induction satisfy the following equations:

$$(\nabla^2 B)r + K^2 B_r \quad = \frac{1}{r^2}\frac{\partial^2}{\partial r^2}(r^2 B_r) + \frac{1}{r^2 \sin\theta} \times \frac{\partial}{\partial\theta}\left(\sin\theta \frac{\partial B_r}{\partial\theta}\right) + K^2 B_r = 0 \quad (2.2.2.2.3)$$

$$(\nabla^2 B)\theta + K^2 B_\theta = \frac{1}{r}\frac{\partial^2}{\partial r^2}(rB_\theta) - \frac{1}{r}\frac{\partial^2 B_\theta}{\partial r \partial\theta} + K^2 B_\theta = 0 \quad (2.2.2.2.4)$$

Similarly for the B_φ component we would have the equation:

$$(\nabla^2 B)\varphi + K^2 B_\varphi = \frac{1}{r}\frac{\partial^2}{\partial r^2}(rB_\varphi) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial\theta} \times \left(\sin\theta \frac{\partial B_\varphi}{\partial\theta}\right) - \frac{1}{r^2 \sin\theta^2} B_\varphi + K^2 B_\varphi = 0 \quad (2.2.2.2.5)$$

These are analogous to equations (2.2.2.1.2)), (2.2.2.1.3)and (2.2.2.1.4)in connection with the vector Laplace equation. In order to solve Eq (2.2.2.2.3)we let

$$B_r(r,\theta) = \frac{j(r)}{r} P(\theta), \quad (2.2.2.2.6)$$

Where upon separation yields

$$\frac{d^2 j}{dr^2} + \frac{2}{r}\frac{dj}{dr} + \left[K^2 - \frac{n(n+1)}{r^2}\right] = 0 \quad (2.2.2.2.7)$$

Equation (2.2.2.2.7) is the spherical Bessel equation of order n with variable kr. therefore, the general solution for B_r is

$$B_r(r,\theta) = \sum_{n=0}^{\infty}\left[a_n \frac{j_n(kr)}{r} + b_n \frac{n_n(kr)}{r}\right] P_n(\cos\theta) \quad (2.2.2.2.8)$$

Depending on boundary conditions, the spherical Henkel function h_n instead of the spherical Bessel function j_n , n_n may be used. For B_θ and we again write

$$B_\theta(r,\theta) = \sum_{n=0}^{\infty} w_n(r) \frac{d}{d\theta} P_n(\cos\theta), \quad (2.2.2.2.9)$$

And use $\nabla . B = 0$ to obtain now

$$w_n = \frac{a_n}{n(n+1)r}\frac{d}{dr}[rj_n(kr)] + \frac{b_n}{n(n+1)r}\frac{d}{dr}[rn_n(kr)] \quad (2.2.2.2.10)$$

For $n \geq 1$ with $a_0 = b_0 = 0$. The other coefficient $a_n$andb_n are determined so that the boundary conditions for the vector field are exactly satisfied. In the case of B_φ component the general solution is

$$B_\varphi(r,\theta) = \sum_{n=0}^{\infty}\left(c_n j_n(Kr) + d_n n_n(Kr)\right)\frac{d}{d\theta}P_n(\cos\theta), \qquad (2.2.2.2.10)$$

The same type of equations applies for the electric field.

(2.3)The photon mass

The photon is a very mysterious quantic phenomenon, moving as a wave, but appearing as a particle. It is a boson with spin one and rest mass either zero, or extremely small, it carries energy, it has a frequency (in a given referential) and presents phenomena of polarization. If we assume a very small but non-zero rest mass, the photon goes slower than the limit velocity c and we can study it in the referential in which it is at rest. In such referential and in vacuum the basic hypothesis is that all photons are identical. In the other referential, according to their velocity, they present frequency and energy that can be studied by the usual Lorentz transformations that will be our main tool. We will see that if photons have a non-zero rest mass they have also a well defined proper period and thus the phenomenon of photon can perhaps be associated to vibrations or rotations, which fit particularly well with the property of polarization and the different possible presentations of a rotating phenomenon [18].

In this section existence of photon mass is proven with using different models.

(2.3.1) General theory of massive photon electromagnetism

Electromagnetic phenomena in vacuum are characterized by two three-dimensional vector fields, the electric and magnetic fields, ***E(x, t)*** and ***B(x, t)***, which are subject to Maxwell's equations and which can also be thought of as the classical limit (limit in large quantum numbers) of a quantum mechanical description in terms of photons. The photon mass is ordinarily assumed to be exactly zero in Maxwell's electromagnetic field theory, which is based on gauge invariance. If gauge invariance is abandoned, a mass term can be added to the

Lagrangian density for the electromagnetic field in a unique way (Greiner and Reinhardt 1996):

$$L = \frac{1}{4\mu_0} F_{\mu v} F^{\mu v} - J_{\mu v} A^{\mu} + \frac{\mu_\gamma^2 A_\mu A^\mu}{2\mu_0} \qquad (2.3.1.1)$$

where μ_γ^{-1} is a characteristic length associated with the photon rest mass, $A\mu$ and $j\mu$ are the four-dimensional vector potential $(\boldsymbol{A}, i\varphi/c)$ and four-dimensional vector current density $(\boldsymbol{J}, ic\rho)$, with φ and $\boldsymbol{A}$ denoting the scalar and vector potentials, and ρ and $\boldsymbol{J}$ are the charge and current densities, respectively. $\boldsymbol{\mu_0}$ is the permeability constant of free space and $F\mu v$ is the antisymmetric field strength tensor. It is connected to the vector potential through

$$F_{\mu v} = \frac{\partial A_v}{\partial x_\mu} - \frac{\partial A_\mu}{\partial x_v} \qquad (2.3.1.2)$$

The variation of Lagrangian density with respect to $A\mu$ yields the Proca equation (Proca 1930a,b,c, 1931, 1936a,b,c,d, 1937, 1938, de Broglie 1940):{175-189].

$$\frac{\partial F_{\mu v}}{\partial x_v} + \mu_\gamma^2 A_\mu = \mu_0 J_\mu \qquad (2.3.3)$$

Substituting equation (2.3.1..2) into (2.3.1.3), we obtain the wave equation of the Proca vector field Aμ:

$$(\square - \mu_\gamma^2) A_\mu = -\mu_0 J_\mu \qquad (2.3.1.4)$$

Where the d'Alembertian symbol □ is shorthand for $\nabla^2 - \partial^2/\partial(ct)^2$. In free space,

Equation (2.3.1.4) reduces to

$$(\square - \mu_\gamma^2 A_\mu) = 0 \qquad (2.3.1.5)$$

Which is essentially the Klein–Gordon equation for the photon? The parameter μ_γ could be interpreted as the photon rest mass m_γ , with

$$m_\gamma = \frac{\mu_\gamma \hbar}{C} \qquad (2.3.1.6)$$

With this interpretation, the characteristic scaling length μ_γ^{-1} becomes the reduced Compton wavelength of the photon, which is the effective range of the electromagnetic interaction. An additional point is that static electric and magnetic fields would exhibit exponential damping governed by the term exp $(\mu_\gamma^{-1} r)$ if the photon is massive instead of mass less. Therefore, a finite photon mass is accommodated in a unique way by changing the inhomogeneous Maxwell's equations to the Proca equations. In the presence of sources ρ and $\boldsymbol{J}$, the three-dimensional versions of the Proca equations can be written in SI units as

$$\nabla \cdot E = \frac{\rho}{\varepsilon_0} - \mu_\gamma^2 \emptyset \tag{2.3.1.7}$$

$$\nabla \times E = -\frac{\partial B}{\partial t} \tag{2.3.1.8}$$

$$\nabla \cdot B = 0 \tag{2.3.1.9}$$

$$\nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t} - \mu_\gamma^2 A \tag{2.3.1.10}$$

Together with

$$B = \nabla \times A \tag{2.3.1.11}$$

$$E = -\nabla \emptyset - \frac{\partial A}{\partial t} \tag{2.3.1.12}$$

And Lorentz condition

$$\nabla \cdot A + \frac{1}{C^2}\frac{\partial \emptyset}{\partial t} = 0 \tag{2.3.1.13}$$

where ε_0 and μ_0 are the permittivity and permeability of free space, respectively. The Proca equations provide a complete and self-consistent description of electromagnetic phenomena. The equation for conservation of charge is obtained from equations (2.3.1.7) and (2.3.1.10) and the Lorentz condition (2.3.1.13), so that

$$\nabla \cdot J + \frac{1}{C^2}\frac{\partial \rho}{\partial t} = 0 \tag{2.3.1.14}$$

Obviously, in massive photon electromagnetism, the Lorentz condition is identical to the law of charge conservation, or in other words, the Lorentz condition is a necessary result of charge conversation. Similarly, from equations

(2.3.1.9), (2.3.1.10), (2.3.1.12) and (2.3.1.13), the equation for conservation of energy can be written as

$$\nabla \cdot S + \frac{1}{C^2}\frac{\partial w}{\partial t} = -J.E \qquad (2.3.1.15)$$

Where the Poynting vector, ***S***, represents the energy flow density and *w* is the energy density of the electromagnetic field (de Broglie 1940, Bass and Schrödinger 1955, Burman 1972a):

$$S = \frac{1}{\mu_0}\left(E \times B + \mu_\gamma^2 \emptyset A\right) \qquad (2.3.1.16)$$

And

$$w = \frac{1}{2}\left(\varepsilon_0 E^2 + \frac{1}{\mu_0}B^2 + \varepsilon_0 \mu_0^2 \emptyset^2 + \frac{1}{\mu_0}\mu_\gamma^2 A^2\right) \qquad (2.3.1.17)$$

In a Proca field, obviously, the potentials themselves have physical significance; it does not arise just through their derivatives. The scalar potential φ and the vector potential ***A*** described by the Proca equations are observable since the potentials acquire energy density $\varepsilon_0 \mu_0^2 \emptyset^2/2$ and $\frac{1}{2\mu_0}\mu_\gamma^2 A^2$ respectively. Phase invariance (*U*(1) invariance) is lost in Proca theory, but the Lorentz gauge is automatically held, and this is indispensable to charge conservation, i.e. the Lorentz condition becomes a condition of consistency for the Proca field. As a consequence, the field equation takes the form of equation (2.3.1.4). However, if $m_\gamma = 0$, the Proca equations

would reduce smoothly to Maxwell’s equations. The theoretical problem of describing the photon is profound and difficult, and the arguments presented can often be speculative and controversial. There is a huge literature on this topic and the articles in it vary widely in their scope of investigation. A number of the more well-known works in this area include (Feynman 1949, Coester 1951, and Feldman and Matthews 1963, Strocchi 1967, Chakravorty 1985, Masood 1991, Mendon¸ca et al 2000). Although the theoretical problem is an area of great interest, it is not our objective here to dwell on it, but rather to touch only on those fundamental principles that can help shed light on the experimental consequences of a nonzero photon rest mass.

(2.3.2) the dispersion of light

The most direct consequence of a finite photon mass is frequency dependence in the velocity of electromagnetic waves propagating in free space. From the Proca equations, the electric and magnetic fields in free space are given by

$$,A_v \sim \exp[i(k.r - wt)] \qquad (2.3.2.1)$$

where the wave vector ***k***, the angular frequency *ω* and the rest mass μ_γ(note that here and in what follows, the rest mass of the photon μ_γ has units of reciprocal length (wave numbers), which is related to the mass m_γ in grams by equation (2.3.1.6), i.e. 1 cm−1 ≡ 3.5 × 10−38 g ≡ 2.0 × 10−5 eV) satisfy the Klein–Gordon equation,

$$k^2C^2 = w^2 - \mu_\gamma^2 C^2 \qquad (2.3.2.2)$$

The phase velocity and the group velocity (the velocity of energy flow) of a free massive wave would then take the form

$$u = \frac{w}{k} = C\left(1 - \frac{\mu_\gamma^2 C^2}{w^2}\right)^{\frac{-1}{2}} \approx C\left(1 + \frac{\mu_\gamma^2 C^2}{2w^2}\right) \qquad (2.3.2.3)$$

$$v_g = \frac{dw}{dk} = C\left(1 - \frac{\mu_\gamma^2 C^2}{w^2}\right)^{\frac{1}{2}} \approx C\left(1 - \frac{\mu_\gamma^2 C^2}{2w^2}\right) \qquad (2.3.2.4)$$

Where $k = |\boldsymbol{k}| = 2\pi\lambda^{-1}$ with *λ* being the wavelength. Because of the nonzero photon mass, the dispersion produces frequency dependence, and the group velocity will differ from the phase velocity. In the Proca equations, *c* becomes the limiting velocity as the frequency approaches infinity.

For two wave packets with different propagating frequencies (denoted by ω_1 and ω_2, and assuming $\omega_1 > \omega_2 \gg \mu_\gamma C$), the velocity differential between them is given by

$$\frac{\Delta v}{C} = \frac{v_{g1} - v_{g2}}{C} = \frac{\mu_\gamma^2 C^2}{2}\left(\frac{1}{w_2^2} - \frac{1}{w_1^2}\right) + 0\left[\left(\frac{\mu_\gamma^2 C^2}{w_1^2}\right)^2\right]$$

$$= \frac{\mu_\gamma^2}{8\pi^2}(\lambda_2^2 - \lambda_1^2)$$

$$+ 0\left[\left(\mu_\gamma \lambda_1\right)^4\right] \qquad (2.3.2.5)$$

If the two waves move through the same distance *L*, the time interval between their arrivals is expressed as

$$\Delta t = \frac{L}{v_{g1}} - \frac{L}{v_{g2}} = \frac{L}{8\pi^2 C}(\lambda_2^2 - \lambda_1^2)\mu_\gamma^2 \qquad (2.3.2.6)$$

in which the terms of order higher than $\left(\mu_\gamma \lambda_1\right)^4$ are neglected. Equations (2.3.2.4)–(2.3..2.6) are the starting points for detecting a dispersion effect due to the photon rest mass in both the terrestrial and extra-terrestrial approaches.

(2.3.3) Gravitational deflection of massive photons

In 1973, Lowenthal proposed a method for setting limits on the photon mass by exploiting the gravitational deflection of electromagnetic radiation. As is well-known, the theory of general relativity predicts a deflection of starlight by the Sun of 1.75 arcsec (Hawking 1979). If the photon has a nonzero rest mass, this deflection angle would become

$$\theta = \theta_0\left(1 + \frac{m_\gamma^2 C^4}{2h^2 C^2}\right) \qquad (2.3.3.1)$$

where $\theta_0 = 4MG/Rc^2$ is the deflection angle for a mass less photon ,*M* is the solar mass ,*G* the Newtonian gravitational constant, *R* the photon impact parameter (normally the solar radius), and hv the photon energy. Lowenthal set the correction term $\Delta = \theta_0\,(m^2_\gamma\, c^4)/(2h^2v^2)$ equal to the difference between the measured deflection angle and the deflection angle calculated for photons with zero rest mass. By so doing, an expression setting an upper limit on the photon mass could be written as

$$m_\gamma^2 \leq \frac{hv}{C^2}\sqrt{\frac{2\Delta}{\theta_0}} \qquad (2.3.3.2)$$

Using the above equation and the data available at the time on the deflection of electromagnetic radiation by the Sun, Lowenthal considered three cases and obtained: (1) for visible light, $m_\gamma < 1 \times 10^{-33}$ g with $v = 5 \times 10^{15}$ Hz and $\Delta \approx 0.1$ arcsec; (2) for radio source 3C 270, $m_\gamma < 7 \times 10^{-40}$ g with $v = 3 \times 10^{9}$ Hz and _ ≈ 0.1 arcsec; (3) for intercontinental baseline interferometry, a promising limit would be $m_\gamma < 7 \times 10^{-41}$ g if the deflection measurement at radio frequencies could be improved to 0.001 arcsec. Recently, Accioly and Paszko (2004) analyzed the energy-dependent deflection of a massive photon by an external gravitational field and arrived at the same expressions for setting limits on the photon mass as found in equation (2.3.3.1). Using the best measurement of the deflection of radio waves by the gravitational field of the Sun ($\approx 1.4 \times 10^{-4}$ arcsec) and the lowest frequency employed by radio astronomers (≈2 GHz), they found a limit of $m_\gamma < 10^{-40}$ g. The values of m_γ derived from gravitational deflection are considerably weaker than the other bounds obtained recently, and this method for setting limits on the photon mass is, in principle, less precise than the approaches that directly measure the dispersion of light passing through interstellar space (Lowenthal 1973). Even so, the method is an interesting independent approach and its presentation adds to the evidence restricting the size of the photon mass.

(2.3.4)The Yukawa potential in static fields

The next effect we discuss regarding massive photons arises in static fields. For a static electric field (the case of a static magnetic field $\partial/\partial t = 0$) and the wave equation reduces to

$$\left(\nabla^2 - \mu_\gamma^2\right)\emptyset = -\frac{\rho}{\varepsilon_0} \quad (2.3.4.1)$$

For a point charge ρ(r) = Q δ(r), yields a Yukawa or Debye type of potential,

$$\emptyset(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}exp\left(-\mu_\gamma r\right) \quad (2.3.4.2)$$

And the electric field becomes

$$E(r) = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{r^2} + \frac{\mu_\gamma}{r}\right)exp\left(-\mu_\gamma r\right) \quad (2.3.4.3)$$

Inspection of equations (3.8) and (3.9) shows that if $r \ll \mu_\gamma^{-1}$ the inverse square law is indeed a good approximation, but if $r \gg \mu_\gamma^{-1}$ then the law departs drastically from the predictions of Maxwell's equations. (Analogously, in plasma, the static scalar potential does have a Debye form,

$$\emptyset(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}exp(-\mu_D r) \quad (2.3.4.4)$$

Where $\mu_D = \sqrt{\frac{ne^2}{\varepsilon_0 T}}$the inverse Debye shielding distance, n is is the plasma density and T (in joules) is the plasma temperature. Likewise, in a superconductor, a static magnetic field obeys

$$(\nabla^2 - \mu_L^2)B = 0 \quad (2.3.4.5)$$

Where $\mu_\gamma = \frac{w_p}{c}$ is the London skin depth, with $w_p = \sqrt{\frac{ne^2}{\varepsilon_0\, me}}$ denoting the electron plasma frequency)? So the static fields would be characteristic of exponential decay with a range $\mu_\gamma{}^{-1}$ the exponential deviation from Coulomb's law and its magnetic analogue in Ampere's law provide many sensitive approaches to test for a photon rest mass in laboratory Experiments.

(2.3.5) Effect of massive photon on the static electric field

Once the photon is provided with a finite mass, three immediate consequences may be deduced from the Proca equations: the frequency dependence of the velocity of light propagating in free space; the third state of the polarization direction, namely the 'longitudinal photon'; and some modifications in the characteristics of classical static fields. All those effects are useful approaches for laboratory experiments and Cosmological observations to determine the upper bound on the photon mass.

So the most interest in this section is the effect of a massive photon in a static electric field. In the case of a massive photon, the wave equation will be modified for all potentials (including the Coulomb potential) in the form

$$\left(\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2} - \mu_\gamma\right)\emptyset = -\rho/\varepsilon_0 \qquad (2.3.5.1)$$

For a point charge and in the static case, this yields a Yukawa type potential,

$$\emptyset(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}\exp(-\mu_\gamma r) \qquad (2.3.5.\ 2)$$

and the electric field

$$E(r) = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{r^2} + \frac{\mu_\gamma}{r}\right)\exp(-\mu_\gamma r) \qquad (2.3.5.3)$$

The 1924 de Broglie Einstein equations for photon mass are derived from Cartan geometry within the context of ECE theory. The latter produces the 1934 Proca wave equation straightforwardly, the main counter example to the obsolete twentieth century physics because it is not gauge invariant and signals the existence of finite photon mass, a counter example to the Higgs boson. The cosmological red shift is derived straightforwardly from the de Broglie Einstein equations as an implication of photon mass without an expanding cosmology. The photon mass is derived for the first time using light deflection by gravitation calculated with a Planck distribution for one photon, giving a consistent result.

Compton scattering theory is worked out with finite photon mass, giving another method of measuring the mass. The de Broglie Einstein equations of 1923 and 1924 [29- 30] used the concept of photon mass to lock together the Planck theory of the photon as quantum of energy and the theory of special relativity. Louis de Broglie quantized the photon momentum, producing wave particle

dualism. His papers of 1923 and 1924 led directly to the inference of the Schrödinger equation. Recently,photon mass has been shown to be responsible for light deflection and time change due to gravitation, the obsolete methods of calculating these were shown to be incorrect. This is an example of a pattern in which ECE theory has made the old physics entirely obsolete [31-40]. In this paper it is emphasized that finite photon mass is the main counter example to the standard model of physics, so called. This standard model was based to a large extent on the arbitrary and experimentally false assumption that the mass of the photon is identically zero. Unsurprisingly, this idea produces many well known problems, notably in canonical quantization of the electromagnetic field [31] and in gauge theory [32]. It is well known that the 1934 Proca equation [43] for finite photon mass is not gauge invariant, meaning that the use of a U(1) sector symmetry and Higgs mechanism is incompatible with finite photon mass. It follows that standard electroweak theory and standard attempts at a unified field theory are incompatible with photon mass, and in consequence that it is futile to search for a Higgs boson. Standard model
unified field theory is bound to fail, it is a mixture of false assumptions. The Higgs boson does not exist because of finite photon mass. The latter implies that there is a cosmological red shift without an expanding universe. This red shift is derived in Section 2 directly from the original 1924 de Broglie Einstein equations without any further assumption. The de Broglie Einstein equations are derived straightforwardly in Section 2 from Cartan geometry in the context of ECE theory

In Section 3, the existence of photon mass is proven with light deflection due to gravitation using the Planck distribution for one photon. The result is consistent with a photon mass of about 10-51 kg for a light beam heated to about 2,500 K as it grazes the Sun. This result proves the existence of photon mass for the first time. All previous estimates of photon mass are given as a value less than an upper bound, the best estimate [44] of the upper bound being of the order of 10-

52 kg, close to the value obtained in this paper from light deflection due to gravitation.

In Section 4 the simplest type of Compton scattering theory is developed using Finite photon mass, showing that photon mass is observable in principle with Compton scattering and other types of particle scattering. Photon mass works its way through into all the experiments that signals the onset of quantum theory [45], notably black body radiation, specific heats, Compton scattering, the photoelectric effect, and atomic and molecular spectra.

Finally one conclude that gives some development of the Proca wave and field equations to show that there exists a potential of space time itself because of the existence of photon mass. This potential exists in the absence of any other type of mass, notably electron mass. This potential can be amplified by spin connection resonance to produce electric power from space time.

(2.3.6) Photon mass and the cosmological red shift.

The de Broglie Einstein equations are the classical limit of the Proca wave equation of special relativistic quantum mechanics. The Proca equation has been shown in this series [31-40] to be itself the limit of the ECE wave equation of generally covariant quantum mechanics, the long sought unification of general relativity and quantum mechanics. The ECE equation of quantum electrodynamics [31-40] is:

$$(\square^2 + R)A^a_\mu = 0 \qquad (2.3.6.1)$$

Where R is a well defined scalar curvature and where $\square^2 = \frac{\nabla^2 - \partial^2}{\partial (ct)^2}$ d' Alembert an. and

$$A^a_\mu = Aq^a_\mu \qquad (2.3.6.2)$$

Here A is a scalar potential magnitude and q^a_μ is the Cartan tetrad [31-40]. Equation (2.3.2.1) reduces to the 1934 Proca equation [43] in the limit:

$$R \rightarrow \left(\frac{mC}{h}\right)^2 \tag{2.3.6.3}$$

Where m is the mass of the photon, c is a universal constant and ħ is the reduced Planck constant. Note carefully that c is not the velocity of the photon of mass m. In the photon mass theory of de Broglie [29, 30], c is the maximum speed attainable in the theory of relativity. The old physics ignored the de Broglie Einstein theory and asserted erroneously that c is the speed of light in a vacuum. By habit this verbiage became accepted uncritically, an example of Langmuir´s scientific pathology, the acceptance of dogma instead of fact.

Eq. (2.3.6.1) in the classical limit is the Einstein energy equation:

$$P^\mu P_\mu = m^2C^2 \tag{2.3.6.4}$$

Where

$$P^\mu = \left(\frac{E}{C}\right) \tag{2.3.6.5}$$

and where m is the mass of the photon. Here E is the relativistic energy:

$$E = \gamma mC^2 \tag{2.3.6.6}$$

And _P is the relativistic momentum:

$$P = \gamma m v_g \tag{2.3.6.7}$$

The factor γ is the result of the Lorentz transform [31 -40] and was denoted by de Broglie [29, 30] as:

$$\gamma = \left(1 - \frac{v_g^2}{C^2}\right)^{\frac{-1}{2}} \tag{2.3.6.8}$$

Where $\boldsymbol{v}_g$ is the group velocity;

$$v_g = \frac{\partial w}{\partial k} \tag{2.3.6.9}$$

The de Broglie Einstein equations are:

$$P^\mu = \hbar k^\mu \tag{2.3.6.10}$$

Where the four wave numbers are:

$$k^{\mu} = \left(\frac{w}{c}.\mathbf{k}\right) \qquad (2.3.6.11)$$

Eq. (2.3.2.10)is a logically inevitable consequence of the Planck theory of the energy. Quantum of light later called “the photon”, published in 1901 [44], and the theory of special relativity [31 - 40, 45]. The standard model has attempted to reject the inexorable logic of Eq. (2.3.6.10)by rejecting m. This is illogical and fallacious, delaying and greatly damaging the progress of natural philosophy. In retrospect it is farcical to reject the particle in wave particle duality, which the standard model accepts at the same time as rejecting m. Eq. (2.3.2.10) can be written out as:

$$E = \hbar w = \gamma m v_g \qquad (2.3.6.12)$$

And

$$P = \hbar k = \gamma m v_g \qquad (2.3.6.13)$$

In his original papers of 1923 and 1924 [29, 30] de Broglie defined the velocity in the Lorentz transform as the group velocity [40], which is the velocity of the envelope of two or more waves. For two waves:

$$v_g = \frac{\Delta w}{\Delta k} = \frac{w_2 - w_1}{k_2 - k_1} \qquad (2.3.6.14)$$

And for many waves, Eq. (2.3.6.9) applies. The phase velocity (+ was defined by de Broglie [29, 30] as:

$$v_p = \frac{E}{P} = \frac{w}{k} \qquad (2.3.6.15)$$

The phase velocity is the average velocity of the waves in a wave packet. It follows that:

$$v_g v_p = c^2 \qquad (2.3.6.16)$$

This is an equation independent of the Lorentz factor γ, and universally valid. The standard model makes the arbitrary and fundamentally erroneous assumptions:

$$m = ?\ 0 \quad , v_g = v_p = ?\ c \tag{2.3.6.17}$$

If there were no "standard model", these assumptions would be considered to be ludicrous, revealing the extent to which imposed pathology has supplanted science in the twentieth century.

In physical optics [42] the phase velocity is defined by:

$$v_p = \frac{w}{k} = \frac{C}{n} \tag{2.3.6.18}$$

Where n (w) is the frequency dependent refractive index, in general a complex quantity.

The group velocity in physical optics is [42]:

$$v_g = C\left(n + w\frac{dn}{dw}\right)^{-1} \tag{2.3.6.19}$$

It follows that:

$$v_p v_g = C^2 = \frac{C^2}{n\left(n + w\frac{dn}{dw}\right)} \tag{2.3.6.20}$$

Giving the differential equation:

$$\frac{dn}{dw} = \frac{-n}{2w} \tag{2.3.6.21}$$

A solution of this equation is:

$$n = \frac{c}{w^{\frac{1}{2}}} \tag{2.3.6.22}$$

Where C is a constant of integration with the units of angular frequency, so:

$$n = \left(\frac{w_0}{w}\right)^{\frac{1}{2}} \tag{2.3.6.23}$$

Where $w_0$is a characteristic angular frequency of the electromagnetic radiation. Eq. (2.3.6.23) has been derived directly from the original papers of de Broglie [30, 31] using only the equations (2.3.6.18) and (2.3.6.19) of physical optics, or wave physics. The photon mass does not appear in the final Eq. (2.3.6.23), but the photon mass is basic to the meaning of the calculation. If $w_0$is interpreted as the emitted angular frequency of light in a far distant star, then w_0 is the angular frequency of light reaching the observer. If:

$$n > 1 \qquad (2.3.6.24)$$

Then

$$w_0 < w \qquad (2.3.6.25)$$

and the light has been red shifted, meaning that its observable angular frequency (w) is lower than its emitted angular frequency (w_0), and this is due to photon mass, not an expanding universe. The refractive index, n(w) is the refractive index of the space time between star and observer. Therefore in 1924, de Broglie effectively explained the cosmological red shift in terms of photon mass. “Big Bang” (words in a derisory joke coined by Hoyle) is now known to be erroneous in many ways, and was the result of imposed and muddy pathology supplanting the clear science of de Broglie.

In 1924 de Broglie also introduced the concept of least (or “rest”) angular Frequency:

$$\hbar w_0 = mC^2 \qquad (2.3.6.26)$$

and kinetic angular frequencyw_k. The latter can be defined in the non relativistic limit:

$$\hbar \mathrm{w} = \mathrm{mC}^2 \left(1 - \frac{\mathrm{v}_\mathrm{g}^2}{\mathrm{C}^2}\right)^{\frac{-1}{2}} \sim \mathrm{mC}^2 + \frac{1}{2}\mathrm{mv}_\mathrm{g}^2 \qquad (2.3.6.27)$$

So:

$$\hbar \mathrm{w}_\mathrm{k} \sim \frac{1}{2}\mathrm{mv}_\mathrm{g}^2 \qquad (2.3.6.28)$$

Similarly, in the non relativistic limit:

$$\hbar \mathrm{k} + \mathrm{mv}_\mathrm{g} + \frac{1}{2}\mathrm{mv}_\mathrm{g}^3 \qquad (2.3.6.29)$$

So the least wave number, k_0, is:

$$\hbar \mathrm{k}_0 \sim \mathrm{mv}_\mathrm{g} \qquad (2.3.6.30)$$

And the kinetic wave number is

$$\hbar \mathrm{k}_\mathrm{k} \sim \frac{1}{2}\mathrm{m}\frac{\mathrm{v}_\mathrm{g}^3}{\mathrm{C}^2} \qquad (2.3.6.31)$$

The total angular frequency in this limit is:

$$w = w_0 + w_k \qquad (2.3.6.32)$$

And the total wave number is:

$$k = k_0 + k_k \qquad (2.3.6.33)$$

The kinetic energy of the photon was defined by de Broglie by omitting the least (or "rest") frequency:

$$T = \hbar k_k \sim \frac{1}{2} m v_g^2 = \frac{P^2}{2m} \qquad (2.3.6.34)$$

Where:

$$P = mv_0 \qquad (2.3.6.35)$$

Using Eqs. (2.3.6.26) and (2.3.6.30) it is found that:

$$v_p = \frac{C^2}{v_g} = \frac{w_0}{k_0} \qquad (2.3.6.36)$$

And using Eqs.(2.3.2.28) and (2.3.6.31):

$$v_p = \frac{C^2}{v_g} = \frac{w_k}{k_k} \qquad (2.3.6.37)$$

Therefore:

$$v_p = \frac{w}{k} = \frac{w_0 + w_k}{k_0 + k_k} \qquad (2.3.6.38)$$

a possible solution of which is:

$$\frac{w_k}{k_0} = v_g \qquad (2.3.6.39)$$

Using Eqs. (2.3.2.30) and (2.3.6.28):

$$\frac{w_k}{k_0} = \left(\frac{1}{2}\right) v_g \qquad (2.3.6.40)$$

So it is found that in these limits that:

$$v_g = \left(\frac{1}{2}\right) v_g \qquad (2.3.6.41)$$

This is the actual work of de Broglie [29, 30], which has been extended to give a simple derivation of the cosmological red shift due to the existence of photon mass. Inter alia, the cosmological red shift is an experimental proof of photon mass.

(2.3.7) Photon mass and light deflection due to gravitation.

The current best estimate of photon mass [49, 50] is of the order 10^{-52} kg. The photon mass from light deflection was calculated as:

$$m = \frac{R_0}{aC^2} E \tag{2.3.7.1}$$

Using:

$$E = \hbar w \tag{2.3.7.2}$$

This gave a result

$$m = 3.35 \times 10^{-41} \text{ kg.} \tag{2.3.7.3}$$

Here R_0 is the distance of closest approach, taken to be the radius of the Sun:

$$R_0 = 6.955 \times 10^8 \text{ m} \tag{2.3.7.4}$$

and a is a distance parameter computed to high accuracy:

$$a = 3.3765447822 \times 10^{11} \text{ m.} \tag{2.3.7.5}$$

More realistically, the photon in a light beam grazing the Sun has a mean energy given by the Planck distribution [55]:

$$< E > = \hbar w \left(\frac{e^{-\hbar w / kT}}{1 - e^{-\hbar w / kT}} \right) \tag{2.3.7.6}$$

where k is Boltzmann's constant and T is the temperature of the photon. It is found that a photon mass of:

$$m = 9.74 \times 10^{-52} \text{ kg} \tag{2.3.7.7}$$

Is compatible with a temperature of 2,500 K. The temperature of the photosphere at the Sun´s surface is 5,778 K, while the temperature of the Sun´s corona is(1 – 3) million K .Using Eq. (2.3.7.6) it is found that

$$Vg = 2.99757 \times 10^{8} \text{ m s}^{-1} \tag{2.3.7.8}$$

This is less than the maximum speed of relativity theory:

$$c = 2.9979 \times 10^8 \text{ m s}^{-1} . \tag{2.3.7.9}$$

The mean energy < E > is related to the beam intensity I in joules per square meter by:

$$I = 8\pi \left(\frac{f}{c}\right)^2 < E > \tag{2.3.7.10}$$

where f is the frequency of the beam in hertz. The intensity can be expressed as:

$$I = 8\pi f^2 m\left(1-\frac{v_g^2}{C^2}\right)^{\frac{-1}{2}} \qquad (2.3.7.11)$$

The total energy density of the light beam in joules per cubic meter is:

$$U = \frac{f}{C} I \qquad (2.3.7.12)$$

and its power density in watts per square meter (joules per second per square meter) is:

$$\Phi = CU = fI = 8\pi f^3 m\left(1-\frac{v_g^2}{C^2}\right)^{\frac{-1}{2}} \qquad (2.3.7.13)$$

The power density is an easily measurable quantity, and implies finite photon mass through Eq. (2.3.7.13). In the standard model there is no photon mass, so there is no power density, an absurd result. The power density is related to the magnitude of the electric field strength (***E***) and magnetic flux density (***B***) of the beam by:

$$\Phi = \varepsilon_0 C\boldsymbol{E}^2 = C\boldsymbol{B}^2/\mu_0 \qquad (2.3.7.14)$$

where ϵ_0 and μ_0 are respectively the vacuum permittivity and permeability, defined by:

$$\varepsilon_0\mu_0 = \frac{1}{C^2} \qquad (2.3.7.15)$$

So:

$$\Phi = 8\pi f^3 m\left(1-\frac{v_g^2}{C^2}\right)^{\frac{-1}{2}} = \varepsilon_0 C\boldsymbol{E}^2 = C\boldsymbol{B}^2/\mu_0 \qquad (2.3.7.15)$$

(2.3.8) Photon mass and Compton´s scattering.

Consider the collision of one photon of mass m with one electron of mass M. Let the initial angular frequency of the photon be w_1 and its angular Frequency after collision is w_2. Then the de Broglie Einstein theory gives:

$$\hbar w_1 = mC^2\left(1-\frac{v_1^2}{C^2}\right)^{\frac{-1}{2}} \quad , \quad \hbar w_2 = mC^2\left(1-\frac{v_2^2}{C^2}\right)^{\frac{-1}{2}} \qquad (2.3.8.1)$$

where $v_1$and v_2 are the group velocities before and after collision with the electron. Consider the electron to be initially at rest, and define its relativistic momentum after collision to be **P**. The electron gains momentum after collision, so the photon loses momentum. So:

$$v_2 < v_1 \tag{2.3.8.2}$$

This shows that the photon group velocity of de Broglie is lower after collision than before collision, a simple deduction that immediately proves the point made by Dr. Gareth J. Evans discussed in Section 2. By conservation of total energy (photon plus electron):

$$\hbar(w_1 - w_2) = (C^2P^2 + M^2C^2)^{\frac{1}{2}} - MC^2 \tag{2.3.8.3}$$

By conservation of total momentum in the X and Y axes:

$$\hbar k_1 = \hbar k_2 \cos\theta + P\cos\theta' \tag{2.3.8.4}$$

$$0 = \hbar k_2 \cos\theta - P\cos\theta' \tag{2.3.8.5}$$

where the initial momentum of the photon is $\hbar k_1$ and its final momentum is $\hbar k_2$So:

$$P^2 = \hbar^2(k_1^2 + k_2^2 - k_1k_2\cos\theta) \tag{2.3.8.6}$$

The photon is scattered at an angle θ to its incoming X axis.

Using the equations:

$$w_1^2 = C^2k_1^2 + \left(\frac{mC^2}{\hbar}\right)^2 \quad \text{and} \quad w_2^2 = C^2k_2^2 + \left(\frac{mC^2}{\hbar}\right)^2 \tag{2.3.8.7}$$

It is found that:

$$w_1 - w_2 = \frac{\hbar}{MC^2}\left(w_1w_1 - (w_1^2 - w_0^2)^{\frac{1}{2}}(w_2^2 - w_0^2)^{\frac{1}{2}}\cos\theta\right) + \frac{m^2C^2}{\hbar M} \tag{2.3.8.8}$$

This is the one photon one electron Compton effect for a photon of mass m colliding with an electron of mass M. The least frequency of the photon is defined by:

$$w_0 = \frac{mC^2}{\hbar} \tag{2.3.8.9}$$

The only unknown in this experiment is m, which can be found given sufficient experimental precision. The usual theory of the Compton effect is developed with:

$$m =? 0 \quad (2.3.8.10)$$

in which case Eq. (2.3.8.7) reduces to:

$$w_1 - w_2 = \frac{\hbar}{MC^2} w_1 w_1 (1 - \cos\theta) \quad (2.3.8.11)$$

Using:

$$w_1 = Ck_1 = \frac{C}{\lambda_1} \quad (2.3.8.12)$$

$$w_2 = Ck_2 = \frac{C}{\lambda_2} \quad (2.3.8.13)$$

the usual description [17] of the Compton effect is obtained:

$$\lambda_1 - \lambda_2 = \frac{2\hbar}{MC^2} \sin^2 \frac{\theta}{2} \quad (2.3.8.14)$$

This theory is valid for the scattering of the photon of mass m with any particle of mass M, including another photon (the case M = m). There are few if any data on photon-photon scattering.

(2.3.9) Proca Equations and the Photon Imaginary Mass

It has been recently proposed that the photon has *imaginary mass* and null real mass. Proca equations are the unique simplest relativistic generalization of Maxwell equations. They are the theoretical expressions of possible nonzero photon rest mass. The fact that the photon has imaginary mass introduces relevant modifications in Proca equations which point to a deviation from the Coulomb's inverse square law.

For quite a long time it has been known that the effects of a *nonzero photon rest mass* can be incorporated into electromagnetism through the *Proca equations* [75-76]. It is also known that particles with imaginary mass can be described by a real Proca field with a negative mass square [77-79]. They could be generated in storage rings, Jovian magnetosphere, and supernova remnants. The existence of imaginary mass associated to the neutrino is already well-known. It has been reported by different groups of experimentalists that the mass square of the neutrino is *negative* [80]. Although the imaginary mass is not a measurable amount, its square is [81]. Recently, it was shown that an imaginary mass exist associated to the *electron* and the *photon* too [82]. The photon *imaginary mass* is given by

$$m_\gamma = \frac{2}{\sqrt{3}}\left({}^{hf}/_{C^2}\right) i \qquad (2.3.9.1)$$

This means that the *photon* has null *real* mass and an *imaginary mass*, m_γ expressed by the previous equation.

Proca equations provide a complete and self-consistent description electromagnetic phenomenon [86]. In the presence of sources ρ and J, these equations may be written as (in SI units).

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0} - \mu_\gamma^2 \emptyset \qquad (2.3.9.2)$$

$$\nabla \cdot \vec{B} = 0 \qquad (2.3.9.3)$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \qquad (2.3.9.4)$$

$$\nabla \times \vec{B} = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \mu_\gamma^2 \overrightarrow{A} \qquad (2.3.9.5)$$

Where $\mu_\gamma = m_\gamma \frac{C}{\hbar}$with the *real* variables $\mu_\gamma$and m_γ. However, according to Eq. (2.3.9.1) m_γ is an *imaginary mass*. Then, $\mu_\gamma$must be also an imaginary variable. Thus, μ_γ^2 is a *negative real* number similarly to m_γ^2 consequently, we can write that

$$\mu_\gamma^2 = \frac{m_\gamma^2 C^2}{\hbar^2} = \frac{4}{3}\left(\frac{2\pi}{\lambda}\right)^2 = \frac{4}{3} k_r^2 \qquad (2.3.9.6)$$

Whence we recognize $\frac{2\pi}{\lambda} = k_r$ as the real part of the propagation vector;$\vec{k}$.

$$k = \left|\vec{k}\right| = k_r + i k_i = \sqrt{k_r^2 + k_i^2} \qquad (2.3.9.7)$$

Substitution of Eq. (6) into Proca equations, gives

$$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0} - \frac{4}{3} k_r^2 \ \emptyset \qquad (2.3.9.8)$$

$$\nabla \cdot \vec{B} = 0 \qquad (2.3.9.9)$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \tag{2.3.9.10}$$

$$\nabla \times \vec{B} = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{4}{3} k_r^2 \overrightarrow{A} \tag{2.3.9.11}$$

In four-dimensional space these equations can be rewritten as

$$\left\{\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2} - \frac{4}{3}k_r^2\right\} A_\mu = -\mu_0 \overrightarrow{J_\mu} \tag{2.3.9.12}$$

Where $A_\mu$and $\overrightarrow{J_\mu}$ are the 4-vector of potential (A ,i$\emptyset / C$)and the current density, (J, iCρ)respectively. In free space the above equation reduces to

$$\left\{\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2} - \frac{4}{3}k_r^2\right\} A_\mu = 0 \tag{2.3.9.13}$$

which is essentially the Klein-Gordon equation for the photon.

Therefore, the presence of a photon in a static electric field modifies the wave equation for all potentials (including the Coulomb potential) in the form

$$\left\{\nabla^2 - \frac{1}{C^2}\frac{\partial^2}{\partial t^2} - \frac{4}{3}k_r^2\right\} \emptyset = \frac{\rho}{\varepsilon_0} \tag{2.3.9.14}$$

For a point charge, we obtain

$$\emptyset(r) = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} e^{-\frac{2}{\sqrt{3}}(k_r r)} \tag{2.3.9.15}$$

and the electric field

$$E(r) = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}\left(1 + \frac{2}{\sqrt{3}}(k_r r)\right) e^{-\frac{2}{\sqrt{3}}(k_r r)} \tag{2.3.9.16}$$

Note that only in the absence of the photon the expression of reduces to the well-known expression: $k_r = 0 \quad E(r) = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$Thus, these results point to an exponential deviation from Coulomb's inverse square law, which, as we know, is expressed by the following equation (in SI units):

$$\vec{F}_{12} = -\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\overrightarrow{r_{12}}|^3}\overrightarrow{r_{12}} \tag{2.3.9.17}$$

As seen in Eq. (2.3.9.16), the term

$$\frac{2}{\sqrt{3}}(k_r r)$$

only becomes significant if

$$r > \sim 10^{-4}\lambda$$

This means that the Coulomb's law is a good approximation when $r < \sim 10^{-4}\lambda$ However, if, $r > \sim 10^{-4}\lambda$ the expression of the force departs from the prediction of Maxwell's equations.

The lowest-frequency photons of the primordial radiation of 2.7K are about $10^8 Hz$ [88]. Therefore, the wavelength of these photons is $\lambda \approx 1$m. Consider the presence of these photons in a terrestrial experiment designed to measure the force between two electric charges separated by a distance *r*. According to Eq. (2.3.9.17)the deviation from the Coulomb's law only becomes relevant if r > 10^{-4} m. Then, if we take r = 0.1 m the result is

$$\frac{2}{\sqrt{3}}(k_r r) = \frac{4\pi}{\sqrt{3}}\left(\frac{r}{\lambda}\right) = 0.73$$

And

$$\left(1 + \frac{2}{\sqrt{3}}(k_r r)\right)e^{-\frac{2}{\sqrt{3}}(k_r r)} = 0.83$$

Therefore, a deviation of 17% in respect to the value predicted by the Coulomb's law. Then, why the above deviation is not experimentally observed? Theoretically because of the presence of Schumann radiation ($f1$=7.83 Hz and $\lambda 1$ =3.8 X10^7 m) [89-90]. According to Eq. (18), for, $\lambda 1$ =3.8 X10^7 m the deviation only becomes significant if $r > \sim 10^{-4}\lambda 1$ =3.8 km

Since the values of *r* in usual experiments are much smaller than 3.8 km the result is that the deviation is negligible. In fact, this is easy to verify. For example, if r = 0.1m, we get

$$\frac{2}{\sqrt{3}}(k_r r) = \frac{4\pi}{\sqrt{3}}\left(\frac{r}{\lambda}\right) = \frac{4\pi}{\sqrt{3}}\left(\frac{01m}{3.8 \times 10^7}\right. = 1.9 \times 10^{-7}$$

And

$$\left(1 + \frac{2}{\sqrt{3}}(k_r r)\right) e^{-\frac{2}{\sqrt{3}}(k_r r)} = 0.999999999$$

Now, if we put the experiment inside an aluminum box whose thickness of the walls are equal to 21cm * the experiment will be shielded for the Schumann (The thickness δ necessary to shield the experiment for Schumann radiation can be calculated by means of the well-known expression [91]: $\delta = 5z = 10 \big/ \sqrt{2\pi\mu\sigma f}$ where μ and σ are, respectively, the permeability and the electric conductivity of the material; f is the frequency of the radiation to be shielded. radiation. By putting inside the box a photons source of λ ≈1m, and making r = 0.1m , then it will be possible to observe the deviation previously computed of 17% in respect to the value predicted by the Coulomb's law.

(2.3.10) Photon Mass and Electric Energy from Space Time.

. The Proca wave equation (49) may be written for each sense of polarization, a as

$$A_\mu = \mu_0 J_\mu \qquad (2.3.10.1)$$

where the charge current four density of space time itself is defined as:

$$J_\mu = -\frac{1}{\mu_0}\left(\frac{mC}{\hbar}\right)^2 A_\mu \qquad (2.3.10.2)$$

The following definitions are used:

$$J_\mu = (C\rho, -J) \qquad (2.3.10.3)$$

And

$$A_\mu = \left(\frac{\phi}{C}, -A\right) \qquad (2.3.10.4)$$

The existence of the current $J_\mu$means that the inhomogeneous Proca field equation is [3 –12]:

$$\partial_\mu F^{\mu v} = \mu_0 J^\mu \qquad (2.3.10.5)$$

and this is a consequence of the inhomogeneous ECE field equation [3-12]. In vector notation:

$$\nabla \cdot \boldsymbol{E} = {}^{\rho}/_{\varepsilon_0} \quad (2.3.10.6)$$

And

$$\nabla \times \boldsymbol{B} - \frac{1}{C^2}\frac{\partial \boldsymbol{E}}{\partial t} = \mu_0 J \quad (2.3.10.7)$$

Here Eq. (2.3.10.6) is the Coulomb law of space time itself, and Eq. (2.3.10.7) is the Ampere Maxwell law of space time itself. Thus:

$$\rho = -\varepsilon_0 \left(\frac{mC}{\hbar}\right)^2 \emptyset \quad (2.3.10.8)$$

$$J = -\frac{1}{\mu_0}\left(\frac{mC}{\hbar}\right)^2 A \quad (2.3.10.9)$$

Therefore the existence of photon mass means that there is a potential of space time itself which gives a charge density and current density of space time itself. This can be amplified with spin connection resonance [31-40] in devices that take energy from

space time. If space time itself can be polarized and magnetized, the equations are:

$$\boldsymbol{\nabla} \cdot \boldsymbol{D} = \rho \quad (2.3.10.10)$$

And

$$\boldsymbol{\nabla} \times \boldsymbol{H} - \frac{\partial \boldsymbol{D}}{\partial t} = \boldsymbol{J} \quad (2.3.10.11)$$

Here

$$\boldsymbol{D} = \varepsilon_0 \boldsymbol{E} + \boldsymbol{P} \quad (2.3.10.12)$$

And

$$\boldsymbol{B} = \mu_0(\boldsymbol{H} + \boldsymbol{M}) \quad (2.3.10.13)$$

So photon mass is central to all aspects of physics

(2.3.11) Photon Mass and Maxwell's equations

In this section Maxwell's equation in free space is solved in presence of polarization. The quantum expression for energy and momentum are used to relate energy to momentum. This relation is compared to the expression of energy in special relativity; this comparison is utilized to find the mass of the photon. Compton theory is also used to find photon mass.

Maxwell's equations are used to describe the behavior of electromagnetic waves, to describe the nature of electromagnetic wave in free space, it is better to bear in mind that its conductivity is very small and can be neglected. The equation of the electric field in free space in the presence of polarization is given by :

$$-\nabla^2 E + \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2} + \mu_0 \frac{\partial^2 P}{\partial t^2} = 0 \qquad (2.3.11.1)$$

The electric polarization P is defined to be:

$$P = ex \qquad (2.3.11.2)$$

Where e is the charge of electron, while x is its displacement. To solve equation (1) one can assume the solution

$$E = E_0 e^{i(\mathrm{kx-wt})} \qquad (2.3.11.3)$$

Where E_0 stand for the amplitude electric field wave, while k and w represents the wave number and angular frequency, respectively.

$$k = \frac{2\pi}{\lambda} \qquad w = 2\pi f \qquad (2.3.11.4)$$

Where is λ the wave length, while f is the frequency. With the aid of (2.3.11.3) one finds:

$$\frac{\partial E}{\partial x} = ikE \qquad (2.3.11.5)$$

$$\frac{\partial^2 E}{\partial x^2} = -k^2 E \qquad (2.3.11.6)$$

$$\frac{\partial E}{\partial t} = -iwE \qquad (2.3.11.7)$$

$$\frac{\partial^2 E}{\partial t^2} = i^2 w^2 E = -w^2 E \qquad (2.3.11.8)$$

To relate polarization P to E it is important to find equation of motion of electron of mass m and charge e in the presence of the electric field E. this equation the form:

$$m_e\ddot{x} = -eE \quad \Longrightarrow \ddot{x} = -\frac{eE}{m_e} \qquad (2.3.11.9)$$

But

$$\mu_0 \frac{\partial^2 P}{\partial t^2} = \mu_0 e \frac{\partial^2 x}{\partial t^2} = \mu_0 e\ddot{x} \qquad (2.3.11.10)$$

With aid of (2.3.11.9);

$$\mu_0 \frac{\partial^2 P}{\partial t^2} = \mu_0 e\ddot{x} = -\mu_0 \frac{e^2}{m_e} E \qquad (2.3.11.11)$$

But;

$$C^2 = \frac{1}{\mu_0 \varepsilon_0} \qquad (2.3.11.12)$$

Substituting (2.3.11.6, 2.3.11.8, 2.3.11.11, and 2.3.11.12) in (2.3.11.1) yield:

$$C^2k^2E - w^2E + \mu_0 \frac{e^2C^2}{m_e} E = 0 \qquad (2.3.11.13)$$

From which photon mass can be calculated

Eliminating E from both sides of (2.3.11.13) yields;

$$C^2k^2 - w^2 + \mu_0 \frac{e^2C^2}{m_e} = 0 \qquad (2.3.11.14)$$

Multiplying both sides by $\hbar^2$ yields :

$$C^2k^2\hbar^2 - \hbar^2 w^2 + \mu_0 \frac{e^2C^2\hbar^2}{m_e} = 0 \qquad (2.3.11.15)$$

According to the laws of quantum mechanics:

$$E = \hbar w \qquad P = \hbar k \qquad (2.3.11.16)$$

Then inserting (2.3.11.16) in (2.3.11.15) yields

$$C^2P^2 - E^2 + \mu_0 \frac{e^2C^2\hbar^2}{m_e} = 0 \qquad (2.3.11.17)$$

Therefore

$$E^2 = C^2P^2 + \mu_0 \frac{e^2C^2\hbar^2}{m_e} \qquad (2.3.11.18)$$

On the other hand the energy E is related to the momentum P and rest mass m_0 in special relativity according to the relation

$$E^2 = C^2P^2 + m_0^2C^4 \qquad (2.3.11.19)$$

Where m_0 here stands for photon rest mass .

Comparing (2.3.11.18) and (2.3.11.19) the photon rest mass is given by:

$$m_0^2C^4 = \mu_0 \frac{e^2C^2\hbar^2}{m_e}$$

$$m_0 = \frac{\hbar e}{C}\sqrt{\frac{\mu}{m_e}} \qquad (2.3.11.20)$$

Mathematically:

$$m_0 = \frac{6.63 \times 10^{-34} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 3 \times 10^8}\sqrt{\frac{4 \times 3.14 \times 10^{-7}}{9.1 \times 10^{-31}}} = 0.6587 \times 10^{-49} g \;)$$

(2.3.12) Photon Mass and Compton´s scattering.

Consider the collision of one photon of mass m with one electron of mass M.

. Let the initial angular frequency of the photon be w_1 and its angular frequency after collision is w_2. Then the de Broglie Einstein theory of Section 2 gives:

$$\hbar w_1 = mC^2\left(1 - \frac{v_1^2}{C^2}\right)^{\frac{-1}{2}} \quad , \quad \hbar w_2 = mC^2\left(1 - \frac{v_2^2}{C^2}\right)^{\frac{-1}{2}} \qquad (2.3.12.1)$$

where $v_1$and v_2 are the group velocities before and after collision with the electron. Consider the electron to be initially at rest, and define its relativistic momentum after collision to be **P**. The electron gains momentum after collision, so the photon loses momentum. So:

$$v_2 < v_1 \qquad (2.3.12.1)$$

This shows that the photon group velocity of de Broglie is lower after collision than before collision, a simple deduction that immediately proves the point made by Dr. Gareth J. Evans discussed. By conservation of total energy (photon plus electron):

$$\hbar(w_1 - w_2) = (C^2P^2 + M^2C^2)^{\frac{1}{2}} - MC^2 \qquad (2.3.12.2)$$

By conservation of total momentum in the X and Y axes:

$$\hbar k_1 = \hbar k_2 \cos\theta + P\cos\theta' \tag{2.3.12.3}$$

$$0 = \hbar k_2 \cos\theta - P\cos\theta' \tag{2.3.12.4}$$

where the initial momentum of the photon is $\hbar k_1$ and its final momentum is $\hbar k_2$So:

$$P^2 = \hbar^2(k_1^2 + k_2^2 - k_1 k_2 \cos\theta) \tag{2.3.12.5}$$

The photon is scattered at an angle θ to its incoming X axis.

Using the equations:

$$w_1^2 = C^2 k_1^2 + \left(\frac{mC^2}{\hbar}\right)^2 \quad \text{and} \quad w_2^2 = C^2 k_2^2 + \left(\frac{mC^2}{\hbar}\right)^2 \tag{2.3.12.6}$$

It is found that:

$$w_1 - w_2 = \frac{\hbar}{MC^2}\left(w_1 w_1 - (w_1^2 - w_0^2)^{\frac{1}{2}}(w_2^2 - w_0^2)^{\frac{1}{2}}\cos\theta\right) + \frac{m^2C^2}{\hbar M} \tag{2.3.12.7}$$

This is the one photon one electron Compton effect for a photon of mass m colliding with an electron of mass M. The least frequency of the photon is defined by:

$$w_0 = \frac{mC^2}{\hbar} \tag{2.3.12.8}$$

The only unknown in this experiment is m, which can be found given sufficient Experimental precision. The usual theory of the Compton Effect is developed with:

$$m = 0 \tag{2.3.12.9}$$

In which case Eq. (65) reduces to:

$$w_1 - w_2 = \frac{\hbar}{MC^2} w_1 w_1 (1 - \cos\theta) \tag{2.3.12.10}$$

Using:

$$w_1 = Ck_1 = \frac{C}{\lambda_1} \tag{2.3.12.11}$$

$$w_2 = Ck_2 = \frac{C}{\lambda_2} \tag{2.3.12.12}$$

The usual description [17] of the Compton effect is obtained:

$$\lambda_1 - \lambda_2 = \frac{2\hbar}{MC^2}\sin^2\frac{\theta}{2} \qquad (2.3.12.13)$$

This theory is valid for the scattering of the photon of mass m with any particle of mass M, including another photon (the case M = m).

(2.4) Special Theory of Relativity for Photons

The photon mass is ordinarily assumed to be exactly zero. However, this is merely a theoretical assumption; there is no experimental evidence to indicate that the photon mass is identically zero. In contrast, there are various experimental methods that have been used to set upper limits on the photon mass. If there is any deviation from zero, it must be very small. Nevertheless, even a small nonzero value would have many consequences in many theories in modern physics. It would mean that we could treat the photon as a particle that is approximately analogous to an electron. Photon mass would imply that the famous ! is not a universal constant but instead depends on the photon energy, just as in the case of other particles within nonzero mass. In a related problem, we will study the Lorentz contraction of a rod using the Lorentz transformation equations. We will see how Lorentz transformations can demonstrate, remarkably, that under certain special conditions, length expansion is also possible! The aim of this study is combine all of these components – photon mass, length variation, and Doppler effect – to develop a complete special theory of relativity for the photon as a particle.

There are many consequences of nonzero photon mass: the speed of light would depend on its frequency, the usual Coulomb potential would become a Yukawa potential, Maxwell's equations would be replaced by Proca's equations, the black-body radiation formula would take on a new form, and many other theories would also be affected. In addition, it seems that a nonzero photon mass would have an impact on the special theory of relativity, because the photon mass would affect the universal constant C. In fact, however, this is not necessarily true. We could simply consider that the velocity that is the key quantity in special relativity is not the velocity of light but rather a constant of nature, which is the maximum speed that any object could theoretically attain in space-time.

Although the mass of the photon is very small, any nonzero photon mass would have many consequences at a theoretical level. In this study, we will attempt to derive a dynamical relativistic energy equation for the photon as a particle. We then will see how Lorentz transformations can demonstrate, remarkably, that under certain special conditions, length expansion is also possible. All of these results together provide us with a bizarre new picture of the photon behavior.

(2.4.1) Laboratory Limits on the Photon Mass

Photons, just like any other observed particle, possess a real physical identity and are not just a conceptualization of the physicist's mind. Once the photon is provided with a finite mass, three immediate consequences may be deduced from the Proca equations: (2.3.5.1) there will be a frequency dependence in the velocity of light propagating in free space, (2.3.5.2) a third state of polarization, the 'longitudinal photon' will exist and (2.3.5.3) there will be some modifications in the characteristics of the classical static fields. Critical scientific minds since the time of Cavendish and before have repeatedly come to the conclusion that the photon may have mass. The question is a persistent one and has spurred several reviews of the topic over the past 30 years (Goldhaber and Nieto 1971b, Chibisov 1976, Byrne 1977, Dolgov and Zeldovich 1981, Vigier 1990, 1992, 1997, Gray 1997, Zhang 1998). In this section, we will discuss the history of the various experimental searches for the photon mass that have been carried out in the terrestrial laboratory or on the surface of the earth.

Table (2.3.1) the upper limit mass of photon according to Particle data group

Author (date)	**Experimental approach**	**Upper limit on** m_γ / g
Terrestrial results		
Goldhaber et al. (1971)	Speed of light	$5.6x10^{-46}$
Williams et al. (1971)	Test of Coulomb's law	$1.6x10^{-47}$
Chernikov et al. (1992)	Test of Ampere's law	$8.4x10^{-46}$
Lakes (1998)	Static torsion balance	$2x10^{-50}$
Luo et al. (2003)	Dynamic torsion balance	$1.2x10^{-51}$
Extraterrestrial results		
De Broglie (1940)	Dispersion of starlight	$0.8x10^{-39}$
Feinberg (1969)	Dispersion of starlight	10^{-44}
Schaefer (1999)	Dispersion of gamma-ray bursts	$4.2x10^{-44}$
Davis et al. (1975)	Analysis of Jupiter's magnetic field	8x10-49
Fischbach et al. (1994)	Analysis of Earth's magnetic field	$1x10^{-48}$
Ryutov (1997)	Solar wind magnetic field and plasma	10^{-49}
Gintsburg (1964)	Altitude dependence of geomagnetic field	$3x10^{-48}$
Patel (1965)	Alfvén waves in Earth'sMagnetosphere	$4x10^{-47}$
Hollweg (1974)	Alfvén waves in the interplanetary medium	$1.3x10^{-48}$
Barnes et al. (1974)	Hydromagnetic waves	$3x10^{-50}$
DeBernadis et al. (1984)	Cosmic background radiation	$3x10^{-51}$
Williams et al. (1971)	Galactic magnetic field	$3x10^{-56}$
Chibisov (1976)	Stability of the galaxies	$3x10^{-60}$
Goldhaber and Nieto (2003)	Stability of plasma in Coma cluster	
Accioly and Paszko (2004)	Gravitational defection of radio waves	

(2.4.2) Solution of Maxwell and Proca equations

In the presence of a nonzero photon mass, Maxwell's equations will become Proca's equations in the form

$$\left(\frac{1}{C^2}\frac{\partial^2}{\partial t_2} - \nabla^2 + \mu_\gamma^2\right) A_\mu \qquad \textbf{(2.4.2.1)}$$

Where $\mu_\gamma^{-1} = \frac{\hbar}{m_\gamma C}$ m_γ is the mass of photon

The solution of equation (2.4.2.1) is the electromagnetic field in free space,

$$A_v = e^{-i(wt-kx)} \qquad (2.4.2.2)$$

With

$$k^2 = \frac{w^2}{C^2} - \mu_\gamma^2 \qquad (2.4.2.3)$$

Where k is the wave vector and w is the angular frequency. Then, the group velocity will be

$$v_g = \frac{dw}{dk} = C\sqrt{1 - \frac{\mu_\gamma^2 C^2}{w^2}} \qquad (2.4.2.4)$$

$$v_g = \frac{dw}{dk} = C\sqrt{1 - \frac{m_\gamma^2 C^4}{h^2 v^2}} \qquad (2.4.2.5)$$

This is the most important consequence of nonzero photon mass: the speed of light will depend on the frequency of the electromagnetic wave. It is clear that $v_g = C$

Only when $m_\gamma \to 0$ or when the frequency approaches infinity, $v \to \infty$..

(2.4.3) Relativistic Total Energy of the Photon

If we use the quantum energy formula for photons and the relativistic total energy of particles, we will find, directly, that

$$E = hv = \frac{m_\gamma C^2}{\sqrt{1 - \frac{v_g^2}{C^2}}} \quad \Longrightarrow \quad v_g = C\sqrt{1 - \frac{m_\gamma^2 C^4}{h^2 v^2}} \qquad (2.4.3.1)$$

When $v_g = C$ it must be that $m_\gamma \to 0$ and E will be unknown. Also, $v_{g=0}$ only when

$$\frac{m_\gamma^2 C^4}{h^2 v^2} = 1 \quad \Longrightarrow m_\gamma^2 C^4 = h^2 v^2 \qquad (2.4.3.2)$$

This means that the photon is in its rest frame. We know that there is no rest frame for the photon if the speed of light does not change. However, if C is variable with mass and frequency, we could imagine, theoretically, that the photon could have a rest frame. Then, v would be the rest frequency, which would correspond, in some way, to the photon rest mass m_γ.Now; we will combine the relativistic Doppler Effect with equation (2.4.3.1). The relativistic Doppler Effect for an observer receding from the light source is given by:

$$\mathrm{v} = \mathrm{v}' \sqrt{\frac{1-\frac{\mathrm{v}}{\mathrm{C}}}{1+\frac{\mathrm{v}}{\mathrm{C}}}} \qquad (2.4.3.3)$$

For an observer approaching the light source, it is given by [82]

$$\mathrm{v} = \mathrm{v}' \sqrt{\frac{1+\frac{\mathrm{v}}{\mathrm{C}}}{1-\frac{\mathrm{v}}{\mathrm{C}}}} \qquad (2.4.3.4)$$

Where $\mathrm{v}'$the rest frequency, and v is is the velocity of the observer. When we insert equations (2.4.3.3)and (2.4.3.4)into (2.4.3.1)we find, after some algebra, that

$$E = h\mathrm{v} = h\mathrm{v}' \sqrt{\frac{1-\frac{\mathrm{v}}{\mathrm{C}}}{1+\frac{\mathrm{v}}{\mathrm{C}}}} \qquad (2.4.3.5)$$

and

$$E = h\mathrm{v} = h\mathrm{v}' \sqrt{\frac{1+\frac{\mathrm{v}}{\mathrm{C}}}{1-\frac{\mathrm{v}}{\mathrm{C}}}} \qquad (2.4.3.6)$$

Using (7) instead, we find

$$E = m_\gamma C^2 \sqrt{\frac{1-\frac{v}{c}}{1+\frac{v}{c}}} \qquad (2.4.3.7)$$

$$E = m_\gamma C^2 \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \qquad (2.4.3.8)$$

Equation (2.4.3.7) shows that the energy of the single photon, treated as a particle, decreases as the observer's velocity increases, whereas equation (2.4.3.8)shows that the energy increases with an increase in the observer's velocity. Equations (2.4.3.6) and (2.4.3.5) are merely the normal Doppler-shift effect, i.e., (2.4.3.3) and (2.4.3.4) , multiplied by Planck's constant. However, the interpretation of the two sets of equations is entirely different. The Doppler effect treats light as a wave, but equations (2.4.3.7)and (2.4.3.4)apply to a single photon with a tiny mass m_γ . Thus, we must be careful here, because the photon has finite dimensions like other particles.

(2.4.4) Lorentz contraction and Lorentz Expansion

Equation (2.4.3.7)indicates that space-time has a special character. We know that all kinematical and dynamical phenomena in the special theory of relativity arise as necessary consequences of the nature of space-time and the Lorentz transformations. Diagram (2.7.3.1) illustrates how the equations of the special theory of relativity have been carefully constructed in relation to each other.

Lorentz transformations

⇓

$$\frac{d\tau}{dt} = \sqrt{1-\frac{v^2}{C^2}} \quad , \qquad L = L_0\sqrt{1-\frac{v^2}{C^2}}$$

⇓

$$u^i = \frac{v^i}{\sqrt{1-\frac{v^2}{C^2}}}$$

$$\Downarrow$$

$$P = mu^i$$

$$\Downarrow$$

$$E = \frac{mC^2}{\sqrt{1-\frac{v^2}{C^2}}}$$

Diagram (2.7.3.1)

Where $d\tau$ the proper is time, and u^i is the proper velocity.

We have shown, in equation (2.4.3.8) that the energy of the photon, when treated as a tiny particle, decreases as the velocity of the light source increases. This phenomenon is familiar from the relativistic Doppler effect, but here, we focused our attention on a single photon, which is clear from the presence of Planck's constant in equations (2.4.3.5) and (2.4.3.6) Equation (2.4.3.7) poses an important and exciting question: are there kinematical and dynamical equations that are consistent with equation ((2.4.3.7) . Fortunately, just as Lorentz transformations lead to length contraction, we will show that, under very special conditions, Lorentz transformations can also lead to both expansion and invariance in length! Suppose that there is reference frame S with spatial coordinates x, y, z and time t. Let S' be another reference frame with coordinates x', y',z' and time t' that moves with speed v relative to S in the positive direction along the x- axis. The relation between the coordinates and time of an event in the inertial frame S and the coordinates and time of the same event as observed in the second inertial frame

S' is given by the following Lorentz transformations [80]:

$$x' = \beta(x - vt) \tag{2.4.4.1}$$

$$y' = y \tag{2.4.4.2}$$

$$z' = z \quad (2.4.4.3)$$

$$t' = \beta\left(t - \frac{vx}{C^2}\right) \quad (2.4.4.4)$$

Where $\beta = \sqrt{1 - \frac{v^2}{C^2}}$ If S' instead moves in the negative direction along the x axis, we have only to change the sign of the relative velocity v because of the symmetry of the equations. Therefore,

$$x = \beta(x' + vt) \quad (2.4.4.5)$$

$$y' = y \quad (2.4.4.6)$$

$$z' = z \quad (2.4.4.7)$$

$$t = \beta\left(t' + \frac{vx}{C^2}\right) \quad (2.4.4.8)$$

The famous consequences of the Lorentz transformations are length contraction and time dilation, as revealed by Einstein in his famous paper in 1905 [75]. However, the Lorentz transformations also lead to other results concerning the relativity of length. Under certain special conditions, Lorentz transformations also result in length invariance and length expansion! This result was demonstrated by

Sadanand D. Agashe [80]. Therefore, we will follow his derivation to illustrate how Lorentz transformations can lead to length contraction and then how these transformations can also lead to length invariance and expansion. He wrote the following:

"In deducing the Lorentz contraction in such a scenario, most authors talk about a rigid rod lying at rest on the x'axis of the moving system S' The ends $P_1$and P_2 of this rod can thus be thought of as a series of events $P_1 \equiv \{ (x_1', 0, 0, t')\}$and $P_2 \equiv \{ (x_2', 0, 0, t')\}$ of with $x_2' - x_1' > 0$, say, so that we can call L the constant (in S') length of the rod, and so we are justified in calling the rod "rigid" in S'Next, one shows that although the rod is at rest in S' it is "observed" to be moving in S with speed v, of course. Further, as it moves in S, its length remains constant in S and so it is rigid in S also. However, its length in

S is different from its length L inS', and is, in fact, $\beta^{-1}L$, which is smaller than L Hence the term "contraction". Indeed, using [(1.29)...(1.32)], at any time t of S the coordinates of P_1 in S are $(\beta(x' + vt_2'), 0, 0)$ and the coordinates of P_2 in S are$(\beta(x' + vt_2'). 0 .0)$ where t_2' and t_2' in S' correspond to a common time S in t and so,

$$t = \beta\left(t_1' + \frac{vx_1'}{C^2}\right) = \beta\left(t_2' + \frac{vx_2'}{C^2}\right) \qquad (2.4.4.9)$$

The distance betweenP_1andP_2 in S at time t, and, thus, the length of the rod in S at time t are given by,

$$\beta(vt_2' + x_2') - \beta(vt_1' + x_1') = \beta(x_2' - x_1') - \beta v(t_2' - t_1') = \beta(x_2' - x_1') - \frac{v}{C^2}\beta v(x_2' - x_1') = \beta(x_2' - x_1')\left(1 - \frac{v^2}{C^2}\right) = \frac{1}{\beta}L \qquad (2.4.4.10)$$

All this is very familiar and is written only to fix the notation and to avoid misunderstanding. Note that one could allow the rod to be anywhere in the space of S' provided it is parallel to the x' –axis.

He then derived length expansion and invariance, under the title "What happens to a rod moving with an arbitrary velocity?":

Again

What are the motions of P_1 andP_2 in S'? Is the distance between them constant in S' too, so that the rod remains rigid in S'? Indeed the motions of P_1 and P_2 are uniform in S' too, since they are given by,

$$P_1: \left[\left(\beta(x_0 + ut - vt), 0, 0, \beta\left(t - \frac{v(x_0 + ut)}{C^2}\right)\right)\right] \qquad (2.4.4.11)$$

$$P_2: \left[\left(\beta(x_0 + L + u\bar{t} - v\bar{t}), 0, 0, \beta\left(\bar{t} - \frac{v(x_0 + L + u\bar{t})}{C^2}\right)\right)\right]$$

Their common speed is given by,

$$\frac{u - v}{1 - \frac{uv}{C^2}} \qquad (2.4.4.12)$$

The S' distance between P1 and P2 at a time t' in S' is given by

$$\beta(x_0 + L + u\bar{t} - v\bar{t}) - \beta(x_0 + ut - vt) \qquad (2.4.4.13)$$

Where t and $\bar{t}$ are related to t' by,

$$t' = \beta\left(t - \frac{v(x_0+ut)}{C^2}\right) = \beta\left(t' - \frac{v(x_0+L+u\bar{t})}{C^2}\right) \qquad (2.4.4.14)$$

The distance calculates out to be,

$$\frac{1}{\beta\left(1 - \frac{uv}{C^2}\right)} L \qquad (2.4.4.15)$$

Thus, the rod is observed to stay rigid in S' too. But is its length in S' necessarily smaller than its length L observed in S? Denoting the factor multiplying L in (2.4.4.15)by k(u), the function k has the following values:

$$k\left(\frac{C^2}{v}\right) = \infty \qquad (2.4.4.16)$$

$$k(c) = \frac{1}{\beta\left(1 - \frac{v}{C}\right)} = \sqrt{\frac{1 + {}^{v}/_{C}}{1 - {}^{v}/_{C}}} > 1 \qquad (2.4.4.17)$$

$$k(v) = \frac{1}{\beta\left(1 - {}^{v^2}/_{C^2}\right)} = \beta > 1 \qquad (2.4.4.18)$$

$$k(0) = \frac{1}{\beta} < 1 \qquad (2.4.4.19)$$

$$k(-C) = \frac{1}{\beta(1 - {}^{v}/_{C})} = \sqrt{\frac{1 - {}^{v}/_{C}}{1 + {}^{v}/_{C}}} < 1 \qquad (2.4.4.20)$$

$$k(-\infty) = 0 \qquad (2.4.4.21)$$

With

$$k(-C) < k(0) < 1 < k(v) < k(C)$$

The case u = 0 corresponds to the rod being at rest in S and its length in S' is observed to be smaller than its length in S, but if u = v the rod is at rest in S' its length in S' is observed to be larger than its length in S. Further, there is a particular value of u, namely:

Such that $k(\bar{u}) = 1$ and 0 <. $(\bar{u}) < v$ Thus, there is a speed v for which the rod is observed to be moving in both S and S' but its length is observed to be the same in both. So, we can have not only a contraction but also an expansion and even invariance!" [6] Agashe analyzed all of these results in detail, and he also carefully discussed Einstein's papers [6][7][8]. He considered that [6]

[…the "change" in length is purely a kinematical fact, arising out of the manner in which the two systems S and S' and their coordinates and times are related, and we need not look for any dynamical reason for the change in either system].

(4.4.5) What About the Relativistic Time?

We know that the length, or, more accurately, space, is working together with time to keep the speed of light a universal constant. In the special theory of relativity, length contraction and time dilation maintain the speed of light at a constant. They also conserve Lorentz invariance. Diagram 1 shows very clearly that the equations of the special theory of relativity depend on one another. Therefore, any change in one of them will lead to a change in all other equations. We derived the new equation of energy; the energy of photons, when they are treated as particles, can decrease. We then showed, as derived by Agashe, that the length of a rod can expand or remain invariant, and length expansion is consistent, in principle, with the equation of decreasing energy. Because of this consistency, the proper

velocity, the relativistic momentum and all other dynamical quantity must exist. However, the most bizarrely affected quantity is the time. If equation (2.4.4.9) is correct and is applied to the length of a rod, time or the clocks used to measure it must be speeding up! We can easily demonstrate the truth of this statement. Consider again (fig.2.4.4 1), and suppose that there is a particle the frame S' with a mean lifetime τ ". If equation (2.4.4.8) is correct, the length of the rod in frame S will expand to

$$L = \frac{L0}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (4.4.5.1)$$

In this case, however, to the observer in the particle frame, all space behind the observer will appear to

Expand according to equation (4.4.5.1)not just the rod in frame S. Thus, if the time interval between two events as measured in the particle frame S' is " $d\tau$, it will be different in frame S. In this frame, the length will not change, so the particle will occupy a smaller distance than in frame S', but the two

Observers must agree on the time at which the particle disappears. For this to happen there is only one possibility: time must speed up in frame S' relative to frame S This means that the equation for the time interval must reverse in frame S to obtain the same result for the two reference frames. Therefore, for S, time must obey this equation:

$$\frac{dt}{d\tau} = \sqrt{1 - \frac{v^2}{C^2}} \qquad (4.4.5.2)$$

Of course, time also speeds up in frame S relative to frame S'. The two equations (4.4.5.1)and (4.4.5.2)will leave the speed of light, universally, constant, and they satisfy Lorentz invariance and the laws of physics.

In conclusion, we can say that if photons have a mass, albeit a very tiny one, there will be many surprising consequences at the theoretical level. A nonzero photon mass would allow the photon to have a mean lifetime and to decay to lighter particles! If the photon really has a mass and a mean lifetime and if the equations (4.4.4.20) (4.4.5.1)and (4.4.5.2)are correct, using some experimental arrangement that simulates Fig 1, one could verify that time speeds up for the photon and that its energy decreases. Of course, it is very difficult to verify equation (4.4.5.1) because there is no direct evidence of length contraction, but we know that it must occur to be consistent with time dilation. The same logic applies for these new results: evidence of one of them is sufficient to know that the others must also be correct.

This model may apply for photons because of the dual nature of the photon.

Space-time, according to this model, does not exhibit only spatial contraction accompanied by time dilation but also spatial expansion accompanies by time speeding up. Space-time may be very elastic. It may be able to contract and expand in both length and time to leave the speed of light universally constant.

Chapter Three

Literature Review

3.1 Introduction:

Physicists have considered massive photons for decades, starting with Alexander Proca in 1930 [16]. Who wrote down the modified form of Maxwell's equations for an electromagnetic. Later Hideki Yukawa used Proca's work as an inspiration for his Nobel prize-wining research in to nuclear force. Yukawa showed that a short ranged force like that holding atoms of nuclei together were the result of massive particle mediating the interaction, and calculated the mass of the poem from the principle.

Yukawa's equation for this interaction also describe a massive photon, it suffice to say that the mass of particle whether a peon or massive photon or other subatomic provides a natural range for the force it carries.

More massive particle have mass less particles technically extending to infinity.

Photons are mediators of the electromagnetic force. For massive photon law between two electric q and Q separated by a distance r is a short range force.

The role of field in affection the motion of particles and photons were talked by many researcher [100, 101, 102, 103, and 104].

One of the most interesting is the one which recognize the effect of the field on Lorentz transformation [100, 101, 102, 103, 104].

In this chapter some of these attempts are discussed.

(3.2) Matter, Antimatter Generation, Repulsive Gravity Force.

Hashim and other studies repulsive gravity using the energy relation according to Einstein generalized relativity which is given by [100].

$$E = \frac{m_0 c^2 \left(1 + \frac{2\varphi}{c^2}\right)}{\sqrt{1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}}} \qquad (3.2.1)$$

Where m_0, φ, v stands for rest of mass, potential and velocity respectively one can rewrite E to be

$$E = m_0 c^2 \left(1 + \frac{2\varphi}{c^2}\right)\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{-\frac{1}{2}} \qquad (3.2.2)$$

To find vacuum minimum energy, the energy, one minimize E to get

$$\frac{dE}{d\varphi} = m_0 c^2 \left[\left(1 + \frac{2\varphi}{c^2}\right) \times -\frac{1}{2}\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{-\frac{3}{2}} \times \frac{2}{c^2} + \left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{-\frac{1}{2}} \times \frac{2}{c^2}\right]$$

Thus

$$\frac{dE}{d\varphi} = \frac{2m_0 c^2}{c^2} \frac{\left(\frac{1}{2} + \frac{\varphi}{c^2} - \frac{v^2}{c^2}\right)}{\left(1 + \frac{\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{3}{2}}} \qquad (3.2.3)$$

Hence

$$\frac{1}{2} + \frac{\varphi}{c^2} - \frac{v^2}{c^2} = 0$$

Therefore

$$\frac{\varphi}{c^2} = \frac{v^2}{c^2} - \frac{1}{2} \quad , \quad \varphi = c^2\left(\frac{v^2}{c^2} - \frac{1}{2}\right) \qquad (3.2.4)$$

Thus the value of φ which make E minimum is given by

$$\varphi = v^2 - \frac{c^2}{2} \qquad (3.2.5)$$

Due to the wave nature of light $C_e = \frac{C_m}{\sqrt{2}}$

$$\sqrt{2}\, C_e = C_m \qquad (3.2.6)$$

Let

$$C = \sqrt{2}\, C_e = C_m \qquad (3.2.7)$$

$$\varphi = v^2 - C_e^2 \qquad (3.2.8)$$

When $v = 0$

$$\varphi = -C_e^2 \quad (3.2.9)$$

Thus the potential is given by

$$V = m_0\varphi = -m_0 C_e^2 \quad (3.2.10)$$

In this case the vacuum constituents are at rest (v=0).

But when a photon, which constitute vacuum move with speed c, thus

$$v = c \quad (3.2.11)$$

Substitute in (3.2.5) to get

$$\varphi = c^2 - \frac{c^2}{2} = \frac{c^2}{2} \quad (3.2.12)$$

When inserting equation (3.2.7), one gets

$$\varphi = C_e^2 \quad (3.2.13)$$

But the potential energy is given by

$$V = m_0\varphi$$

Thus from (3.2.13) and (3.2.1) the potential is given by

$V = m_0 C_e^2$

The vacuum energy can be found by inserting (3.2.11) and (3.2.12) in (3.2.11) to got

$$E = m_0 c^2(1 + 1) = 2m_0 c^2 \quad (3.2.14)$$

Thus one can imagine vacuum energy levels as shown below

$E = m_m c^2 = m_0 c^2$ ______________________________

$E = 0$ ______________________________

$E = -m_0 c^2 = m_0 C_e^2$ ______________________________

Figure (3.2.1): vacuum states as consisting of photons producing and destructing particles and antiparticles with rest masses m_0.

The production of pair particles can be regarded as due to electron transfer state the lower to the upper state after absorbing a photon.

Where

$$m_0 = \text{matter mass} = m_0$$

$$m_0 = \text{antimatter mass} = -m_0 \quad (3.2.15)$$

The energy diagram is shown in figure (3.2.1)

According to Newton's laws the potential is given by

$$\varphi = -\frac{Gm}{r} \quad (3.2.16)$$

For matter $m_m = m_0$

Thus

$$\varphi_0 = matter\ potential = -\frac{Gm_m}{r} = -\frac{Gm_0}{r} \quad (3.2.17)$$

This is an attractive force.

For antimatter $m_a = -m_0$

$$\varphi_a = matter\ potential = -\frac{Gm_a}{r} = +\frac{Gm_0}{r} \quad (3.2.18)$$

This is a repulsive force

When matter and antimatter interact with each other the potential is given by

$$V = -\frac{GmM}{r} \quad (3.2.19)$$

Where the force is given by

$$F = -\nabla V = -\frac{\partial V}{\partial r} = GmM\frac{\partial r^{-1}}{\partial r}$$

Hence the force is given by

$$F = -\frac{GmM}{r^2} \quad (3.2.20)$$

For matter and antimatter reaction

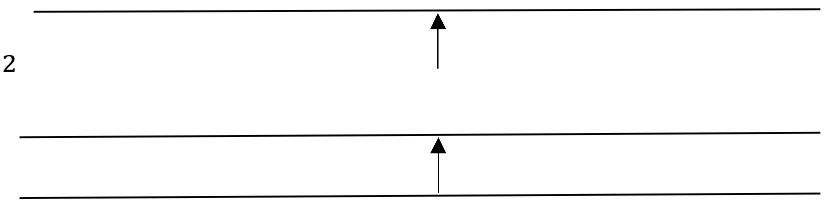
$$m = m_m = m_0 \quad , \quad M = m_a = -m_0 \quad (3.2.21)$$

Thus the force between matter and antimatter is given by

$$F = -\frac{G(m_0)(-m_0)}{r^2} = \frac{G\,{m_0}^2}{r^2} \quad (3.2.22)$$

Thus there is repulsive force between matter and antimatter.

$E_v =$ m_0c^2



$-E_v =$ $-m_0c^2$

Figure (3.2.2): vacuum energy levels

In Generation of particle and antiparticle on the basis of conservation law the energy conservation requires

$$E_v = mc^2 + 2m\varphi \qquad (3.2.23)$$

The GSR mass was proposed by some authors to be

$$m = \frac{m_0}{\sqrt{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}} \qquad (3.2.24)$$

From equation (3.2.23) and 3.2.(24) one gets

$$E = \frac{m_0c^2}{\sqrt{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}} + \frac{2m_0c^2}{\sqrt{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}} \qquad (3.2.25)$$

To find vacuum state, the energy E need to be minimized With respect to φ, to get

$$\frac{\partial E}{\partial \varphi} = -\frac{1}{2}m_0c^2(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{-3/2} \times \frac{2}{c^2} + 2m_0[\varphi - \frac{1}{2}(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{-3/2}$$

$$\times \frac{2}{c^2} + (1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{-1/2}$$

$$\frac{\partial E}{\partial \varphi} = \frac{-m_0}{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{3/2}} - \frac{2m_0\varphi/_{c^2}}{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{3/2}} + \frac{2m_0}{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{1/2}}$$

$$\frac{\partial E}{\partial \varphi} = \frac{-m_0 - 2m_0\varphi/_{c^2} + 2m_0(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{1/2}}{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{3/2}} \qquad (3.2.26)$$

Thus equation can be satisfied, when

$$2m_0(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{1/2} = m_0 + {2m_0\varphi}/{c^2}$$

$$(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{1/2} = \frac{1}{2} + \frac{\varphi}{c^2} \quad , \quad \frac{1}{2} - \frac{v^2}{c^2} = \frac{\varphi}{c^2}$$

$$\varphi = v^2 - \frac{c^2}{2} \tag{3.2.27}$$

If vacuum particle are at rest v=0, thus equation (3.2.27) become

$$\varphi = -\frac{c^2}{2} \tag{3.2.28}$$

Substituting this value in (3.2.23) and (3.2.24) yield

$$m = \frac{m_0}{\sqrt{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}} = \frac{m_0}{0} = \infty \tag{3.2.29}$$

Thus from (3.2.25)

$$E = \infty \tag{3.230}$$

Thus condition (3.2.25) is the condition for maximum E.

No one can use equation (3.2.23)

$$E = mc^2 + 2m\varphi \tag{3.2.31}$$

But the mass term is in the form

$$m = \frac{(1 + \frac{2\varphi}{c^2})m_0}{\sqrt{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}} \tag{3.2.32}$$

Inserting (3.2.32) in (3.2.31) yields

$$E = \frac{(1 + \frac{2\varphi}{c^2})m_0c^2}{\sqrt{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}} + \frac{2\varphi(1 + \frac{2\varphi}{c^2})m_0}{\sqrt{(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}} \tag{3.2.33}$$

$$E = m_0c^2\left(1 + \frac{2\varphi}{c^2}\right)(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})^{\frac{-1}{2}} + 2m_0(\varphi + \frac{2\varphi^2}{c^2}) \tag{3.2.34}$$

The differentiation of E with respect to φ requires

$$\frac{\partial E}{\partial \varphi} = m_0c^2 \left\{\left(1 + \frac{2\varphi}{c^2}\right) \times \frac{-1}{2}\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{-3}{2}} \times \frac{2}{c^2} + \left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{-1}{2}} \times \frac{2}{c^2}\right\}$$

$$+ \ 2m_0\{\left(\varphi + \frac{2\varphi^2}{c^2}\right) \times \frac{-1}{2} \ \left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{-3}{2}} \times \ \frac{2}{c^2} + \ \left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{-1}{2}}$$

$$\times \ \left(1 + \frac{4\varphi}{c^2}\right)\}$$

$$\frac{\partial E}{\partial \varphi} = \frac{-m_0\left(1 + \frac{2\varphi}{c^2}\right)}{\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{3}{2}}} + \ \frac{2m_0}{\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{1}{2}}} - \frac{\frac{2m_0}{c^2}\left(\varphi + \frac{2\varphi^2}{c^2}\right)}{\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{3}{2}}}$$

$$+ \frac{2m_0\left(1 + \frac{4\varphi}{c^2}\right)}{\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{1}{2}}} \quad (3.2.35)$$

$$\frac{\partial E}{\partial \varphi} = 0 \qquad (3.2.36)$$

$$= \frac{-m_0\left(1 + \frac{2\varphi}{c^2}\right) + 2m_0\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right) - \frac{2m_0}{c^2}\left(\varphi + \frac{2\varphi^2}{c^2}\right) + 2m_0\left(1 + \frac{4\varphi}{c^2}\right)(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2})}{\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)^{\frac{3}{2}}}$$

$$\left(1 + \frac{2\varphi}{c^2}\right) + 2\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right) - \frac{2}{c^2}\left(\varphi + \frac{2\varphi^2}{c^2}\right) + 2\left(1 + \frac{4\varphi}{c^2}\right)\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right) = 0$$

$$-1 - \frac{2\varphi}{c^2} - \frac{2\varphi}{c^2} - \frac{4\varphi^2}{c^4} + 2\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right) + 2\left(1 + \frac{4\varphi}{c^2}\right)\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right) = 0$$

$$\left(1 + \frac{2\varphi}{c^2}\right) - \frac{2\varphi}{c^2} - \frac{4\varphi^2}{c^4} + \left(-\frac{2v^2}{c^2}\right) + 2\left(1 + \frac{4\varphi}{c^2}\right)\left(1 + \frac{2\varphi}{c^2} - \frac{v^2}{c^2}\right)$$

$$= 0 \quad (3.2.37)$$

$$3\left(1 + \frac{2\varphi}{c^2}\right) + \frac{8\varphi^2}{c^4} - \frac{4v^2}{c^2} + \frac{2\varphi}{c^2} - \frac{8\varphi v^2}{c^4} \ = 0 \qquad (3.2.38)$$

$$3 + \frac{8\varphi}{c^2} + \frac{8\varphi^2}{c^4} - \frac{4v^2}{c^2} - \frac{8\varphi v^2}{c^4} = 0 \tag{3.2.39}$$

For stationary vacuum constituents

$$v = 0 \tag{3.2..40}$$

Equation(3.2.39) reads

$$3 + \frac{8\varphi}{c^2} + \frac{8\varphi^2}{c^4} = 0$$

$$8\varphi^2 + 8\varphi c^2 + 3c^4 = 0$$

Solving for φ

$$\varphi = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{3.2.41}$$

$$\varphi = \frac{-8c^2 \pm \sqrt{64c^4 - 48c^4}}{16} \tag{3.2.42}$$

Substituting (3.2.42)in the energy E relation (3.2.23)

$$E = \pm\sqrt{-2}\ mc^2 \tag{3.2.43}$$

Consider now a vacuum is full of photons, this means that

$$\frac{8\varphi}{c^2} + \frac{8\varphi^2}{c^4} - 1 = 0 \tag{3.2.44}$$

Using (3.2.41)

$$\varphi = \frac{-4c^2 \pm \sqrt{16c^4 + 12c^4}}{8}$$

$$\varphi = \frac{-4c^2 \pm 2\sqrt{7c^4}}{8} = \frac{-1}{2}c^2 \pm \frac{\sqrt{7}}{4}c^2 \tag{3.2.45}$$

Inserting equation (3.2.45) in equation (3.2.23) the energy is given by

$$E_v = mc^2 + 2m\left(\frac{-1}{2}c^2 \pm \frac{1}{\sqrt{2}}c^2\right) \tag{3.2.46}$$

$$E = \pm\sqrt{-2}\ mc^2 \tag{3.2.47}$$

(3.3) Energy Conservation Relations in Newton , Generalized Special Relativistic Mechanics and Force

Mubarak Dirar work is concerned with energy conservation in GSR. To see how energy is conserved he considered the generalized special relativistic energy equation.

$$E = \frac{m_0 c^2}{\sqrt{1 - 2\varphi - \frac{v^2}{c^2}}} \tag{3.3.1}$$

Rearranging and multiplying by m, yields

$$E = \frac{m_0 c^2}{\sqrt{\frac{mc^2 - 2\left(m\varphi - \frac{1}{2}mv^2\right)}{mc^2}}} \tag{3.3.2}$$

Thus when Newtonian energy

$$E_N = T + V \tag{3.3.3}$$

The definition of Force in Terms of Potential a Newton law, the energy wave equation is takes the form.

$$E = \frac{p^2}{2m} + V = constant \tag{3.3.4}$$

Where the total energy is constant differencing the equation (3.3.4) with respect to time given

Where the momentum is given by

$$p = mv \tag{3.3.5}$$

Using relation (3.3.5) and substituting in equation (3.3.4)

$$v\frac{dp}{dt} = -\frac{dV}{dt} \tag{3.3.6}$$

And the force is

$$F = \frac{dp}{dt} \tag{3.3.7}$$

Using relation in (3.3.6)

$$F = -\frac{1}{v}\frac{dv}{dt} = -\frac{dt}{dx}\frac{dv}{dt} \quad (3.3.8)$$

Thus equation (3.3.8) becomes

$$F = -\frac{dV}{dx} \quad (3.3.9)$$

This is the formal definition of F in terms of V for special relativity one has:

$$E^2 = c^2 p^2 + m_0^2 c^4 \quad (3.3.10)$$

By differencing equation (3.3.10) with respect to time gives

$$2E\frac{dE}{dt} = 2c^2 P\frac{dp}{dt} + 0 \quad (3.3.11)$$

The force is defined as

$$F = \frac{dp}{dt} \quad (3.3.12)$$

Substituting in (3.3.11) and dividing by $(2c^2 P)$ yields

$$\frac{2E}{2c^2 P}\frac{dE}{dt} = F \quad (3.3.13)$$

But $P = mv \qquad E = mc^2 \quad (3.3.14)$

Substituting in (23) gives

$$\frac{mc^2}{c^2(mv)}\frac{dE}{dt} = \frac{1}{v}\frac{dE}{dt}$$

$$\frac{dt}{dx}\frac{dE}{dt} = \frac{dE}{dx} = F \quad (3.3.15)$$

Which relates force to energy but according to GSR the energy satisfies

$$E = \frac{m_0 c^2}{\sqrt{g_{00} - \frac{v^2}{c^2}}} \quad (3.3.16)$$

$$E^2 = \frac{{m_0}^2 c^4 E^2}{g_{00}E^2 - c^2 p^2} \quad (3.3.17)$$

Divides by E^2

$$1 = \frac{{m_0}^2c^4}{g_{00}E^2 - c^2p^2} \tag{3.3.18}$$

$$g_{00}E^2 - c^2p^2 = {m_0}^2c^4 \tag{3.3.19}$$

Thus

$$g_{00}E^2 = c^2p^2 + {m_0}^2c^4 \tag{3.3.20}$$

Differentiating with respect to given

$$E^2\frac{dg_{00}}{dt} + g_{00}2E\frac{dE}{dt} = 2c^2P \ \ \frac{dP}{dt} \tag{3.3.21}$$

Rearranging again by dividing by $2c^2P$ yields

$$\frac{E^2}{2C^2P}\frac{dg_{00}}{dt} + \frac{2Eg_{00}}{2C^2P}\frac{dE}{dt} = F \tag{3.3.22}$$

From energy equation E= mC^2 substituting in (3..3.21) gives

$$\frac{m^2c^4}{2C^2mv}\frac{dg_{00}}{dt} + \frac{2\mathrm{m}C^2}{2C^2mv}g_{00}\frac{dE}{dt} = F$$

Thus

$$\frac{mc^2}{2}\frac{dt}{dx}\frac{dg_{00}}{dt} + \frac{dt}{dx}g_{00}\frac{dE}{dt} = F \tag{3.3.23}$$

Thus

$$F = \frac{dP}{dt} = \ \frac{E}{2}\frac{dg_{00}}{dx} + g_{00}\frac{dE}{dx} = \tag{3.3.24}$$

$$g_{00} = 1 + \frac{2\varphi}{c^2} \tag{3.3.25}$$

Divides by m

$$g_{00} = 1 + \frac{2m\varphi}{mc^2} = \ 1 + \frac{2V}{E} \tag{3.3.26}$$

Substituting

$$g_{00} = 1 + \frac{2V}{E} \tag{3.3.27}$$

Inserting (3.3.27) in (3.3.24) yields

$$F = \frac{dP}{dt} = \frac{E}{2}\frac{2d(VE^{-1})}{dx} + (1 + \frac{2V}{E})\frac{dE}{dx}$$

Thus

$$F = \frac{E}{2}(2)(E^{-1})\frac{dV}{dx} - E^{-2}VE\frac{dE}{dx} + \frac{dE}{dx} + \frac{2V}{E}\frac{dE}{dx} \qquad (3.3.28)$$

Cancelling similar terms in equation (3.3.28) yields

$$F = \frac{dV}{dx} - \frac{V}{E}\frac{dE}{dx} + \frac{dE}{dx} + \frac{2V}{E}\frac{dE}{dx} \qquad (3.3.29)$$

Thus

$$F = \frac{dV}{dx} + \frac{dE}{dx} + \frac{V}{E}\frac{dE}{dx} \qquad (3.3.30)$$

When E is conserved

$$\frac{dE}{dx} = 0 \qquad (3.3.31)$$

When the potential is positive .i.e. repulsive

$$V = \longrightarrow\longrightarrow \ -V \qquad (3.3.32)$$

This is since g_{00} is derived by assuming negative attractive potential. Thus using (3.3.31) and (3.3.32) in equation (3.3.30) yields

$$F = \frac{dV}{dx} \qquad (3.3.33)$$

This is the ordinary definition of energy.

3.4) Sunspots and Its Effects on Space Weather

Mubarak Derar, and others tries to explain change of photon energy by using GSR.Sun, a star of spectral type G2 is main source of energy to the earth.

Being close to earth, Sun produces a resolvable disk of great details

, which is not possible for other stars. Solar flares and control mass ejections are the enigmatic phenomena that occur in the solar atmosphere and regularly bombard the Earth's environment in addition to the solar wind .Thus it become important for us not only to understand these physical processes of the sun ,but in addition how these activates affect the earth and it's surrounding .Thus a branch of study called "Space Weather " had emerged in the recent past ,which connects activity and associated energetic phenomena that occur in the atmosphere of the sun

and their influence on the Earth.(RAMAN,K,S,Febrauary 22,2011)

Sunspots are regions in the sun's photosphere where intense magnetic files cause the temperature and radiation to be less than in the surrounding, hotter and brighter photosphere gases. A single sunspot

Consists of one or more dark cores, called umbra. Often surrounding by a less dark area called penumbra. In the umbra, very intense, longitudinally oriented magmatic fields cause the photosphere gasses to become very cool, and thus dark compared to overall photosphere.

Sunspots have tendency to appear in magnetically bipolar groups. In each group there are normally tow major spots, oriented approximately east-west, called the leading, preceding or western, and the following or eastern spot. The leading spot is usually larger in size and has stronger magnetic field strength. It is first to form, first to develop penumbra, and last to dissipate. Also the leading spot is often located slightly closer to the equator than the following.

Sunspot, in contrast to the thin flux tubes associated with NBPs, are must larger structures (with typical thickness in the range of 10000 to 20000km) that are strongly magnetized (around 3000 G in the central regions) . they are visible on the solar surface as dark features with a dark core called the umbra with a much lower temperature (around 40000 K) than the ambient atmosphere and surrounded by lighter region called the penumbra .the darkness of sunspots has traditionally been attributed to suppression of convective energy transport (relative to the surrounding photosphere) by the strong magnetic field. Orientation of the magnetic field is mainly vertical in the centre of the umbra and becomes increasingly inclined with radial distance to about 700 (with respect to the vertical) at the edge of the penumbra , where the field strength drops to about 1000 G .the penumbra displays radial filaments along which fluid motions with speeds OF several kilometers per second occur .this is well-known E vershed effect , discovered in Kodaikanal, India in 1909 ,the origin of which is still being debated .sunspot umbrae also reveal fine structure in the form of bright point's orumbral dots with atypical diameter of about 150 km and brightness comparable to the photosphere .it was earlier believed that the magnetic field in umbra dots is reduced compared to the background umbra but recent observations do not indicate a decrease in field strength .the physical mechanism responsible frothier information is most likely related to convention in a vertical magnetic field . Recent high- resolution observations have shown that the penumbral magnetic field exhibits an "interlocking comb structure ", consisting of two distinct group of field lines associated with :(a) inclined bright filaments, and (b) almost horizontal dark filaments,. From a theoretical viewpoint this dual topology is also not well understood, it has been suggested that buoyancy and downward pumping of magnetic may contribute to creating and maintaining such structures.

The number of sunspots and sunspot group (sunspot number) present on the solar surface changes with time and exhibit a cycle behavior with an approximately 11 year period. The amplitude of the cycle (often called the strength of the cycle) varies from one cycle to another .

Sunspots occur typically in the latitude range $\pm 35^0$ and drift in latitude towards the equator as the cycle progresses (spÖrer law)

In recent year evidence has accumulated that the solar cycle has a long – term modulation consisting of epochs of hyperactivity (most recent being the Medieval maximum in the 12th century) as well as spells without sunspots (maunder minimum during 1645-1715). These periods of abnormal activity are without explanation incidentally , the total solar irradiance (the energy from the sun observed at earth per unit time and unit wavelength interval) also exhibits a

11 year cycle which is in phase with the sunspot cycle and has implications for the terrestrial climate .

The sun consists of very dense plasma gas this gas consist of some fast electrons elementary particles .these fast particles can suitably describe by the special relativity (SR) where the time t, displacement x and mass m for any frame moving with constant velocity v with respect to the particle is given by :

$$t = \frac{t_0}{\sqrt{1 - v^2/c^2}} = \Upsilon_{0t_0}$$

$$x = \frac{x_0}{\gamma_0} = x_0\sqrt{1 - \frac{v^2}{c2}}$$

$$m = \gamma_{0m0} \qquad (3.4.1)$$

Where x_0 $t_{0\,,m0}$ is the time, displacement and mass for the frame in which the particles is at rest with respect to it. These SR relations, suffers from atermstarding for potential energy. This motirate some physics to propose generalized version of SR.

Known as generalized SR (GSR) .in this new model x , $t_{,m}$ are given by

$$t = \gamma t_0$$

$$x = \gamma^{-1} x_0$$

$$m = \gamma m_0 \qquad (3.4.2)$$

Where

$$\gamma = \left(1 + \frac{2\varphi}{C^2} - \frac{v^2}{C^2}\right)^{\frac{-1}{2}} \qquad (3.4.3)$$

Where

φ = potenial per unit mass

$$\varphi = \frac{v}{m} \qquad (3.4.4)$$

The particles energy E in this version is given by :

$$E = MC^2 = \gamma\, m_{0c^2} \qquad (3.4.5)$$

For funately, unlike SR, GSR, energy farmutaeredces to new tantian one for weak field and

Small velocity, where $V \ll C\varphi \ll C$

$$E = m_0 c^2 \left(1 + \frac{2\varphi}{C^2} - \frac{v^2}{C^2}\right)^{\frac{-1}{2}}$$

$$m_0 c^2 \left(1 + \frac{2\varphi}{C^2} - \frac{v^2}{C^2}\right)^{\frac{-1}{2}}$$

$$= m_{0c^2 - \varphi m_{0+\frac{1}{2}m_{0c^2}}}$$

For repulsive force, the potential and kinetic energy are given by:

$$V = -m_{0\varphi}$$

$$T = \frac{1}{2} m_{0v^2}$$

This is the total energy is given by :

$$E = T + V + M_{0C^2} \quad (3.4.6)$$

This is usual Newton energy formula with additional term starting for rest mass energy.

In explanation of darkness of sunspots by using generalized relativity

Sunspots are closely related to the sun magnetic storms this relation is explained by using GSR theory.

Plasma equation of motion relates the acceleration of particles to the applied pressure P and potential V according to the relation

$$nm \frac{dv}{dt} = -\nabla P - \nabla V \quad (3.4.7)$$

Where n is the number of particles per unit volume, m is the mass of are particles and v is the particles velocity.

Rearranging (3.4.7) in are dimension yields.

$$nm \frac{dv}{dx}\frac{dx}{dt} = -\frac{\partial P}{\partial x} - \frac{\partial V}{\partial x} \quad (3.4.8)$$

This

$$nmv\frac{dv}{dx} = -\frac{dP}{dx} - \frac{dV}{dx}$$

$$nm\int vdv = -\int dP - \int dV + C$$

$$E = \frac{n}{2}mv^2 + P + V = C$$

Hence the energy per unit volume I,e. the fluid energy density is given by :

$$E = K_e + V + P \qquad (3.4.9)$$

Where K_e is the kmethi energy henle

$$E = \frac{n}{2}mv^2 + P + V \qquad (3.4.10)$$

E t is interesting to note that this new expression consists of an additional term representing the pressure .for a single particle, where neglecting pressure the energy radius to the ordinary new Tinian are i.e.

$$E = \frac{1}{2}mv^2 + V \qquad (3.4.11)$$

On the other hand GSR energy relation is given by

$$E = MC^2 = \gamma\, m_{0c^2}$$

$$hf = \gamma hf_0$$

Where

$$hf = MC^2\, m_0c^2 = hf_0$$

$$hf = \left(1 + \frac{2\varphi}{C^2} - \frac{v^2}{C^2}\right)^{\frac{-1}{2}} hf_0$$

Ignoring the velocity effect by assuming very large potential compared to very low speed of reference frame yields

$$hf = \left(1 + \frac{2m_0\,\varphi}{m_0c^2}\right)^{\frac{-1}{2}} hf = \left(1 - \frac{2V}{m_0C^2}\right)^{\frac{-1}{2}} hf_0$$

By assuming that

$$\varphi \ll c^2$$

$$hf = \left(1 - \frac{2V}{m_0c^2}\right)$$

this means that any attractive strong magnetic field lowers photon energy and make it the strong attractive uniform magnetic field .

$$\bar{\bar{E}} = -V_m$$

$$n_P = n_0 e^{-E_P/\bar{\bar{E}}} = n_0 e^{-\frac{E_P}{V_m}} = e^{hf_0 - v/v_m}$$

Where

V_m = Average uniform magnetic field

The space weathers its effects on human life and then to cause malfunction and also loss of human activities and also to influence the earth weather and climate change.

A lot of broadcast radio communication system base on the reflection of radio waves from the ionosphere layer it is one of the upper layers of earth's atmosphere, the altitude above the ground between 85 kilometer and up to about thousand kilometers. The air in this layer is exposed in Electro ionization (i.e. loose electron from air molecules or atoms) Due to the ultraviolet rays coming from the sun, as well as the impact of the solar wind. For this reason, this variable class constantly, where affected by a succession of night and day, and the succession of the four seasons and the cycle of the solar activity.

Including global positioning system known as GPS and because of changes in terrestrial ionosphere layer during the solar storm, the signals issued by satellites GPS systems has crossed the ionosphere that suffer so-called blink scintillation, and therefore less accurate positioning at the reception on the ground devices, GPS "Global positioning system" system is US system, there is Russian system "Gelosnas""Glosnas", and there is also an European system "Galileo""Gallileo", and finally entered China in satellite navigation system technology.

Storms geomagnetism affect as well as the increase in the radiation intensity above the solar radiation on the Earth's atmosphere, and it is through heating the atmosphere air and make it expands, which increases air resistance to the movement of satellites low orbits, making them slow down to the point where you may drop gradually towards the earth and burn in the atmosphere.

Something similar to the space laboratory Skylab orbital Skylab has happened during the geomagnetism storm in 1979, he fell to wards

(3.5) Generalized the General Relativity Using Generalized Lorentz Transformation

Mubarak Dirar derived new Lorentz transformation dependent on field potential. The Principle of Special Relativity states that the laws of nature are invariant. Under a particular group of space-time coordinate transformations, called Lorentz transformations .A Lorentz transformation is a transformation from one system of space-time coordinates S to another system$\acute{S}$. Let us derive a new coordinate transformation from one inertial system to another, which replaces the Galilean transformation, on the basis of Einstein's two postulates for the special theory of relativity. For this purpose, we consider two inertial systems $S(x, y, z, t)$ and $S\ (x', y', z', t')$. The inertial system S' is assumed to be uniformly moving in the x direction in a potential field $\emptyset$ with velocity v relative to the inertial system S, keeping each coordinate axis parallel to the corresponding axis of the latter. Now, let an event occur at the position (x, y, z) at the time t in the inertial system S, and let the same event occur at the corresponding position (x, y', z') and at the corresponding time t' in the inertial system S. Then, one needs to find how the sets of space-time coordinates, (x, y, z, t) and (x, y', z, t') are transformed to each other under the two postulates for the special theory of relativity..

The distance between the origins of two axes is given by L.

According to Newton's second law of motion the force F can be expressed in terms of the mass m and acceleration a as

$$F = ma \tag{3.5.1}$$

Thus the potential V is given by

$$V = m\varphi = \int F dx = \int madx = ma\int dx = max$$

There φ is defined as the potential per unit mass. Thus $m\varphi = max$

Hence

$$\varphi = ax \tag{3.5.2}$$

Let two refernce frames (x,t) and $(\acute{x} + \acute{t})$ moves with initial velocity v_0 and constant acceleration a with respect to each others. Thus the distance between their origin $\xrightarrow{r}$ at any time t is given by

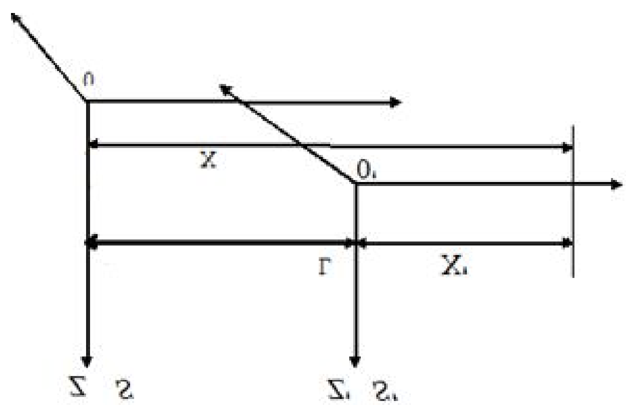


Fig (3.5.2) shows two inertial systems S and $\acute{S}$

$$L = v_0 t + \frac{1}{2} a t^2 \tag{3.5.3}$$

i.e $$L = v_0 t + \frac{1xa}{2x} t^2$$

Using equation (3.5.3) one can rewrite equation (3.5.44) as

$$L = v_0 t + \frac{\varphi}{2x} t^2 \tag{3.5.4}$$

This represents the length as measured by the observer O. assuming v_0

And φ to be the same for all observers, the length for observer $\acute{O}$ is given

by $\acute{L} = v_0 \acute{t} + \frac{1}{2x} axt^2 = v_0 \acute{t} + a\frac{\acute{x}}{2\acute{x}} \acute{t}^2$

$$\acute{L} = v_0\acute{t} + \frac{1}{2x}axt^2 = v_0\acute{t} + \frac{\acute{\varphi}}{2\acute{x}}\acute{t}^2 \qquad (3.5.5)$$

The space time coordinate in two frames can be described by Lorentz transformation. According to Lorentz transformation

$$\acute{x} = \gamma(x + L) = \gamma\left(x + vt + \frac{\varphi}{2x}t^2\right) \qquad (3.5.6)$$

$$x = \gamma(\acute{x} + \acute{L}) = \gamma\left(\acute{x} + v\acute{t} + \frac{\varphi}{2\acute{x}}\acute{t}^2\right) \qquad (3.5.7)$$

Consider now a source of light that emits pulse when the two frames origin coincide, i.e $t = \acute{t} = 0$

The light pulse which is emitted travels distances x and $\acute{x}$ respectively, where

$$x = ct \qquad \acute{x} = c\acute{t} \qquad (3.5.8)$$

Substituting (3.5.8) in (3.5.9) yields

$$c\acute{t} = \gamma\left(ct + vt + \frac{\varphi}{2ct}t^2\right)$$

$$\acute{t} = \gamma\left((1 + \frac{v_0}{c})t + \frac{\varphi}{2c^2}t\right)$$

$$\acute{t} = \gamma\left[1 + \frac{v_0}{c} + \frac{\varphi}{2c^2}\right]t \qquad (3.5.9)$$

Inserting also (3.5.8) in (3.5.7) gives

$$ct = \gamma\left(c\acute{t} - v\acute{t} - \frac{\varphi}{2c\acute{t}}\acute{t}^2\right)$$

$$m = \frac{m_0}{\sqrt{1+\frac{2\varphi}{C^2}-\frac{v^2}{C^2}}} = m = \frac{m_0}{\sqrt{g_{00}-\frac{v^2}{C^2}}} \qquad (3.5.10)$$

From (9) and (10)

$$t = \gamma^2\left[1 - \frac{v_0}{c} - \frac{\varphi}{2c^2}\right]\left[1 + \frac{v_0}{c} + \frac{\varphi}{2c^2}\right]t \qquad (3.5.11)$$

Therefore

$$\gamma = \frac{1}{\sqrt{\left[1-\frac{v_0}{c}-\frac{\varphi}{2c^2}\right]\left[1+\frac{v_0}{c}+\frac{\varphi}{2c^2}\right]}} \qquad (3.5.12)$$

It is very interesting to note that when no field exists

$$\varphi = 0 \tag{3.5.13}$$

The factor γ in equation 3.5.(12) reduces to

$$\gamma = \frac{1}{\sqrt{\left[1 - \frac{v_0}{c} - \frac{\varphi}{2c^2}\right]\left[1 + \frac{v_0}{c} + \frac{\varphi}{2c^2}\right]}} = \frac{1}{\sqrt{\left[1 - \frac{v_0^2}{c^2}\right]}} \tag{3.5.14}$$

which is ordinary SR relation. A direct insertion of equation (3.5.12) in (3.5.6) and (3.5.7) yields

$$\acute{x} = \frac{(x + v_0 t + \frac{\varphi}{2c^2} t^2)}{\sqrt{\left[1 - \frac{v_0}{c} - \frac{\varphi}{2c^2}\right]\left[1 + \frac{v_0}{c} + \frac{\varphi}{2c^2}\right]}} \tag{3.5.15}$$

$$x = \frac{(\acute{x} + v_0 \acute{t} + \frac{\varphi}{2c^2} \acute{t}^2)}{\sqrt{\left[1 - \frac{v_0}{c} - \frac{\varphi}{2c^2}\right]\left[1 + \frac{v_0}{c} + \frac{\varphi}{2c^2}\right]}} \tag{3.5.16}$$

In the absence of fields again (3.5.15) and (3.5.16) reduces to that of SR.

The expression for energy is given by.

$$E = mc^2 = \gamma m_0 c^2 \tag{3.5.17}$$

Inserting (12) in (17) yields

$$E = \frac{m_0 c^2}{\sqrt{\left[1 - \frac{v_0}{c} - \frac{\varphi}{2c^2}\right]\left[1 + \frac{v_0}{c} + \frac{\varphi}{2c^2}\right]}} \tag{3.5.18}$$

When no field exists the energy relation reduces to

$$E = \frac{m_0 c^2}{(1 - \frac{v_0^2}{c^2})} \tag{3.5.19}$$

Let now

$$x = \frac{v_0}{c} + \frac{\varphi}{2c^2} \tag{3.5.20}$$

Assuming

$$\frac{v_0}{c} > \frac{\varphi}{2c^2} \tag{3.5.21}$$

Equation (3.5.18) becomes

$$E = m_0 c^2 (1 - \frac{v_0{}^2}{c^2})^{\frac{-1}{2}} \qquad (3.5.22)$$

But for law speed

$$\frac{v_0}{c} << 1 \qquad (3.5.23)$$

Thus

$$E = m_0 c^2 (1 + \frac{v_0{}^2}{2c^2}) \qquad (3.5.24)$$

But according to Newton's laws

$$v^2 = v_0{}^2 + 2\varphi \qquad (3.5.25)$$

Thus

$$E = m_0 c^2 \left[1 + \frac{v^2}{2c^2} - \frac{\varphi}{c^2}\right]$$

$$E = m_0 c^2 + \frac{1}{2} m_0 v^2 + m_0 \varphi - m_0 c^2 + T + V \qquad (3.5.26)$$

Where

$$V = - m_0 \varphi$$

$$T = \frac{1}{2} m_0 v^2 \qquad (3.5.27)$$

This is the usual Newton energy relation beside rest mass term.

(3.6) Utilization of Photon Equation of motion to obtain Electromagnetic Momentum, Time & Length in Einstein Generalization of Special Relativity

The photon equation of motion was used by Fatima Madani to incorporate the potential term in Lorentz transformation.

The behavior of photons within the framework of (SR) is not consistent within that of general relativity (SR) [11,12].In (SR) the energy of the photon is not affected by the gravitational field [13].this is direct conflict with the prediction of the gravitational red shift by (GR)[14].Such prediction was confirmed experimentally by observing the gravitational red shift at the stars

[15].Thus the expression of photon energy and momentum in the gravitational field from (SR) and (GR) stand points need to be modified.

Several attempts are made to modify (SR) to include the effect of fields.[16.17.18]One of them that made by M.Dirar he study nuclear mass defect and the neutrino mass problem [19,20].But its derivation is complicated A simple derivation is made by Savickas [21].Both derivations are similar to each other ,but the former consists of an additional term in the expression of mass and energy.

uniting this work is concerned with the expression of energy and mass of the photon in both(SR)and (GR).Relaying on the behavior of the photon in the gravitational field to derive the expression for mass and energy ,as well as finding the generalized momentum expression in the presence of electromagnetic fields.

The (GSR) expression for the mass and the energy can be obtained here by using the expression of the invariant proper length in the four dimensional space_ time coordinates. The invariant length is given by [19]:

$$d\tau^2 = g_{\mu\gamma} dx_\mu dx^\nu \qquad (3.6.1)$$

For one dimensional physical system

$$d\tau^2 = g_{00}(Cdt)^2 + g_{xx}(dx)^2 \qquad (3.6.2)$$

Where:

$$x_0 = Ctx^2$$

The invariant length can be written in terms of the velocity in the form

$$d\tau^2 = g_{00}C^2(dt)^2 + g_{xx}(\frac{dx}{dt})^2 dt^2$$

$$= g_{00}C^2(dt)^2 + g_{xx}v_x^2 dx^2 \qquad (3.6.3)$$

In the weak field limit the components of the metric takes the form [19].

$$g_{00} = 1 + \frac{2\varphi}{C^2} \qquad g_{xx} = -1 \qquad (3.6.4)$$

Where φ represents the potential per unit mass

For a system at rest in free space:

$$\varphi = 0$$

$$\frac{dx}{dt} = v_x = 0$$

$$g_{00} = 1 + \frac{2\varphi}{C^2} = 1$$

$$g_{xx} = -1 \qquad t = t_0 \tag{3.6.5}$$

In this case:

$$d\tau^2 = g_{00}C^2(dt)^2 + (-1)(\tfrac{dx}{dt})^2 dt^2$$

$$d\tau^2 = C^2(dt_0)^2 \tag{3.6.6}$$

Since $d\tau^2$ is assumed to be invariant thus equations (3.6.3) and (3.6.6) give

$$C^2(dt_0)^2 = d\tau^2 = C^2[g_{00} + g_{xx}v_x^2]dt^2 \tag{3.6.7}$$

Where:

$$\gamma = [g_{00} + g_{xx}\frac{v_x^2}{C^2}]^{\frac{1}{2}}$$

$$= [g_{00} + \frac{g_{xx}v_x^2}{C^2}]^{\frac{1}{2}} \tag{3.6.8}$$

Where:

$$v_x = v$$

Thus:

$$dt_0 = \gamma dt \tag{3.6.9}$$

If the photon momentum is P, and the force on it is F, The equation of motion of a photon is given by:

$$\frac{dP}{dt} = F \qquad \frac{d(mc)}{dt} = F = \nabla E = \frac{dE}{dx} \tag{3.6.10}$$

Where:

C is the speed of light

E is the energy

$$F = m\frac{dv}{dt} = ma = m\frac{dx}{dt}\frac{dv}{dx}$$

$$= mv\frac{dv}{dx} = \frac{d(\frac{1}{2}mv^2)}{dx} = \frac{dE}{dx} \quad (3.6.11)$$

And

P=mc=momentum

Hence:

$$\frac{d(mc)}{dt} = \frac{dE}{dx}\frac{dmc}{dx}\frac{dx}{dt} = \frac{dE}{dx}$$

Since the speed of the photon is constant:

$$\frac{dx}{dt} = v = C \quad (3.6.12)$$

Hence:

$$C\frac{dmc}{dx} = \frac{dE}{dx}$$

But C is constant therefore

$$\frac{dmC^2}{dx} = \frac{dE}{dx} \quad (3.6.13)$$

Integrating both sides yields

$$\int dE = \int dmC^2$$

$$E = mC^2 \quad (3.6.14)$$

This is the ordinary expression for energy in (SR).

To obtain the expression for the energy in a curved space-time , one can utilize the equation (3.6.10)for a frame to get the rest mass

$$\frac{dm_0c}{dt} = F \quad (3.6.15)$$

Where the rest mass for a system at rest is given by:

$$m = m_0\varphi$$

For a frame in which a system is not at rest the mass is denoted by m, and equation (10) reads

$$\frac{d(mc)}{dt} = F \quad (3.6.16)$$

With the aid of equation (3.6.15) and equation (3.6.10) and utilizing equation (3.6.9), one gets

$$\frac{d(m_0 c)}{\gamma dt} = \frac{d(mc)}{dt} \qquad (3.6.17)$$

Thus:

$$(d\,(m_{10}c/\gamma dx) = d(mc)\,dx/dt\ \ dx/dt$$

But:

$$\frac{dx}{dt} = C$$

Hence:

$$\frac{Cd(m_0 c)}{\gamma dx} = \frac{Cd(mc^2)}{dx}$$

Since C is constant:

$$\frac{d(m_0 c^2)}{\gamma dx} = \frac{d(mC^2)}{dx} \qquad (3.6.18)$$

Thus:

$$\frac{C^2}{\gamma} dm_0 = C_2 dm$$

Viewing equation (8) γ is independent

$$\frac{C^2}{\gamma} \int dm_0 = C^2 \int dm$$

$$\frac{C^2}{\gamma} = C^2 m \qquad (3.6.19)$$

Thus the mass and energy E in a curved space-time is given by:

$$m = \frac{m_0}{\gamma} = mc^2 \qquad (3.6.20)$$

With the aid of the equation (8) is given by:

$$m = \frac{m_0}{\sqrt{g_{00} + g_{xx} \frac{v^2}{C^2}}} \qquad (3.6.21)$$

For Quai- Minkowskian space

$$g_{xx} = -1 \quad , \quad g_{0v} = 1 + \frac{2\emptyset}{C^2} \tag{3.6.22}$$

Thus:

$$m = \frac{m_0}{\sqrt{1+\frac{2\varphi}{C^2}-\frac{v^2}{C^2}}} = m = \frac{m_0}{\sqrt{g_{00}-\frac{v^2}{C^2}}} \tag{3.6.23}$$

The corresponding energy is given according to equation (3.6.14) an equation (3.6.23) by:

$$E = mC^2 = \frac{m_0 C^2}{\sqrt{1+\frac{2\varphi}{C^2}-\frac{v^2}{C^2}}} = \frac{m_0 C^2}{\sqrt{g_{00}-\frac{v^2}{C^2}}} \tag{3.6.24}$$

The expression resembles the energy found by Savickas (3.6.12). If one considers the expression of time in a curved space time the time is thus given by [19].

$$dt_c = \sqrt{g_{0v}}dt \tag{3.6.25}$$

In this case equation (3.6.17) can be rewritten as:

$$\frac{d(m_0 C)}{\gamma dt} = \frac{d}{dt_c}\left[m\frac{dx}{dt_c}\right]$$

$$\frac{C}{\gamma}\frac{dm_0}{dx}\frac{dx}{dt} = \frac{1}{g_{00}}\frac{d}{dt}\left[m\frac{dx}{dt}\right] = \frac{1}{g_{0v}}\frac{d(mC)}{dt}$$

$$\frac{C^2}{\gamma}\frac{dm_0}{dx} = \frac{1}{g_{00}}\frac{d}{dt}\left[mC\frac{dx}{dt}\right] = \frac{1}{g_{0v}}C\frac{d(mC)}{dt} = \frac{C^2}{g_{0v}}\frac{dm}{dx} \tag{3.6.26}$$

Thus

$$\frac{g_{0v}C^2}{\gamma}\int dm_0 = C^2\int dm$$

$$E = mC^2 = \frac{g_{0v}m_0 C^2}{\gamma} \tag{3.6.27}$$

Thus the mass is given by:

$$m = \frac{g_{0v}m_0}{\sqrt{g_{0v}-\frac{v^2}{C^2}}} \tag{3.6.28}$$

The corresponding energy is given with the aid of equation (3.6.14)

$$E = mC^2 = \frac{g_{0v} m_0 C^2}{\sqrt{g_{0v} - \frac{v^2}{C^2}}} \quad (3.6.29)$$

This resembles the expression of energy derived by M.Dirar.

The total momentum of a charged particle in an electromagnetic field can be found by considering the equation of motion of charged particle like the electron in an electromagnetic field. If the electron is affected by a magnetic field of flux density B, the equation of the motion becomes:

$$\frac{d(mv)}{dt} = Bev \quad (3.6.30)$$

But, since velocity ν and B is given by [19]:

$$B = \frac{\partial A}{\partial x} = \frac{dA}{dx} \qquad v = \frac{dx}{dt} \quad (3.6.31)$$

Inserting equation (30) in equation (29) yields:

$$\frac{d(mv)}{dt} = e\frac{dA}{dx}\frac{dx}{dt} = e\frac{dA}{dt} \qquad \frac{d(mv - eA)}{dt} = 0 \quad (3.6.32)$$

This equation looks like the equation of momentum conservation:

$$\frac{dP}{dt} = 0 \quad (3.6.33)$$

Comparing equation (33) and equation (32) yields

$$P = mv - eA \quad (3.6.34)$$

To throw light on termeA, on can use the definition of electric field intensity E in term of A to get:

$$E = -\frac{\partial A}{\partial t} = -\frac{dA}{dt} = -\frac{dA}{dx}\frac{dx}{dt} = -c\frac{dA}{dx} \quad (3.6.35)$$

Where the speed of photon is constant. Thus the work done by photon filed is given by:

$$W = +e\int E.dx = eC\int \frac{dA}{dx}dx = -eC\int \frac{dA}{dx}dx$$

$$W = -eCA \quad (3.6.36)$$

The photon energy is given also in terms of momentum P_P as:

$$E_P = P_P C \quad (3.6.37)$$

Where the mass term is neglected by assuming m_0 to be very small. But W is equalE_P. Thus:

$$E_P = W$$

$$P_P C = -eAC$$

Thus the photon momentum is given by:

$$P_P = -eA \tag{3.6.38}$$

Thus the equation (3.6.34) represents the sum of mechanical and photon momentum, i.e:

$$P = P_{mec} + P_P \tag{3.6.39}$$

Where:

$$P_{mec} = mv \qquad\qquad P_P = -eA \tag{3.6.40}$$

The total momentum can also be found from the equation of motion of the electron in the electric field, where:

$$\frac{d(mv)}{dt} = -eE \tag{3.6.41}$$

With the aid of the equation (3.6.35) one, gets:

$$\frac{d(mv)}{dt} = \frac{edA}{dt} = \frac{d(eA)}{dt}$$

$$\frac{d(mv - eA)}{dt} = 0 \tag{3.6.42}$$

$$\frac{d(mv - eA)}{dt}$$

Using the same procedures as in equation (3.6.32) and equation (3.6.33) again the total momentum P is given by:

$$P = mv - eA = P_{mec} + P_P \tag{3.6.43}$$

(3.7) Summary and Critique

The attempt made by researchers utilizes different approaches to incorporate the effect of potential on the Lorentz transformation besides space time mass and energy. Unfortunately none of them recognize the effect of the pressure on this parameters and quantities . Such effect is important to make special relativity conform with the energy relations of thermodynamics and plasma

Chapter Four

4.1 Pressure - Potential Dependent Lorentz Transformation and short range photon and crystal field from Plasma Equation

Plasma equation is used in this work to derive new non linear Lorentz transformation, beside new special relativistic energy relation dependent on potential, pressure and thermal energy. This expression reduces to the ordinary special relativity, and conforms with Newton thermodynamic and plasma energy equations. The plasma equation also predicts that photon pressure and electron gas potential can produce short range repulsive field. This short range field can be useful in constructing non singular cosmological model and describing the nature of black holes.

Classical physics divided into two different categories. The first one are particles which are described by Newton laws [106]. The second one are waves which are described by using Maxwell's equations [107].

The Newton laws are showed to be unable to describe Michelson and Morley experiment. This experiment shows that the speed of light is constant and is independent on the motion of the source or the observer [108]. This conflict was removed by Einstein who proposed the so called special relativity (SR). Special relativity is based on Lorentz transformation which leaves Maxwell's equations invariant [109].the SR shows that the laws of physics are invariant under Lorentz transformation .it also shows that space and time are not absolute but depends on the frame of reference [110]. The theory of SR succeeded in explaining a wide variety of physical phenomena. It explains photoelectric effect, Compton Effect, pair production, meson decay and transformation [111].the special theory of relativity is useful in describing high speed particles [111].

However SR suffers from noticeable setbacks for instance the SR energy relation does not satisfy correspondence principle. This is since SR energy relation does not have a potential term like that of Newton. Also SR states that electrons having speed v moving in free space and electrons having the same speed v moving around a certain nucleus have the same energy. This is in direct conflict with the laws of quantum mechanics and observed spectra of atoms [112].

Plasma state is the fourth state of matter. Plasma is an ionized fluid in which electric and magnetic field plays an important role [106,107] .thus fluid equation look more general than ordinary fluid equation, since the particles are affected by fields beside pressure effect [108,109].

This general nature of plasma equations motivates some scientists to derive new energy expressions, even to derive new quantum equation [110,111,112,113]. on the other hand special relativity (SR) energy relation seems to be in direct conflict with plasma energy equation for not recognizing thermal, pressure and potential energy [114,115]. This needs searching for a new modified SR version which accounts for these defects and tries to cure them. This was done in this work where a new Lorentz transformation which is pressure and potential dependent. The general nature of plasma equations is also used to describe the behavior of stellar and quasi-stellar objects specially collapsing stars like black holes [116, 117]. The latter problem is tackled in section (2) and section (3), while the former one is investigated in section (4). Sections (5) and (6) are devoted for discussion and conclusion

The history of gravitational field dates starts from the Newton inverse square law of gravitation [106]. This law explains successfully the motion of freely falling objects towards the earth surface. It is also explains some a astronomical phenomenon like the motion of planets around the sun, beside the motion of the moon and satellite around the earth. The satellite of the planets and the satellites in their orbits attributed.

To centrifugal force which counters balance the gravitational attractive force. The motion of astronomical objects is assumed to be inside hypothetical fluid called ether [107]. The effect of earth motion on the speed of light, which was studied by Mickelson and Morley, shows that no ether no ether exist and shows also that the speed of light is a universal constant. This is since the speed of light is not affected or changed by the motion of the source or the observer or both. This fact in direct conflict with Newton's law, specially the law of velocity addition the Galilean transformation [108]. This conflict was removed by the famous Einstein theory of special relativity (SR) which uses Lorentz transformation instead of Galilean transformation. This SR changes radically the motion of space and time. According to SR time interval and distance depend on the relative motion of the observer with respect to the mass energy. Einstein SR succeeded in explaining a wide verity of physical phenomena. It explains photoelectric effect, Compton Effect, pair production, Time dilatation in meson decay, beside more physical observations [109].

Later on Einstein generalizes SR to the so called general relativity (GR) to explain the gravitational phenomena [110, 111]. It assumes that the gravity results from the space bending made by matter [112]. Einstein GR succeeded in explaining most of gravitational phenomena [112]. Namely the so called big bang (BB) cosmological model explain some important cosmological phenomena like universe expansion, existence of relic microwave back ground and galaxy formation , beside stars evaluation filed is measured by the optional φ. This potential is defined as the work done to bring a unit mass from infinity to a certain point. According to the Newton law this potential affected by the matter density ρ.

Einstein special relativity (SR) and general relativity (GR) are one of the big a achievement in physics. Special relativity [106, 107] is concerned with describing the behavior of high speed particles of macro and micro world.

Unfortunately SR suffers from noticeable setbacks. First of all does not reduce to Newton one, since its energy expression for small velocity does not recognize potential term [108].Also SR in general does not have any term which is sensitive to field which is in direct conflict with the physics mean stream[113,114,115]. General relativity which partially solves this problem for gravitational field, successfully describes many astronomical and cosmological phenomena [112, 113]. However GR gives singular solutions for massive and super massive objects [116, 117]

This means that GR predicts its own break down in these application [116, 117] different attempts were made to cure these defects. The so called generalized special relativity think that still SR is valid by generalizing Lorentz transformation in the so called generalized SR (GSR)[118, 119]. Some authors also try to cure singularity problem by suggesting repulsive gravity force [120, 121, and 122]. But they are not based on Poisson equation or Maxwell statistical distribution. One thus needs a new model which cures some of these defects. This is done in section (4.1.2), which is concerned with non singular model and section (4.1.3) which is devoted for potential dependent Lorentz transformation.

4.1.1 Lorentz Pressure and Potential dependent Lorentz transformation

Plasma equation recently pays attention of many scientists. This is due to its general nature.

According to plasma equation when pressure only affects the motion of an electron moving with velocity v on gets:

$$nm\frac{dv}{dt} = mna = -\frac{dP}{dx} \qquad (4.1.1)$$

For thermal pressure:

$PV = NkT$, $P = \frac{N}{V}kT$ From which

$$P = nkT \qquad (4.1.2.)$$

Where $n = \frac{N}{V}$ number of particles per unit volume (density)

For constant uniform density of particles n, equation (1) becomes:

$$nma = -n\frac{dkT}{dx}$$

Then integrating both sides after omitting n one gets:

$$\int madx = -\int dkT = -kT$$

For constant mass m and acceleration a

$$max = -kT \qquad (4.1.3)$$

But more generally for constant acceleration and constant number density

$$nma = -\frac{dP}{dx}$$

Then

$$\int adx = -\int \frac{dP}{nm} = -\int dP_0$$

thus

$$ax = -P_0 \qquad (4.1.4)$$

Where dP_0= change of pressure for one particle per until mas (4.1.4)

This is similar to $\nabla\emptyset$ which is potential change per unit mass. Consider now the effect of pressure and potential on the particle. This makes equation (4.1.2.1)becomes:

$$nm\frac{dv}{dt} = man = -mn\frac{dP_0}{dx} - mn\frac{d\emptyset}{dx} \qquad (4.1.5)$$

Again when a is constant

$$ax = -P_0 - \emptyset \qquad (4.1.6)$$

Following ordinary Lorentz transformation, Consider now Lorentz transformation for two frames S and $\acute{S}$ such that:

$$x = \gamma(\acute{x} + L) \qquad (4.1.7)$$

Here one assumes that the two frames S and S/ moves in a field having potential $\emptyset$ with constant acceleration obeys Newton second law of motion. The two frames are assumed to be a distance L apart from each other at time t. thus :

$$\acute{x} = \gamma(x - L) \qquad (4.1.8)$$

Where L is given by:

$$L = v_0 t + \frac{1}{2}at^2 = v_0 t + at^2 - \frac{1}{2}at^2$$

$$=(v_0 + at)t - \frac{1}{2}\frac{ax}{x}t^2 = vt + \frac{1}{2}\left(\frac{P_0+\emptyset}{x}\right)t^2 \qquad (4.1.9)$$

$$x = \gamma\left(\acute{x} + v\acute{t} + \frac{1}{2}\left(\frac{\emptyset+P_0}{\acute{x}}\right)\acute{t}^2\right) \qquad (4.1.10)$$

$$\acute{x} = \gamma\left(x - vt - \frac{1}{2}\left(\frac{\emptyset+P_0}{x}\right)t^2\right) \qquad (4.1.11)$$

It is very interesting to note that this is a nonlinear Lorentz transformation, which is non linear in time. For simplicity let:

$$\emptyset + P_0 = \mathrm{D} \qquad (4.1.12)$$

For pulse of light moving with speed c. such that the origin of the two frames coincide at $(t = \acute{t} = 0)$. Thus:

$$x = ct \quad and \quad \acute{x} = c\acute{t} \qquad (4.1.13)$$

Thus

$$ct = \gamma\left(c\acute{t} + v\acute{t} + \frac{D}{2c\acute{t}}\acute{t}^2\right) = \gamma c\left(1 + \frac{v}{c} + \frac{1}{2}\frac{D}{c^2}\right)\acute{t} \text{ or}$$

$$t = \gamma\left(1 + \frac{v}{c} + \frac{1}{2}\frac{D}{c^2}\right)\acute{t} \qquad (4.1.14)$$

Similarly

$$c\acute{t} = \gamma\left(ct - vt - \frac{1}{2}\frac{D}{ct}t^2\right) = \gamma c\left(1 - \frac{v}{c} - \frac{1}{2}\frac{D}{c^2}\right)t$$

$$\acute{t} = \gamma\left(1 - \frac{v}{c} - \frac{1}{2}\frac{D}{c^2}\right) = n\gamma(1 - f)t \qquad (4.1.15)$$

Where

$$f = \frac{v}{c} + \frac{D}{2c^2} = \frac{v}{c} + \frac{(\emptyset+P_0)}{2c^2} \qquad (4.1.16)$$

Thus inserting equation (4.1.15) in (4.1.14) yields

$t = \gamma^2(1 + f)(1 - f)t$ so that $1=\gamma^2(1 - f^2)$ and $\gamma = (1 - f^2)^{\frac{-1}{2}}$

Thus

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c} + \frac{\emptyset+P_0}{2c^2}\right)^2}} \qquad (4.1.17)$$

This represents new potential and pressure dependent Lorentz transformation

This expression reduces to SR one when $\emptyset = 0$, $P_0 = 0$.

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \tag{4.1.18}$$

Therefore the energy is given by:

E=$mc^2 = \gamma m_0 c^2$

It is very interesting to note that this term of energy relation is nothing but that of ordinary SR.

For small v and$\emptyset$, such that $\emptyset \ll c^2 \quad P_0 \ll c^2$

$$E = m_0c^2\left(1 - \left(\frac{v}{c} + \frac{(\emptyset+P_0)}{2c^2}\right)^2\right)^{\frac{-1}{2}} = m_0c^2\left[1 + \frac{1}{2}\left(\frac{v}{c} + \frac{\emptyset+P_0}{2c^2}\right)^2\right]$$

$$E = m_0c^2 + \frac{1}{2}m_0v^2 + \frac{v}{c}\left(\frac{\emptyset+P_0}{2}\right) + \frac{\emptyset^2}{4c^2} + \frac{P_0^2}{4c^2} + \frac{\emptyset P_0}{2c^2} \tag{4.1.19}$$

It is very interesting to note that the presence of pressure in the energy expression resembles that of general relativity where

$T_{\mu v} = g_{\mu v}\rho + (\rho + P)U_\mu U_v$

It is also important to note that equation (4.1.17) can be simplified further by assuming

$$\frac{\emptyset + P_0}{2C^2} < \frac{v}{C}$$

To get

$$\left(\frac{v}{C} + \frac{(\emptyset+P_0)}{2C^2}\right)^2 = \frac{v^2}{C^2}\left(1 + \frac{(\emptyset+P_0)}{2v}\right)^2 \approx \frac{v^2}{C^2}\left(1 + \frac{(\emptyset+P_0)}{2v}\right)$$

But from plasma equation

$$m_0nv\frac{dv}{dx} = -m_0n\frac{dP_0}{dx} - m_0n\frac{d\emptyset}{dx} \quad ,$$

Rearrange this one get

$$\frac{1}{2}v^2 = -P_0 - \emptyset$$

Thus

$$\frac{1}{2}\left(\frac{v}{C} + \frac{\emptyset + P_0}{2C^2}\right)^2 = -\frac{(\emptyset + P_a)}{C^2}\left(1 + \frac{(\emptyset + P_0)}{v}\right) = -\frac{(\emptyset + P_0)}{C^2} + \cdots$$

According to equation (4.1.2.19).

$$E = m_0C^2 + \frac{1}{2}m_0v^2 - m_0P_0 - m_0\emptyset \qquad (4.1.20)$$

It is clear that the energy expression consists of potential beside pressure term similar to that of plasma equation

4.1.2 Short range force due to photon pressure

Photon plays an important role in the early universe and inside young star. Therefore it is very important to see how these photons affects the evolution of the universe and stars.

Consider Newton second law where the force is related to the momentum, i.

$$F = \frac{dp}{dt} = \frac{d(Mv)}{dt} \qquad (4.1.2.1)$$

For v = constant, equation (4.1.2.1) becomes

$$F = v\frac{dM}{dt} \qquad (4.1.2.2)$$

Where $\frac{dM}{dt}$ is mass flow rate and can be given for constant speed flow by:

$$\frac{dM}{dt} = m.n.v.A$$

Where n is number of photons, A cross section area and v is speed of the particle.

Insert $\frac{dM}{dt}$ in equation (4.1.3.2) we get:-

$$F = v.(mnvA) = mnv^2A \qquad (4.1.2.3)$$

For photon v = c where c is speed of light. Thus

$$F = mnAv^2 = \text{mnA}c^2 = \text{nAmC}^2 \qquad (4.1.2.4)$$

This relation can also be derived by using dimensional analysis where

$$F = \frac{mnAxv^2}{x} = \frac{mNc^2}{x} \qquad (4.1.2.5)$$

N = n x A total numbers of photon in the included volume.

$$F = \frac{Mc^2}{x} = \frac{energy}{x} \qquad (4.1.2.6)$$

Where

M= m N is the total mass.

But the pressure is given by

$$P = \frac{F}{A} = mnc^2 = 2\frac{S_{avg}}{c} \quad (4.1.2.7)$$

Where S_{avg} is energy flow per unit time per unit area, also

$$S_{avg} = \frac{1}{2}(mc^2n)c \quad (4.1.2.8)$$

Where mc^2n represents energy density. Thus the intensity of photons is given by:

$$\text{I} = \text{intensity} = (\text{energy density}) \times \text{c} \quad (4.1.2.9)$$

Also the force is related to the potential according to the expression

$$F \sim \frac{\partial V}{\partial x} \sim \frac{Energy}{distance} \quad (4.1.2.10)$$

Consider a photon as a particle moving inside fluid of photons in gravity field of potential per unit mass $\emptyset$. Assume also the photon is affected by fluid force. Thus

$$F = mnc^2A \quad (4.1.2.11)$$

Using Newton second law for plasma, thus the photon equations is given by:

$$mn\frac{dv}{dt} = F - m\nabla\emptyset \quad (4.1.2.12)$$

Since the photon moves with constant speed thus

$$mn\frac{dv}{dt} = mn\frac{dc}{dt} = 0 \quad (4.1.2.13)$$

Thus the equation of motion of the photon is given by

$$m\nabla\emptyset = m\frac{d\emptyset}{dx} = F = mnAc^2 \quad (4.1.2.14)$$

Considering the photon as gas obeying Maxwell-Boltzmann distribution

$$n = n_0 e^{-\beta\emptyset} \quad (4.1.2.15)$$

For very small value of β such that

$$\beta\emptyset < 1$$

$$n = n_0(1 - \beta\emptyset) \quad (4.1.2.16)$$

Inserting ((4.1.3.15) in (4.1.3.14) yields

$$m\frac{d\emptyset}{dx} = mn_0AC^2(1-\beta\emptyset) = C_1f$$

$$\frac{d\emptyset}{dx} = n_0AC^2(1-\beta\emptyset) = C_1f$$

Where

$$C_1 = n_0AC^2$$

$$f = 1-\beta\emptyset \qquad (4.1.2.17)$$

Thus

$$\frac{df}{dx} = -\beta\frac{d\emptyset}{dx} \qquad (4.1.2.18)$$

Hence equation (4.1.2.17) yields

$$-\frac{1}{\beta}\frac{df}{dx} = C_1f$$

Rearranging gives

$$\int\frac{df}{f} = -C_1\beta\int dx + C_2 \ , \ln f = -C_1\beta x + C_2$$

$$f = e^{C_2}e^{-C_1\beta x}=C_3e^{-C_1\beta x} \qquad (4.1.2.19)$$

From equation (4.1.3.18)

$$\emptyset = \frac{1}{\beta}\left(1-C_3e^{-C_1\beta x}\right) \qquad (4.1.2.20)$$

At: $x = 0 \ , \emptyset = \emptyset_0$

Where $\emptyset_0$ is the self energy.

Hence:

$$\emptyset_0 = \frac{1}{\beta}(1-C_3)$$

At: $x \to \infty$

$\emptyset = \emptyset_c$ = cosmic potential

Thus

$$\emptyset_c = \frac{1}{\beta}$$

Thus

$$\emptyset = \frac{1}{\beta}\left[1 - (1 - \beta\emptyset_0)e^{-C_1\beta x}\right]$$

$$\emptyset = \emptyset_0 e^{-C_1\beta x} \quad (4.1.2.21)$$

This is a short range repulsive field. This means that a photon gas at the early universe or inside stars can produce repulsive force which prevents singularity and gravitational collapse.

4.1.3 Short range field generated by electron gas in crystals

Four conductors and semiconductors free electrons plays an important role in their electronic properties. These electrons produce electric field inside the crystal. Thus they contribute to the crystal field. Since these electrons can be considered as a gas, thus it is quite obvious to use plasma equation to describe their behavior.

Consider an electron surrounded by electron cloud of density n and each contributes an electric field E_0 .The force on the electron is electric field beside crystal field $\emptyset$. Thus the equation of motion

$$m\frac{dv}{dt} = -\nabla\emptyset + nE_0 = -\nabla\emptyset - E_0 n_0 e^{-\beta\emptyset} \quad (4.1.3.1)$$

Let

$$c_0 = n_0 E_0$$

Using Taylor's series $e^{-\beta\emptyset}$ can be expanded in the form.

$$e^{-\beta\emptyset} = 1 - \beta\emptyset + \frac{(\beta\emptyset)2}{2!} + \frac{(\beta\emptyset)3}{3!} + \cdots \cong 1 - \beta\emptyset \quad (4.1.3.2)$$

For smallβ , such that $\beta\emptyset < 1$, $e^{-\beta\emptyset} \approx 1 - \beta\emptyset$

Thus equation (43)

$$m\frac{dv}{dt} = -\nabla\emptyset + c_0(1 - \beta\emptyset) \quad (4.1.3.3)$$

Consider uniform motion, such that

$$\frac{dv}{dt} = 0$$

Where speed of electrons are considered to be a uniform. Hence equation (4.1.4.3)reduced to

$$\nabla\emptyset = c_0(1-\beta\emptyset) \tag{4.1.3.4}$$

Or

$$\nabla\emptyset = c_0(1-\beta\emptyset) \tag{4.1.3.5}$$

$$\frac{d\emptyset}{dx} = c_0(1-\beta\emptyset) = c_0 - c_0\beta\emptyset \tag{4.1.3.6}$$

Define f such that

$$\frac{d\emptyset}{dx} = c_0 - c_0\beta\emptyset = f \tag{4.1.3.7}$$

Now let

$$c_1 = c_0\beta$$

Thus

$$c_0 - c_1\emptyset = f \tag{4.1.3.8}$$

Differentiating equation (4.1.3.8)yields

$$-c_1 d\emptyset = df$$

$$d\emptyset = -\frac{1}{c_1}df \tag{4.1.3.9}$$

Thus equation (4.1.3.9)gives

$$\frac{-1}{c_1}df = fdx \tag{4.1.3.10}$$

$$\frac{df}{f} = -c_1 dx \tag{4.1.3.11}$$

Integrating both side yields

$$\ln f = -c_1x + c_2 \tag{4.1.3.12}$$

Where c_2 is constant of the integration.

$$f = e^{-c_1x+c_2} \tag{4.1.3.13}$$

$$f = ce^{-c_1x} \tag{4.1.3.14}$$

Where

$$c = e^{c_2}$$

Equate equation (4.1.3.14) with (4.1.4.8) to get

$$c_0 - c_1\emptyset = ce^{-c_1 x} \qquad (4.1.3.15)$$

Let

$$c_3 = \frac{c_0}{c_1} \quad , \quad c_4 = \frac{c}{c_1}$$

$$\emptyset(x) = c_3 - c_4 e^{-c_1 x} \qquad (4.1.3.16)$$

Since self energy exists the origin, hence

At $x = 0$ $\quad \emptyset(0) = c_3 - c_4 = \emptyset_0$

Also vacuum energy exists at infinity hence

And $x = \infty$ $\quad \emptyset(\infty) = c_3 = \emptyset_v$

Therefore

$$\emptyset(0) = \emptyset_0 = \emptyset_v - c_4 \qquad (4.1.3.17)$$

Hence

$$C_4 = \emptyset_v - \emptyset_0$$

Inserting equation (4.1.3.16) in (4.1.3.17) yields

$$\emptyset = \emptyset_v + (\emptyset_0 - \emptyset_v)e^{-C_2 x} \qquad (4.1.3.18)$$

For negligible vacuum energy

$$\emptyset = \emptyset_0 e^{-C_2 x} \qquad (4.1.3.19)$$

Thus electron gas inside the crystal can produce short range repulsive fields which resembles that proposed some superconductors models.

4.2 Short Range Gravity Potential self energy and Nonlinear potential dependent Lorentz Transformation

Using Poisson equation beside Maxwell distribution law for very hot star core consisting of elementary particles one can find new Poisson equation. This equation predicts existence of short range gravity force. This short force may have a link with short range nuclear force, thus raises a hope in unifying gravity and nuclear force. This short range field beside long range field secures singular finite self energy. This central role of potential in unifying self energy for high relativistic particles at star cores requires seeking Lorentz transformation that accounts for effect of fields. This work derived new Lorentz transformation for accelerated frame. This transformation is potential dependent and reduces to SR and explains time dilation and gravitational red shift.

The history of gravitational field dates starts from the Newton inverse square law of gravitation [1]. This law explains successfully the motion of freely falling objects towards the earth surface. It is also explains some a astronomical phenomenon like the motion of planets around the sun, beside the motion of the moon and satellite around the earth. The satellite of the planets and the satellites in their orbits attributed.

To centrifugal force which counters balance the gravitational attractive force. The motion of astronomical objects is assumed to be inside hypothetical fluid called ether [107]. The effect of earth motion on the speed of light, which was studied by Mickelson and Morley, shows that no ether no ether exist and shows also that the speed of light is a universal constant. This is since the speed of light is not affected or changed by the motion of the source or the observer or both. This fact in direct conflict with Newton’s law, specially the law of velocity addition the Galilean transformation [108]. This conflict was removed by the famous Einstein theory of special relativity (SR) which uses Lorentz transformation instead of Galilean transformation. This SR changes radically the motion of space and time. According to SR time interval and distance depend on the relative motion of the observer with respect to the mass energy. Einstein SR succeeded in explaining a wide verity of physical phenomena. It explains photoelectric effect, Compton Effect, pair production, Time dilatation in meson decay, beside more physical observations [109].

Later on Einstein generalizes SR to the so called general relativity (GR) to explain the gravitational phenomena [110, 111]. It assumes that the gravity results from the space bending made by matter [112]. Einstein GR succeeded in explaining most of gravitational phenomena [112]. Namely the so called big bang (BB) cosmological model explain some important cosmological phenomena like universe expansion, existence of relic microwave back ground and galaxy formation , beside stars evaluation filed is measured by the optional φ. This potential is defined as the work done to bring a unit mass from infinity to a certain point. According to the Newton law this potential affected by the matter density ρ.

Einstein special relativity (SR) and general relativity (GR) are one of the big a achievement in physics. Special relativity [106, 107] is concerned with describing the behavior of high speed particles of macro and micro world.
Unfortunately SR suffers from noticeable setbacks. First of all does not reduce to Newton one, since its energy expression for small velocity does not recognize potential term [108].Also SR in general does not have any term which is sensitive to field which is in direct conflict with the physics mean stream[113,114,115]. General relativity which partially solves this problem for gravitational field, successfully describes many astronomical and cosmological phenomena [112, 113]. However GR gives singular solutions for massive and super massive objects [116, 117]

This means that GR predicts its own break down in these application [116, 117] different attempts were made to cure these defects. The so called generalized special relativity think that still SR is valid by generalizing Lorentz transformation in the so called generalized SR (GSR)[117, 118]. Some authors also try to cure singularity problem by suggesting repulsive gravity force [15, 120, and 121]. But they are not based on Poisson equation or Maxwell statistical distribution. One thus needs a new model which cures some of these defects. This is done in section (4.2.2), which is concerned with non singular model and section (4.2.3) which is devoted for potential dependent Lorentz transformation.

4.2.1 Short range Gravity field

Poisson Newton equation states that matter density ρ generates gravity field of potential per unit mass $\emptyset$.according to the equation

$$\nabla^2 \emptyset = 4\pi G\rho = 4\pi G m n_0 e^{-\beta_0 \emptyset} = (1 - \beta\emptyset)C_0 \qquad (4.2.1.1)$$

$C_0 = 4\pi G\rho$

Where the particle density obeys Maxwell's equations:

Consider the behavior of elementary particles which form very hot gas at the star core. This meaning that:

$$m_0 \ll 1 \qquad \beta(kT)^{-1} \ll 1 \quad \text{therefore } x = \beta_0\varphi \ll 1$$

$$n = n_0 e^{-\beta E} = n_0 e^{-\beta m_0 \emptyset} = n_0 e^{-\beta_0 \emptyset} \approx n_0(1 - \beta_0\emptyset) \qquad (4.2.1.2)$$

For spherically symmetric field

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \frac{\partial \emptyset}{\partial r}\right) = (1 - \beta_0\emptyset)C_0 \qquad (4.2.1.3)$$

To simplify this equation let us define the function f to be

$$f = (1 - \beta_0\emptyset)C_0 \qquad (4.2.1.4)$$

Consider solution of the form

$$f = r^n e^{\gamma r} \qquad (4.2.1.5)$$

From equation (3)

$$df = -\beta d\emptyset$$

$$d\emptyset = -\frac{1}{\beta_1} df \qquad (4.2.1.6)$$

Where $\beta_1 = C_0\beta_0$

Let

$$\beta_1 = -C_2 \qquad (4.2.1.7)$$

Divide equation (4.2.2.5) both side by dr to get

$$\frac{d\emptyset}{dr} = \frac{1}{c_2}\frac{df}{dr} \qquad (4.2.1.8)$$

$$\frac{df}{dr} = nr^{n-1}e^{\gamma r} + \gamma r^n e^{\gamma r} \qquad (4.2.1.9)$$

Hence inserting eq,s (4.2.1.9) , (4.2.1.8) and (4.2.1.3) in (4.2.1.2) yields

$$\frac{1}{c_2}\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2(nr^{n-1}e^{\gamma r} + \gamma r^n e^{\gamma r})\right) = f \qquad (4.2.1.10)$$

$$\frac{1}{c_2}\frac{1}{r^2}\frac{\partial}{\partial r}(\gamma r^{n+2} + nr^{n+1})e^{\gamma r} = r^n e^{\gamma r} \qquad (4.2.2.11)$$

Multiply both sides by $r^2 c_2$

$$\frac{\partial}{\partial r}(\gamma r^{n+2} + n r^{n+1})e^{\gamma r} = c_2\, r^{n+2} e^{\gamma r} \qquad (4.2.1.12)$$

$$(\gamma^2 r^{n+2} + \gamma(n+2) r^{n+1} + n(n+1) r^n + n\gamma r^{n+1}) e^{\gamma r}$$

$$= c_2 r^{n+2} e^{\gamma r} \qquad (4.2.1.13)$$

Eliminating $e^{\gamma r}$ from both sides of equation (4.2.2.13) yields:

$$\gamma^2 + \frac{\gamma(n+2)}{r} + \frac{n(n+1)}{r^2} + \frac{n\gamma}{r} = c_2 \qquad (4.2.1.14)$$

For $n = -1$

$$\gamma^2 + \frac{\gamma(-1+2)}{r} + \frac{-1(-1+1)}{r^2} + \frac{-\gamma}{r} = c_2$$

$$\gamma^2 = c_2 \qquad (4.2.1.15)$$

Or

$$\gamma = \pm\sqrt{c_2} \qquad (4.2.1.16)$$

Therefore f can be written according to (4.2.1.4) and (4.2.1.16) as:

$$f = \frac{1}{r} e^{+\sqrt{c_2} r} \qquad (4.2.2.17)$$

According to equations (4.2.1.1) ,(4.2.1.2) and (4.2.1.7) equation (4.2.1.17) reads

$$C_0 - C_0 \beta_0 \emptyset = \frac{1}{r} e^{-\sqrt{4\pi G m n_0 \beta_0}\, r}$$

$$\emptyset = \frac{1}{\beta_0} - \frac{1}{C_0 \beta_0 r} e^{-\beta_1 r} = \frac{1}{\beta_0}\left(1 - \frac{1}{4\pi G m n_0} e^{-\sqrt{4\pi G m n_0 \beta_0}\, r}\right) \qquad (4.2.1.18)$$

Assuming the existence of attractive long range field beside the short one, the total potential is given by

$$= \emptyset_s + \emptyset_L = \frac{1}{\beta_0}\left(1 - \frac{1}{C_0 r} e^{-\beta_r r}\right) - \frac{Gm}{r} \qquad (4.2.1.19)$$

. Consider now the region near the center of mass $(r \to 0)$

Thus:

$$e^{-\beta_1 r} \approx 1 - \beta_1 r$$

Hence

$$\emptyset = \frac{1}{\beta_0}\left(1 - \frac{1}{C_0 r}(1 - \beta_1 r)\right) - \frac{Gm}{r} = \frac{1}{\beta_0} - \frac{1}{\beta_0 C_0 r} + \frac{\beta_1}{C_0} - \frac{Gm}{r} \qquad (4.2.1.20)$$

The finiteness of $\emptyset$ requires

$$\beta_0 C_0 = -\frac{1}{Gm} \qquad (4.2.1.21)$$

In this case

$$\emptyset = \boldsymbol{\emptyset_0} = \frac{\mathbf{1}}{\boldsymbol{\beta_0}} + \frac{\boldsymbol{\beta_1}}{\boldsymbol{C_0}} \qquad (4.2.1.22)$$

Thus the self energy, at which energy is a minimum, is given by

$$\mathrm{E} = \mathrm{m}_0 \emptyset_0 = \mathrm{m}_0\left(\frac{1}{\beta_0} + \frac{\beta_1}{\mathrm{C}_0}\right) \qquad (4.2.1.23)$$

This means that when r is very small the potential is finite, and no singularity exists. The minimum r can be obtained from equation (4.2.1.19) to get

$$\frac{1}{\beta_0 C_0 r^2} e^{-\beta 1 r} + \frac{\beta_1}{\beta_0 C_0 r} e^{-\beta 1 r} + \frac{G}{r^2} = 0$$

$$(1 + \beta_1 r)e^{-\beta 1 r} + C_1 \beta_0 C_0 = 0$$

For small r

$$(1 + \beta_1 r)(1 - \beta_1 r) + C_0 \beta_0 G = 0$$

$$1 - \beta_1^2 r^2 = C_0 \beta_0 G$$

$$r = \sqrt{\frac{1 - C_0 \beta_0 G}{\beta_1^2}}$$

Thus r is real when $C_0 \beta_0 G$ <1 this means that critical mass is

$$\mathrm{M} < \frac{\mathrm{R}^{\frac{3}{2}}}{\mathrm{G}(3\beta)^{\frac{3}{2}}} \qquad M\beta(4\pi G\rho)G < 1$$

This means that the star mass should be less than a certain critical mass Mc, i.e.

$$M < M_c$$

Where

$$\mathrm{M_c} = \frac{\mathrm{R}^{\frac{3}{2}}}{\mathrm{G}(3\beta)^{\frac{3}{2}}}$$

Since self energy requires $r \to 0$. Thus it is quite natural to expect M to be small and less than certain critical value

4.2.2 Nonlinear potential dependent Lorentz transformation

The Principle of Special Relativity states that the laws of nature are invariant Under a particular group of space-time coordinate transformations, called Lorentz transformations .A Lorentz transformation is a transformation from one system of space-time coordinates S to another system $\acute{S}$. Let us derive a new coordinate transformation from one inertial system to another, which replaces the Galilean transformation, on the basis of Einstein's two postulates for the special theory of relativity. For this purpose, we consider two inertial systems $S(x, y, z, t)$ and $S\ (x', y', z', t')$. The inertial system S' is assumed to be uniformly moving in the x direction in a potential field $\emptyset$ with velocity v relative to the inertial system S, keeping each coordinate axis parallel to the corresponding axis of the latter. Now, let an event occur at the position (x, y, z) at the time t in the inertial system S, and let the same event occur at the corresponding position (x, y', z') and at the corresponding time t' in the inertial system S. Then, one needs to find how the sets of space-time coordinates, (x, y, z, t) and (x, y', z, t') are transformed to each other under the two postulates for the special theory of relativity..

The distance between the origin of two axis is given by L, where

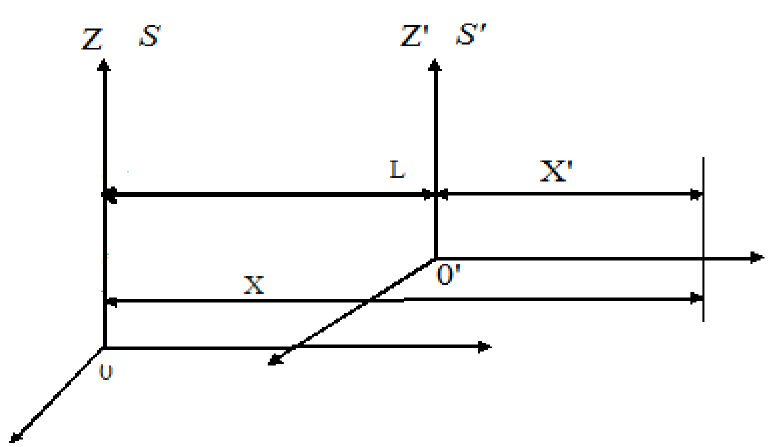


Figure (4.2.3.1) shows two inertial systems S and $\acute{S}$

For motion with constant acceleration

$$L = v_0 t + \frac{1}{2}at^2 \qquad (4.2.2.1)$$

The velocity at instant of time is given by

$$v = v_0 + at \qquad (4.2.2.2)$$

by adding and subtracting $\frac{1}{2}at^2$ for equation (4.2.3.1) we get

$$L = v_0 t + \frac{1}{2}at^2 - \frac{1}{2}at^2 + \frac{1}{2}at^2 = v_0 + at^2 - \frac{1}{2}at^2 \qquad (4.2.2.3)$$

$$= (v_0 + at)t - \frac{1}{2}at^2 \qquad (4.2.2.4)$$

From equation (4.2.3.2) this quantity $v_0 + at$ equal to v

$$L = vt - \frac{1}{2}at^2 \qquad (4.2.2.5)$$

One can write L in terms of the potential per unit mass, to be in the form

$$L = vt - \frac{1}{2x}axt^2 = vt + \frac{\emptyset}{2x}t^2 \qquad (4.2.2.6)$$

Where $\emptyset = -ax$

Consider now the nonlinear Lorentz transformation, in time of the form

$$x = \gamma(\acute{x} + \acute{L})$$

$$x = \gamma\left(\acute{x} + v\acute{t} + \frac{\emptyset}{2\acute{x}}\acute{t}^2\right) \qquad (4.2.2.7)$$

Where x is the position of event in S. Thus the equivalent position in S' is given by

$$\acute{x} = \gamma(x - L)$$

$$\acute{x} = \gamma\left(x - vt - \frac{\emptyset}{2x}t^2\right) \qquad (4.2.2.8)$$

Consider a pulse of light emitted when the origins of S and $\acute{S}$ coincide at t = $\acute{t}$ = 0

Thus x = ct and $\acute{x}$ = c$\acute{t}$. Substitute these quantities in equations (4.2.2.7) & (4.2.2.8) respectively gives

$$ct = \gamma\left(c\acute{t} + v\acute{t} + \frac{\emptyset}{2c\acute{t}}\acute{t}^2\right)$$

$$= \gamma \left(c + v + \frac{\emptyset}{2c}\right) \acute{t} \qquad (4.2.2.10)$$

$$= \gamma c \left(1 + \frac{v}{c} + \frac{\emptyset}{2c^2}\right) \acute{t} \qquad (4.2.2.1)$$

from which we get t as

$$t = \gamma \left(1 + \frac{v}{c} + \frac{\emptyset}{2c^2}\right) \acute{t} \qquad (4.2.2.12)$$

And from equation (4.2.2.12)

$$c\acute{t} = \gamma \left(ct - vt - \frac{\emptyset}{2ct} t^2\right) \qquad (4.2.2.13)$$

$$= \gamma \left(ct - vt - \frac{\emptyset}{2c} t\right) = \gamma c \left(1 - \frac{v}{c} - \frac{\emptyset}{2c^2}\right) t \qquad (4.2.2.14)$$

$$\acute{t} = \gamma \left(1 - \frac{v}{c} - \frac{\emptyset}{2c^2}\right) t \qquad (4.2.2.15)$$

Substitute equation (4.2.2.12) in to equation ((4.2.2.15) yields

$$\acute{t} = \gamma \left(1 + \frac{v}{c} + \frac{\emptyset}{2c^2}\right) \cdot \gamma \left(1 - \frac{v}{c} - \frac{\emptyset}{2c^2}\right) \acute{t} \qquad (4.2.2.16)$$

$$1 = \gamma^2 \left(1 + \frac{v}{c} + \frac{\emptyset}{2c^2}\right) \left(1 - \frac{v}{c} - \frac{\emptyset}{2c^2}\right) \qquad (4.2.2.17)$$

$$\gamma^{-2} = \left(1 + \frac{v}{c} + \frac{\emptyset}{2c^2}\right) \left(1 - \frac{v}{c} - \frac{\emptyset}{2c^2}\right) \qquad (4.2.2.18)$$

This expiration represents potential and speed dependent Lorentz's transformation

From the fact that $(1 + f)(1 - f) = 1 - f^2$

Where $f = \left(\frac{v}{c} + \frac{\emptyset}{2c^2}\right)$ yields

$$\gamma^{-1} = \left(1 - \left(\frac{v}{c} - \frac{\emptyset}{2c^2}\right)^2\right)^{\frac{1}{2}} \qquad (4.2.3.19)$$

$$\gamma^{-1} = \left(1 - \left(\frac{v^2}{c^2} - 2\frac{v\emptyset}{2c^3} + \frac{\emptyset^2}{4c^4}\right)\right)^{\frac{1}{2}} \qquad (4.2.3.20)$$

$$\gamma^{-1} = \left(1 - \left(\frac{v^2}{c^2} - \frac{v\emptyset}{c^3} + \frac{\emptyset^2}{4c^4}\right)\right)^{\frac{1}{2}} \qquad (4.2.3.21)$$

$\emptyset = \frac{V}{m}$ or $V = m\emptyset$ and $V = -\int F dx$

$$V = -\int F dx = -\int ma dx = -ma \int dx = -max \qquad (4.2.3.22)$$

From which we conclude that $\emptyset = -ax$

Let us now see how this new Lorentz transformation related to SR one. For $\emptyset = 0$ clearly equation (4.2.2.17).

$$\boldsymbol{\gamma^{-1}} = \left(\mathbf{1} - \frac{\mathbf{v^2}}{\mathbf{c^2}}\right)^{\frac{1}{2}} \qquad (4.2.3.23)$$

Thus it reduces to Einstein SR when no potential exist one needs also to see its relation within general relativity predictions.

Consider the case when

$$\frac{\emptyset}{2c^2} \ll \frac{v}{c} \qquad (4.2.3.24)$$

Thus equation (4.2.2.15) gives

$$\gamma^{-1} = \left(1 - \left(\frac{v}{c}\right)^2 \left(1 - \frac{v\emptyset}{2c}\right)^2\right)^{\frac{1}{2}} = \left[1 - \left(\frac{v}{c}\right)^2 \left(1 - \frac{v\emptyset}{c}\right)\right]^{\frac{1}{2}} \qquad (4.2.3.25)$$

For particle moving from rest

$$v^2 = v_0^2 + 2ax = 2ax = -2\emptyset \qquad (4.2.3.26)$$

Thus

$$\gamma = \left[1 + \frac{2\emptyset}{c^2}\left(1 - \frac{v\emptyset}{c}\right)\right]^{\frac{-1}{2}} \approx \left[1 + \frac{2\emptyset}{c^2}\right]^{\frac{-1}{2}} \qquad (4.2.2.27)$$

According to this relation

$$t = \gamma \acute{t} = \gamma t_0 = \left[1 + \frac{2\emptyset}{c^2}\right]^{\frac{-1}{2}} t_0 \qquad (4.2.2.28)$$

This equation resembles the general relativistic time dilation relation which was verified experimentally.

4.3 Discussion

The SR energy relation appears to be in conflict with plasma and thermodynamics energy equations [106, 107], which consists of thermal beside mechanical pressure energy, where

$$\mathrm{E_{sr}} = \mathrm{m_0}\left(1 - \frac{\mathrm{v^2}}{\mathrm{C^2}}\right)^{\frac{-1}{2}}$$

$$E_{plas} = \frac{1}{2} m_0 v^2 + V + \gamma kT + P_m$$

$$dQ = dU + PdV = dU + dw$$

This conflict is removed here by suggesting new Lorentz transformation, nonlinear in time [see equations (4.1.1) to (4.1.12)]. By assuming homogeneity of space - time and equivalence of coordinates, beside constancy of speed of light in vacuum, one finds new Lorentz transformation which reduces to the ordinary one when no potential or pressure exists [see equation (4.1.19)]. It is also reduces to ordinary plasma energy equation as shown by equation (4.1.21)

The stability of stars against collapse, to avoid singularity is one of the important issues in cosmology and particle physics. Section (4.1.3) proves that photon pressure inside black holes or any collapsing stellar object can support collapse by generating short range repulsive gravitational or nuclear field as shown by equation (4.2.2.5). Here one uses plasma equation (4.2.2.6) by considering the photon number density a gas obeying Maxwell equation (which is a limiting case of Bose – Einstein distribution when $e^{\beta\emptyset} > 1$). Then by expanding the exponential, potential term, as a Taylor series, one gets a useful equation see equation (4.2.2.10) which leads to short range potential [see equation (4.2.2.14)].

This is a short range repulsive field. Similarly electron gas within crystal can also generate short range field due to the effect of the crystal and electric field [see equation (4.2.2.15)], assuming electron density obeys Maxwell distribution [see equation (4.2.2.17)], and β to b small, one can find a useful expressions (4.2.2.17),(4.2.2.20) for uniform velocity. These expressions predicts the existence of short range field [see eqn.(4.3.27)] affected by self energy and vacuum energy for negligible vacuum energy equation (4.3.28) shows presence of short range repulsive field. This short range field is very important for stars evolution since it prevents singularity and gravitational collapse. It is also helps in describing free universe.

Using Poisson equation (4.1.1), beside Maxwell distribution law in equation (4.1.2), one can find new Poisson equation. For very small β_0 $(\beta_0 \sim (kT)^{-1}$, i.e. for very high temperature, a short range gravity field exist see equation (4.2.1.18). This is agrees with the assumptions that such short range field is observed near the stars cores, where the temperature is very high, to prevent collapse. According to equation (4.2.1.19), when one assumes the existence of attractive force, beside the short range one, the potential $\emptyset$ is constant and finite at the center of mass. This means that the stars and elementary particles have finite self mass (see equation 4.2.1.23) .thus this model is more advanced than that SR. The relativistic behavior of particles in this short or long range field can also be found by seeking Lorentz transformation that accounts for the effect of fields. This is done by equations (4.2.1.31) and (4.2.1.32).Assuming the speed of light to be constant. One find the Lorentz transform (4.2.1.43) which depends on speed v and potential $\emptyset$ [(see equation (4.2.43)].surprisingly equation (4.2.1.43) reduces to SR one for no potential and predict general relativistic time dilation for weak field [see equation (4.2.1.47), (4.2.1.52)].

The capability of this model in predicting finite self mass and it is agreement with wide experimental observation shows that this version of SR is still capable of describing of physical phenomena

4.4 Conclusion

Plasma equation general nature make it capable of recognizing the effect of potential, pressure and thermal energy in SR. this enables generalizing Lorentz transformation and special relativity to recognize the effect of potential and pressure effects. Thus makes SR to conform to plasma equations and thermodynamics. It also helps in deriving short range repulsive energy. This opened the door for considering cosmological model which is free of singularity. It also raises a hope in describing black holes by non singular model which prevents gravitational collapse.

Using Newton Poisson equation beside Maxwell statistical distribution law one can predict existence of short range repulsive gravity force. This gravity force may have a link with strong nuclear force and predicts finite self mass energy and help in constructing non singular model for stars and universe. It also enables using describing non singular and non collapsing black holes. By using Newton's second law for constant acceleration one can drive new Lorentz transformation which

Recognize the effect of potential as well as velocity. This reduces to that SR besides predicting the gravity time dilation.

4.5 Recommendation and future work

1**)** It is important to derive short range repulsive gravity to predict finite self mass energy in order to construct non singular model for the universe.

2) Plasma equation general natures make it capable of recognizing the effect of potential, pressure and thermal energy in SR

3) The photon energy equation in the presence of gravitational field (gravitational red shift equation) needs to be used to derive Einstein's energy equation in the presence of fields.

4) construct expression represents and relate potential and speed dependent Lorentz transformation

5) The new relativity equation which stated by Mubarak Dirar should be unified with Einstein and solved either experimentally or by Monte Carlo simulation.

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