Connection between Gravity and Electromagnetism

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Abstract

A new interpretation of electrodynamics and gravity is presented based on the idea that the vacuum electromagnetic and gravitational properties are connected. The space and time are treated as imaginary concepts. With this all electrodynamics and gravitational phenomena can be explained with a Galilean invariant vacuum. Also a new way to explain gravitational attraction will result.

1 Introduction

The electromagnetic field theory initiated by Faraday and Maxwell presume that a special medium called luminiferous aether is the bearer of electric and magnetic fields, aether which was considered at absolute rest in the entire universe. This model of aether and some variants of it were in contradiction with many observed phenomena involving interpretation of electrodynamics in the conditions of relative motion. All this problems open the way to Special Relativity which not need any aether. But now the space-time continuum start to have physical characteristics, especially in General Relativity and quantum theory, we can speak about a physical vacuum background. But this relativistic vacuum background is always at rest relative to any arbitrary chosen reference frame. The problem is exactly this arbitrary relativity of it. This lead to a broken of causality, an arbitrary change of the coordinate system will make the light and the vacuum background to behave accordingly without a physical cause.

A different way to understand electrodynamics and gravity together will be presented here, based on connection between electromagnetic and gravitational properties of vacuum. In quantum mechanics the vacuum is no longer considered pure empty space but a quantum vacuum background which is considered Lorentz invariant. However we will show here that the Lorentz invariance of it is superfluous, all electrodynamics and gravitational phenomena can be more simple and correct explained with a Galilean invariant vacuum background.

The space and time will be considered as imaginary concepts being decoupled by vacuum, this mean that the space and time are only used as an imaginary helper system. The electromagnetic field is immobile in the vacuum background, as was in luminiferous aether and space-time continuum. This presentation is limited at macroscopic properties of vacuum, for this stage is not necessary to deal with its quantum properties.

2 Gravitational Vacuum.

The most simple and direct explanation for bending of light by gravity, knowing that the light is an electromagnetic wave, can be make if we assume that the gravitational potential change the properties of vacuum, which will produce a gravitational refraction of light. This also will have many other implications like the change of the speed of light and a new way to explain how gravitational attraction appear.

The vacuum is characterized by local properties: gravitational potential (Γ), electric permittivity (ε_0), magnetic permeability (μ_0). In absence of any ponderable matter the vacuum properties will be homogeneous distributed in space, having everywhere the same positive value of gravitational potential which is the vacuum background gravitational potential. Now if ponderable matter, characterized by its heavy mass, is present in space, it modify the local gravitational potential of vacuum in accordance with Poisson type equation of gravity

$$\nabla^2\Gamma = 4\pi G\rho_m \tag{1}$$

where G gravitational constant, ρ_m mass density. Assuming a spherical mass distribution (M) we can express gravitational potential at a distance (R) from the center of mass and outside of it, as follow

$$\Gamma = \Gamma_0 - \frac{GM}{R} \tag{2}$$

where Γ_0 background gravitational potential in absence of mass. As we observe, the gravitational potential of vacuum decrease in vicinity of masses and this in turn modify its electromagnetic properties. The electromagnetic properties of vacuum are not universal constants but are dependent by local gravitational potential. The electric permittivity of vacuum depend by gravitational potential as follow

$$\varepsilon_0 = \kappa \cdot f_1(\Gamma) \tag{3}$$

where κ and f_1 are undetermined constant and function. The permittivity must increase with proximity to heavy masses, in order to explain the gravitational refraction and the gravitational force. The magnetic permeability must depend by the gravitational potential in a manner similar of permittivity. To account this we consider an electromagnetic wave propagating through the vicinity of a heavy cosmic body, wave direction is deflected due to electromagnetic properties variation (gravitational refraction) but suffer no reflections to disperse some of its energy, because such a phenomenon have been observed on sky (light reflections around heavy bodies). Consequently we can assume that electromagnetic waves do not suffer reflections when traversing zones with different vacuum properties, which can happen only if vacuum impedance is independent by the gravitational potential.

$$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} \tag{4}$$

$$\mu_0 = Z_0^2 \varepsilon_0 = Z_0^2 \kappa \cdot f_1(\Gamma) \tag{5}$$

As a result the electric permittivity and magnetic permeability become higher and the propagation speed of electromagnetic field become lower in zones with lower gravitational potential. For determination of constant and function from (3) we will use the equality between inertial and heavy mass, but first we must express the electromagnetic force due to permittivity variations.

2.1 Gravitational Force

One result of electromagnetic properties spatial variation is the gravitational force. Let consider a small electric charge characterized only by its charge q distributed on the surface of a sphere with radius b, at rest sitting at a distance R from a heavy mass M. The gravitational potential of vacuum decrease toward the center of mass as described by (2), and consequently the electric permittivity increase. The electric field that surround the charge (unimportant if positive or negative) contain an amount of energy, if take the approximation that the variation of permittivity over the domain of integration cancel, we have the field energy

$$U_{e0} = \frac{q^2}{8\pi\varepsilon_0 b} \tag{6}$$

The energy of electric field decrease when the charge approach the heavy mass due to increase of ε_0, the lost energy is converted into work of a force which is the gravitational attraction force. Because neutral bodies are composed from atoms which have internal electric fields result that they are attracted too, actually all bodies which have internal electromagnetic energy experience this attractive force in zones with spatial variable vacuum properties.

Because permittivity is no longer equal around the outer area of sphere, the charged sphere surface no longer have a constant electric potential and tangential components of electric field appear. Supposing that electrical charge can move freely on spherical surface, this charge will redistribute over the surface until the surface electric potential will be constant, the electric field becoming again normal on surface. But the charge density is no longer uniform over the surface of sphere, being denser where permittivity is higher and gravitational potential lower. Because the electric field is the same over the surface, a net attraction force appear, fueled by the decreasing electric field energy, representing the gravitational force.

When charged sphere go down to lower gravitational potential areas, the outside oriented electric forces over the sphere surface decrease and the inside oriented forces that hold charged surface in equilibrium also must decrease, consequently the gravitational potential must have influence over this forces and over the radius of charged sphere too. In order to obtain the expected expression for the gravitational force, the charge radius (b) must increase with the decrease of gravitational potential as follow

$$b = \alpha \cdot f_2(\Gamma) \tag{7}$$

where α and f_2 are the second undetermined constant and function. To resolve this we consider the charge at rest and make use of the observed fact that inertial mass and heavy mass are equal (not say equivalent because their are the effect of different phenomena). Replacing permittivity and radius in

(6) result

$$U_{e0} = \frac{q^2}{8\pi} \cdot \frac{1}{\kappa\alpha \cdot f_1(\Gamma) \cdot f_2(\Gamma)} \tag{8}$$

The gravitational force

$$\boldsymbol{F_{g0}} = -\frac{\mathrm{d}U_{e0}}{\mathrm{d}R} \cdot \mathbf{e_R} = -m_{h0} \cdot \frac{GM}{R^2} \cdot \mathbf{e_R} \tag{9}$$

where $\mathbf{e_R}$ is the versor of $\boldsymbol{R}$, and m_{h0} is the rest heavy mass of charge q. The only way to satisfy (9) is that

$$f_1(\Gamma) \cdot f_2(\Gamma) = \frac{1}{\Gamma} \tag{10}$$

with which will result

$$\boldsymbol{F_{g0}} = -\frac{\mathrm{d}U_e}{\mathrm{d}R} \cdot \mathbf{e_R} = -\frac{q^2}{8\pi\kappa\alpha} \cdot \frac{\mathrm{d}\Gamma}{\mathrm{d}R} \cdot \mathbf{e_R} = -\frac{q^2}{8\pi\kappa\alpha} \cdot \frac{GM}{R^2} \cdot \mathbf{e_R} \tag{11}$$

and the heavy mass

$$m_{h0} = \frac{q^2}{8\pi\kappa\alpha} \tag{12}$$

At rest the inertial mass depend only by charge electric field energy and must be as follow

$$m_{i0} = \frac{U_{e0}}{c^2} = \frac{\mu_0 q^2}{8\pi b} = \frac{q^2}{8\pi} \cdot \frac{Z_0^2 \kappa \cdot f_1(\Gamma)}{\alpha \cdot f_2(\Gamma)} \tag{13}$$

To satisfy the equality $m_{i0} = m_{h0}$, one condition is that inertial mass must be independent of gravitational potential, which lead to $f_1(\Gamma) = f_2(\Gamma)$ and considering (10) result

$$f_1(\Gamma) = f_2(\Gamma) = \frac{1}{\sqrt{\Gamma}} \tag{14}$$

Also we have the equality

$$\frac{q^2 Z_0^2 \kappa}{8\pi\alpha} = \frac{q^2}{8\pi\kappa\alpha} \tag{15}$$

which lead to

$$\kappa = \frac{1}{Z_0} \tag{16}$$

the inertial and heavy rest mass become

$$m_0 = m_{i0} = m_{h0} = \frac{Z_0 q^2}{8\pi\alpha} \tag{17}$$

Taking into account (16) and (14), we can write permittivity, permeability and speed of light as follow

$$\varepsilon_0 = \frac{1}{Z_0\sqrt{\Gamma}} \tag{18}$$

$$\mu_0 = \frac{Z_0}{\sqrt{\Gamma}} \tag{19}$$

$$c = \sqrt{\Gamma} \tag{20}$$

From equation (20) result that local gravitational potential equal the square of local speed of light.

Above was expressed the electrical part of gravitational force at rest. At near to rest approximation the magnetic field energy alone have no contribution to gravitational forces. To account for this we can express the magnetic field energy of a moving charged sphere relative to local vacuum with a low velocity. The magnetic field energy produced by this movement is

$$U_{m0} = \frac{4}{3} \cdot \frac{\mu_0 q^2 v^2}{16\pi b} = \frac{4}{3} \cdot \frac{Z_0 q^2 v^2}{16\pi\alpha} \tag{21}$$

which is independent by gravitational potential. However we use here near to rest approximation for simplicity, we will show later that, when propagation effects are taken into account, the gravitational force, heavy and inertial mass are the effect of the total electromagnetic energy.

From previously described mechanisms, result that gravitational force is not powered by some gravitational field energy, which not exist, but by body internal electromagnetic energy. The body internal electromagnetic energy also contribute to the phenomenon of inertia. This lead to the possibility that the entire concept of mass may be of electromagnetic nature.

2.2 Atomic Radius variation

Because the permittivity change with gravitational potential, this in turn will lead to the change of atomic radius and the dimensions of bodies. The radius of an electron orbit around the nucleus is given by the equilibrium between nucleus attraction force and centrifugal inertial force of electron over itself. Of course quantum effects have an important influence at a such small scale. Let consider for simplicity the Bohr model of atom, the electron orbit radius is

$$r_n = \frac{4\pi\varepsilon_0\hbar^2 n^2}{\mathbb{Z}e^2 m_{e0}} = \frac{4\pi\hbar^2 n^2}{\mathbb{Z}e^2 m_{e0}} \cdot \frac{1}{Z_0\sqrt{\Gamma}} \tag{22}$$

where $\mathbb{Z}$ is the atomic number and Z_0 vacuum impedance. The m_{e0} is the rest mass of electron and is independent by gravitational potential for low velocities compared with c. The radius of atom vary with the gravitational potential in a similar way than the radius of our sphere of charge considered previously. The atomic radius and dimensions of bodies increase in lower gravitational potentials.

2.3 Gravitational Bonding of Vacuum

One important problem related with the vacuum background is its movement state. In absence of any ponderable matter, the homogeneous distributed vacuum does not have a movement state inside of it and a point of vacuum background is at rest relative to other point of it. The presence of ponderable matter will modify the gravitational properties of vacuum and this properties will follow the movement of ponderable matter. This imply two possibilities.

The first possibility assume that only properties are entrained which require that variations in vacuum properties, which follow ponderable matter position, propagate through it with a finite speed. This will produce a time lag in manifestation of gravitational force.

The second possibility assume that the vacuum background behave in such a way that the gravitational potential of it have no time variations, which eliminate propagation and time lag of gravitational forces. This require that the vacuum background is bonded with the movement of resulted gravitational equipotential surfaces and is entrained by the dominant heavy masses. This imply that the entrainment of it is dependent by the local gradient of gravitational potential. The material derivative of gravitational potential at one vacuum point moving with velocity u relative to a mass, is

$$\frac{\mathrm{D}\Gamma}{\mathrm{D}t} = \frac{\partial \Gamma}{\partial t} + \boldsymbol{u} \cdot \nabla \Gamma \tag{23}$$

For the condition of gravitational bonding exist two possibilities. First that the whole material derivative is zero which imply that all variations in gravitational potential, including those produced by partial time derivative, viewed by the vacuum background are zero, vacuum moving to compensate. Second that only the convective part of the material derivative is zero which imply that only variations in potential produced by movement of masses are compensated by vacuum movement. Which possibility is the real one is still an open question. How accelerated movement of masses affect the vacuum background entrainment is another open question.

The vacuum entrainment is influenced by direction and magnitude of gravitational acceleration, higher the influence of a body to the gravitational acceleration in one point, lower the movement of vacuum from that point relative to body, higher the entrainment exerted by that body. Following we will analyze two simple cases of particular interest.

First is the case of a massive body (like a star or planet) far away from other massive bodies, which impose the value of gravitational acceleration in its vicinity, other bodies having only negligible influence because of their very low mass or very large distances. In this case the vacuum is, with a negligible error, total entrained by this massive body. Small objects with negligible influence, moving in proximity of it, will experience a "gravitational wind" due to their own movement relative to the massive body.

Second case is that of rotation of a massive body around an axis of symmetry. In this case the rotational movement produce no modification over the gravitational potential in its proximity, consequently the vacuum remain unaffected. As a result, this body itself and any object that rotate with it experience a "gravitational wind" due to body rotation around its axis. However the rotation is an accelerated motion and because of this the vacuum around the rotating body may suffer some influences due to this acceleration.

The consequence of vacuum gravitational bonding over electromagnetic field which is immobile relative to vacuum, consist in the advection of the field by the vacuum movement, leading to induction of new field components.

3 Electromagnetic Field and Vacuum

The electromagnetic field consist of electric and magnetic fields which are immobile relative to vacuum, consequently sharing its movement state. The vacuum is used here as physical entity, relative to which are expressed all velocities which appear in electrodynamics equations. We will use the Maxwell-Heaviside form of electrodynamics equations not only because are well known and used, but also because are valid in the actual conditions where permittivity and permeability are no longer uniformly distributed in space.

The electrical charge q with volume density ρ_v may move relative to vacuum with velocity v, which form the current density $\boldsymbol{j} = \rho_v \boldsymbol{v}$. Always a charge movement through vacuum imply that the vacuum will advect the electric field of charge with velocity -v. Similarly, if a magnet move relative to vacuum with velocity v_m, its magnetic field suffer an advection with velocity $-v_m$. A zone of vacuum may move relative to another zone of vacuum or a field frame with velocity u, this also produce field advection between the two zones. Let consider the electric and magnetic field vectors E,D and H,B, additional medium (like substantial bodies) polarization P and magnetization M. We have the relations

$$\boldsymbol{D} = \varepsilon_0 \boldsymbol{E} + \boldsymbol{P} \tag{24}$$

and

$$\boldsymbol{B} = \mu_0 \left(\boldsymbol{H} + \boldsymbol{M} \right) \tag{25}$$

Let consider the spatial elements: volume element $\mathrm{d}V$, surface element $\boldsymbol{dS} = \mathbf{n}\mathrm{d}S$ and line element $\boldsymbol{dr}$, which are tied with the field frame which is the vacuum. The integral form of electric and magnetic flux equations are

$$\oiint \boldsymbol{D} \cdot \boldsymbol{dS} = q \tag{26}$$

and

$$\oiint \boldsymbol{B} \cdot \boldsymbol{dS} = 0 \tag{27}$$

where q is the charge enclosed inside the surface of integration. Using the divergence theorem these two equations can be transformed into their local form

$$\nabla \cdot \boldsymbol{D} = \rho_v \tag{28}$$

and

$$\nabla \cdot \boldsymbol{B} = 0 \tag{29}$$

The induction equations in integral form are

$$\oint \boldsymbol{E} \cdot \boldsymbol{dr} = -\frac{\mathrm{d}\Phi}{\mathrm{d}t} \tag{30}$$

and

$$\oint \boldsymbol{H} \cdot \boldsymbol{dr} = I + \frac{\mathrm{d}\Psi}{\mathrm{d}t} \tag{31}$$

where I, Φ and Ψ are the charge current relative to vacuum, magnetic and electric flux encircled by the curve of integration. To obtain the local form of induction equations, first we must evaluate the total time derivatives of electric and magnetic fluxes and interpret them in relation with the vacuum.

Because the spatial elements are tied with the vacuum, the time derivative of electric and magnetic flux is equal with the flux of material derivative of corresponding fields. In this conditions, considering a generic vector F , time derivative of its flux is

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\iint \boldsymbol{F}\cdot \boldsymbol{dS}\right) = \iint \left(\frac{\mathrm{D}\boldsymbol{F}}{\mathrm{D}t}\right)\boldsymbol{dS}$$

where

$$\frac{\mathrm{D}\boldsymbol{F}}{\mathrm{D}t} = \frac{\partial \boldsymbol{F}}{\partial t} + (\boldsymbol{u}\cdot\nabla)\,\boldsymbol{F} = \frac{\partial \boldsymbol{F}}{\partial t} + \boldsymbol{u}\,(\nabla\cdot\boldsymbol{F}) + \nabla\times(\boldsymbol{F}\times\boldsymbol{u})$$

is the material derivative of the field, u is the velocity between the frame where the field is induced and the frame in which the inductive field F is mathematically expressed. From physical point of view the induced frame is the vacuum, from mathematical point of view can be any frame. The inductive field can be mathematically expressed in the same frame as the induced field, when this velocity is zero, or the field can be expressed in another frame (source or another zone of vacuum), when this velocity is nonzero. When the two frame (induced and inductive) correspond to two zones of vacuum in relative movement we have a case of field advection effect. Using the Stokes theorem and take into account the most general case and condition (29), the equation (30) can be expressed in local form as follow

$$\nabla\times\boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t} + \nabla\times(\boldsymbol{u}\times\boldsymbol{B}) \tag{32}$$

where u is the velocity between electric and magnetic field frames. Similarly, but using condition (28), the equation (31) can be expressed in local form as follow

$$\nabla\times\boldsymbol{H} = \rho_v\boldsymbol{v} + \frac{\partial \boldsymbol{D}}{\partial t} + \rho_v\boldsymbol{u} + \nabla\times(\boldsymbol{D}\times\boldsymbol{u}) \tag{33}$$

where v is the velocity of charge relative to vacuum and u is the velocity between magnetic and electric field frames. Regardless of how is field mathematically expressed, the native state (physical state) of the field is always that of the frame of local vacuum. However is very common in analysis of many electrodynamics problems to express the field in the frame of its source which may not coincide with that of vacuum, in these cases we must include u velocity components from induction equations.

The electromagnetic force represent the measure of electromagnetic energy exchange associated with a system, with the change of system position. In this case the electromagnetic force can be expressed as

$$\boldsymbol{F_{em}} = -\frac{\mathrm{d}U_{em}}{\mathrm{d}r} \cdot \mathbf{e_r} \tag{34}$$

where U_{em} is the electromagnetic energy of system and r is the position of system. While the energetic derivation of electromagnetic force can be a very handy method in some cases, in other cases is more useful to express the electromagnetic force by field-charge interaction. The force that act over a small electric charge q in an electromagnetic field is

$$\boldsymbol{F_{em}} = q\boldsymbol{E} + q\boldsymbol{v} \times \boldsymbol{B} \tag{35}$$

where v is the velocity between charge and vacuum, magnetic field being immobile in vacuum. We have two components, one produced by electric field and one produced by the presence of magnetic field also known as Lorentz force. However the Lorentz force appear only when the charge is in movement relative to vacuum. To clarify this type of problems let consider the case of a charge and a magnet. If both the charge and the magnet are immobile relative to vacuum then we have no force over the charge. If the charge move relative to vacuum and magnet with velocity $v = v_{qm}$ then a Lorentz force act over charge

$$\boldsymbol{F_{qm}} = q\boldsymbol{v} \times \boldsymbol{B} = q\boldsymbol{v_{qm}} \times \boldsymbol{B}$$

Now if the charge is immobile in vacuum and the magnet move relative to vacuum and charge with velocity $v_m = -v_{qm}$ then the magnetic field of the magnet suffer an advection with velocity $-v_m$ and an electric field is induced by this, the force over charge being an electric force

$$\boldsymbol{F_{qm}} = q\boldsymbol{E} = q\boldsymbol{v_{qm}} \times \boldsymbol{B}$$

considering the magnetic field expressed in the frame of magnet. When both charge and magnet move relative to vacuum we have a resultant force composed from the two components described previously, the combined value of them is proportional with the velocity between charge and magnet. Because of this one may wrong believe that the Lorentz force is given by relative movement between charge and magnet, while in fact we have two forces produced by two mechanisms.

The vacuum properties, permittivity and permeability, in the general case, are not uniform distributed in space but form scalar fields. A consequence of this is that they are affected by differential operators, which imply that some methods (like electrodynamics potentials) where these parameters are treated as constants, are no longer general valid, except in the cases when these parameters can be approximate as constants. In the above field equations the medium (including vacuum) parameters are inside the differential operators and represent the most general valid case because are the direct consequence of experimental observations over electromagnetic field.

4 Electromagnetic Momentum.

Let consider a small electric charge characterized only by its charge q distributed on the surface of a sphere with radius b (like in subsection 2.1), moving with constant velocity v through vacuum in condition of uniform gravitational potential. This moving charge have an electromagnetic field momentum with volume density $\boldsymbol{D} \times \boldsymbol{B}$. Electric field around a hypothetical point charge in movement with constant velocity is affected by the finite speed of propagation (Lienard and Wiechert retarded potentials, or Heaviside and Thomson auxiliary system) and become

$$\boldsymbol{E_v} = \frac{q}{4\pi\varepsilon_0 r^2} \cdot \frac{1 - \dfrac{v^2}{c^2}}{\left(1 - \dfrac{v^2}{c^2}\sin^2\theta\right)^{3/2}} \cdot \mathbf{e_r} \tag{36}$$

and magnetic field

$$\boldsymbol{B_v} = \frac{1}{c^2}\left(\boldsymbol{v} \times \boldsymbol{E_v}\right) \tag{37}$$

where θ is the angle between the direction of movement and the direction of position vector. The spherical charge at rest, in movement must change the shape until tangential forces (electric and magnetic) at surface are canceled, which will happen when the charge take the form of an oblate spheroid on the direction of motion. The longitudinal radius (on motion direction) become δ times shorter than the transversal radius which remain unaffected.

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

Now if we integrate the momentum density over the volume around the spheroid shaped charge with

$$b(\theta) = b \cdot \frac{\sqrt{1-\beta}}{\sqrt{1-\beta\sin^2\theta}} \tag{38}$$

we obtain the field momentum

$$\boldsymbol{P_{em}} = \int_0^{\pi}\int_0^{2\pi}\int_{b(\theta)}^{\infty}\left(\boldsymbol{D_v}\times\boldsymbol{B_v}\right) r^2 \sin\theta \mathrm{d}r\mathrm{d}\varphi\mathrm{d}\theta \tag{39}$$

$$\boldsymbol{P_{em}} = \frac{q^2\boldsymbol{v}\,(1-\beta)^{3/2}}{c^2 8\pi\varepsilon_0 b} \cdot 2\int_0^{\pi/2}\frac{\sin^3\theta}{\left(1-\beta\sin^2\theta\right)^{5/2}}\mathrm{d}\theta$$

$$\boldsymbol{P_{em}} = \frac{4}{3}\cdot\frac{q^2\boldsymbol{v}}{c^2 8\pi\varepsilon_0 b}\cdot\frac{1}{\sqrt{1-\beta}} \tag{40}$$

in a similar way result electric field energy

$$U_e = \frac{q^2\,(1-\beta)^{3/2}}{16\pi\varepsilon_0 b}\cdot 2\int_0^{\pi/2}\frac{\sin\theta}{\left(1-\beta\sin^2\theta\right)^{5/2}}\mathrm{d}\theta$$

$$U_e = \left(1-\frac{\beta}{3}\right)\frac{q^2}{8\pi\varepsilon_0 b}\cdot\frac{1}{\sqrt{1-\beta}} \tag{41}$$

magnetic field energy

$$U_m = \frac{v^2}{c^2}\cdot\frac{q^2\,(1-\beta)^{3/2}}{16\pi\varepsilon_0 b}\cdot 2\int_0^{\pi/2}\frac{\sin^3\theta}{\left(1-\beta\sin^2\theta\right)^{5/2}}\mathrm{d}\theta$$

$$U_m = \frac{\beta}{3}\cdot\frac{q^2}{8\pi\varepsilon_0 b}\cdot\frac{1}{\sqrt{1-\beta}} \tag{42}$$

total energy

$$U_e + U_m = \frac{q^2}{8\pi\varepsilon_0 b}\cdot\frac{1}{\sqrt{1-\beta}} \tag{43}$$

We must make distinction between the field propagation momentum and the charge movement momentum (inertial momentum), the field momentum being equal with the inertial momentum only in the case of free fields (electromagnetic wave fields) which form a balanced electromagnetic system.

The fields created by a charge form an unbalanced system, additional stress (Poincare stress) is required to balance the system. Consequently we assume that when this stress is taken into account the 4/3 factor must disappear. With this we can write the charge momentum relative to vacuum as

$$\boldsymbol{P_c} = \boldsymbol{P_{em}} + \boldsymbol{P_s} = \frac{U_e + U_m}{c^2} \cdot \boldsymbol{v} \tag{44}$$

If we have the case of total vacuum entrainment by the body then $v = 0$ also magnetic field is zero and field momentum is zero. To satisfy the charge momentum conservation when the vacuum is entrained the charge momentum relative to an arbitrary reference must be

$$\boldsymbol{P_{cr}} = \frac{U_e + U_m}{c^2} (\boldsymbol{v} + \boldsymbol{u}) \tag{45}$$

From (43) can be observed that the total energy (not only electric field energy like in near to rest approximation) is sensitive to gravitational potential variations, so that the inertial and heavy mass are equals at any velocity and are

$$m_i = m_h = \frac{U_e + U_m}{c^2} = \frac{Z_0^2 q^2}{8\pi\alpha} \cdot \frac{1}{\delta} \tag{46}$$

In the case of an electromagnetic wave, the wave fields form a self-balanced system, the Poincare stress is zero, total inertial momentum density relative to any reference is given only by field momentum density

$$\boldsymbol{p_{wave}} = \frac{\boldsymbol{E} \times \boldsymbol{H}}{c^2} \tag{47}$$

and is completely independent by the vacuum movement.

4.1 Mass Dilation

Let consider the movement through vacuum in the general case, considering a charged particle like in 2.1 moving with constant velocity v through vacuum. We consider the case of low enough acceleration such that the acceleration component of field is negligible compared with the velocity component. The total momentum of moving charge relative to any reference (45) will be

$$\boldsymbol{P_{cr}} = \frac{m_0}{\delta} (\boldsymbol{v} + \boldsymbol{u}) \tag{48}$$

Different transversal and longitudinal inertial mass are associated with the force of inertia, for

$$\boldsymbol{a} = \frac{\mathrm{d}}{\mathrm{d}t}\left(\boldsymbol{v} + \boldsymbol{u}\right)$$

transversal mass when acceleration is perpendicular on the movement direction

$$m_{\perp} = \frac{P_{tot}}{v+u} = \frac{m_0}{\delta} \tag{49}$$

longitudinal mass when acceleration is parallel with the movement direction

$$m_{\parallel} = \frac{\mathrm{d}P_{tot}}{\mathrm{d}\left(v+u\right)} = \frac{m_0}{\delta^3}\left(1 + \frac{vu}{c^2}\right) \tag{50}$$

this show the mass dilation but only with velocity v relative to vacuum. In the case of longitudinal mass the vacuum velocity u also have a small influence but only in the presence of a movement relative to vacuum as well.

4.2 Length Contraction

Now we can extend analysis to atomic radius to prove that all bodies composed from atoms suffer longitudinal contraction when move through vacuum. First let express the electric field of nucleus transversal on atom motion direction at $\sin\theta = 1$

$$E_{\perp} = \frac{\mathbb{Z}e}{4\pi\varepsilon_0 r^2} \cdot \frac{1}{\delta} \tag{51}$$

this field produce an attractive force over the electron in an orbital position with centripetal acceleration transversal on the atom motion direction, so in centrifugal force appear the transversal mass of the electron. Also the presence of a transversal magnetic field of nucleus due to the atom motion produce an additional repulsive Lorentz force over the electron. This transversal magnetic field is

$$B_{\perp} = \frac{\mathbb{Z}e}{4\pi\varepsilon_0 r^2} \cdot \frac{v}{c^2} \cdot \frac{1}{\delta} \tag{52}$$

the centripetal force that act over electron become

$$F_{e\perp} - F_{m\perp} = \frac{\mathbb{Z}e^2}{4\pi\varepsilon_0 r^2} \cdot \frac{1}{\delta}\left(1 - \frac{v^2}{c^2}\right) = \frac{\mathbb{Z}e^2}{4\pi\varepsilon_0 r^2} \cdot \delta \tag{53}$$

Using this and the transversal mass of the electron, result for transversal Bohr orbital radius

$$r_{n\perp} = \frac{4\pi\varepsilon_0 \hbar^2 n^2}{\mathbb{Z}e^2 \delta m_{e\perp}} = \frac{4\pi\varepsilon_0 \hbar^2 n^2}{\mathbb{Z}e^2 m_{e0}} \tag{54}$$

which is the same as the orbital radius at rest. Result that transversal dimensions of moving atom and body remain unmodified $l_\perp = l_0$.

Now let make the same analysis longitudinal on atom motion direction at $\sin\theta = 0$. No magnetic field exist on this direction due to atom motion, the longitudinal electric field of nucleus is

$$E_\parallel = \frac{\mathbb{Z}e}{4\pi\varepsilon_0 r^2} \cdot \delta^2 \tag{55}$$

the centripetal force that act over the electron is $F_{e\parallel} = eE_\parallel$, using this and the longitudinal mass of the electron, longitudinal Bohr orbital radius become

$$r_{n\parallel} = \frac{4\pi\varepsilon_0 \hbar^2 n^2}{\mathbb{Z}e^2 \delta^2 m_{e\parallel}} = \frac{4\pi\varepsilon_0 \hbar^2 n^2}{\mathbb{Z}e^2 m_{e0}} \cdot \delta \tag{56}$$

which is shorter than the orbital radius at rest by δ times. Result that longitudinal dimensions of moving atom and body in the motion direction become

$$l_\parallel = l_0 \delta \tag{57}$$

known as Lorentz-FitzGerald contraction or length contraction. Consequently the length contraction is a real phenomenon produced by movement through vacuum which affect atomic internal equilibrium of forces, acting over the atoms and bodies not over the space which is an imaginary concept.

4.3 Clocks Slowing

Now we can prove that all clocks based on electromagnetic phenomena become slower, measuring larger time intervals when are in movement through vacuum. The most simple example is that of a light clock, which uses onward and backward propagation time of a light pulse (or electromagnetic field in general) as time base. When this clock is at rest in vacuum its time base will be

$$\Delta t_0 = \frac{2l_0}{c} \tag{58}$$

where l_0 is the length at rest of the clock arm where light propagate. If the clock move trough vacuum we have two cases: when the clock arm is transversal on movement direction and when the arm is parallel with movement direction. When the arm is transversal the light are forced to propagate over a larger distance through vacuum due to clock movement, the time base become

$$\Delta t_{\perp} = \frac{2l_0}{\sqrt{c^2 - v^2}} = \frac{\Delta t_0}{\delta} \tag{59}$$

When the arm is parallel the light propagate onward and backward through moving vacuum over a contracted arm length, the time base become

$$\Delta t_{\parallel} = \frac{2cl_0\delta}{(c-v)\,(c+v)} = \frac{\Delta t_0}{\delta} \tag{60}$$

The result indicate that regardless of clock arm orientation, the time base become larger and clock slow down in the same way when subjected to movement through local vacuum. Other types of clocks based on electromagnetic phenomena, even if not use field propagation directly, also slow down as above. As in the case of length contraction, the internal processes on which clock operation is based are slowed down, not the time itself which is an imaginary concept.

All these propagation effects are produced only when exist a movement relative to local vacuum. If the local vacuum is entrained with the movement of the body then these effects are reduced down to zero if entrainment is complete, like in the case of earth itself or an object on earth surface.

From (58) in condition of (20) and (22) result that electromagnetic based clocks also slow down when gravitational potential decrease in the proximity of heavy masses due to decrease of speed propagation of electromagnetic field and gravitational increase of clock arm dimensions. From (22) we can express the arm length

$$l_0 = N \cdot r_n = N\lambda_n \cdot \frac{1}{\sqrt{\Gamma_0}} \tag{61}$$

then we can write for the time base in a lower gravitational potential

$$\Delta t = \frac{2l}{c} = 2N\lambda_n \cdot \frac{1}{\Gamma} = \Delta t_0 \cdot \frac{\Gamma_0}{\Gamma} \tag{62}$$

where Δt_0 is the time base where potential is Γ_0.

5 Interpretation of Phenomena

Some effects and experiments will be analyzed in the new context.

5.1 Vacuum Properties Variations

Speed of light, electric permittivity and magnetic permeability of vacuum are no longer universal constants, but are dependent by gravitational potential as show in equation (18,19,20). This lead to a series of effects like gravitational refraction of electromagnetic waves when they pass close enough to a massive object. The speed of light decrease gradually toward the center of mass due to permittivity and permeability increase and this make the light to refract following a curved path around the mass. The effect is very small around masses like sun and earth due to very high value of background gravitational potential.

Another effect produced by the vacuum properties variations is the slowing down of electromagnetic processes and clocks in lower gravitational potentials. This in turn will produce the gravitational red shift of light emitted from a source localized in a lower gravitational potential if that light is received in an area with higher gravitational potential.

5.2 Gravitational Bonding

In normal conditions the vacuum on earth surface is almost completely entrained with earth orbital movement because the earth has the dominant gravitational influence on its surface, but is not entrained with the earth rotation around its own axis because this rotation not change equipotential surfaces around the earth. The Michelson-Morley experiment and other experiments like it, give a null result because the vacuum is bonded with the gravitational equipotential lines around the earth, even if the experimental device of this kind move relative to earth, the result is also null due to length contraction of apparatus and slow down processes. Trouton-Noble experiment with suspended charged capacitor also give a null result for the same reason.

In Sagnac type of experiments the movement of apparatus relative to vacuum is detected. The Sagnac effect appear because the rotation of apparatus relative to earth and vacuum combined with the fact that light propagate with speed c relative to vacuum, make the two beams of light to propagate over different distances until they reach the receiver. The same effect appear in the case of Michelson-Gale-Pearson experiment where the device rotate with the earth, vacuum being unaffected by the earth rotation.

5.3 Aberration of Light

Star light aberration is produced because the light receiver is immersed in earth vacuum and move with it, the angular deviation of light beam when enter in earth vacuum is just an electromagnetic effect (figure 1). The transition from solar system vacuum (zone 1) to earth vacuum (zone 2) is gradual with the increasing of earth gravitational influence, however for simplicity a step transition is considered instead, the earth vacuum moving with velocity u relative to solar system vacuum.

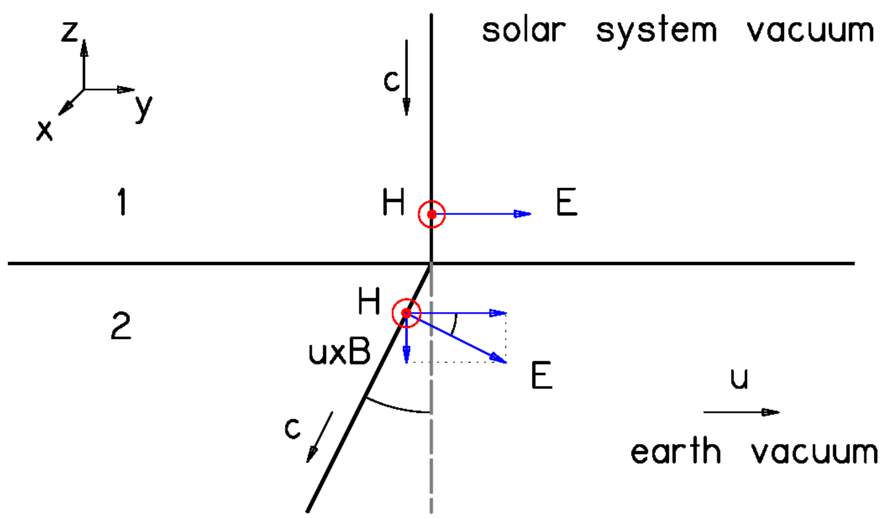

Figure 1: Star light aberration

The angular deviation is produced because the electromagnetic field is advected by the earth vacuum into the new movement state. The vacuum parameters in both zones are the same only the movement state is different, due to advection an additional $\boldsymbol{u} \times \boldsymbol{B}$ (in the case from figure 1 where for simplicity the electric field component was chosen parallel with the movement direction, if magnetic field is chose to be parallel with movement direction then a $\boldsymbol{D} \times \boldsymbol{u}$ component will be induced) component of electric field is induced in the earth vacuum. The wave magnetic field from zone 1 being transversal with the direction of movement pass unaffected in zone 2.

$$H_1 = H_2 = H$$

An electric field component in -z direction is induced in zone 2 by passing magnetic component from zone 1.

$$E_{2z} = u\mu_0 H$$

In both zones we have the relation

$$\frac{E}{H} = Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}}$$

The angle of aberration is

$$\sin\vartheta = \frac{E_{2z}}{E} = \frac{u\mu_0 H}{E} = \frac{u\mu_0}{Z_0} = \frac{u}{c} \tag{63}$$

in the direction opposed to vacuum movement. While the light propagate in that direction is also advected with the vacuum and at any moment the light is located in the extension of zone 1 direction of propagation (dashed line). However an observer located in zone 2 and moving with the local vacuum will see the light coming at angle. If we presume that the zone 2 is just a region of moving vacuum between two zone 1 vacuum, an observer located in the zone 1 beyond the moving region of vacuum will see the light at an unmodified angle and position from original. The same is true if a mirror in zone 2 reflect the light back to zone 1, only travel time of light appear longer, the position remain unmodified. This mean that various regions of vacuum that may move with various velocities between earth and a star, will not affect the direction and position of the starlight due to their movement, only gravitational refraction will have a net effect.

Also if the light source is moving transversal to local vacuum, the emitted light is deflected in the direction of source movement (source aberration), however if the source have a spherical emission then always exist a beam of light emitted in every direction if the speed of the source is much small than that of light. In consequence only the movement of the receiver and its local vacuum, like an observer from earth, will have an effect over the angle of aberration. This independence of aberration angle by the movement of spherical light sources was actually observed in the case of binary stars.

5.4 Fizeau experiment

Fizeau water tube experiment, in this experiment the mass of the moving water is too small to have any influence over the vacuum at earth surface, so the vacuum is immobile relative to apparatus which is immobile relative to earth. The moving water which is a dielectric influence the propagation speed of electromagnetic wave (figure 2).

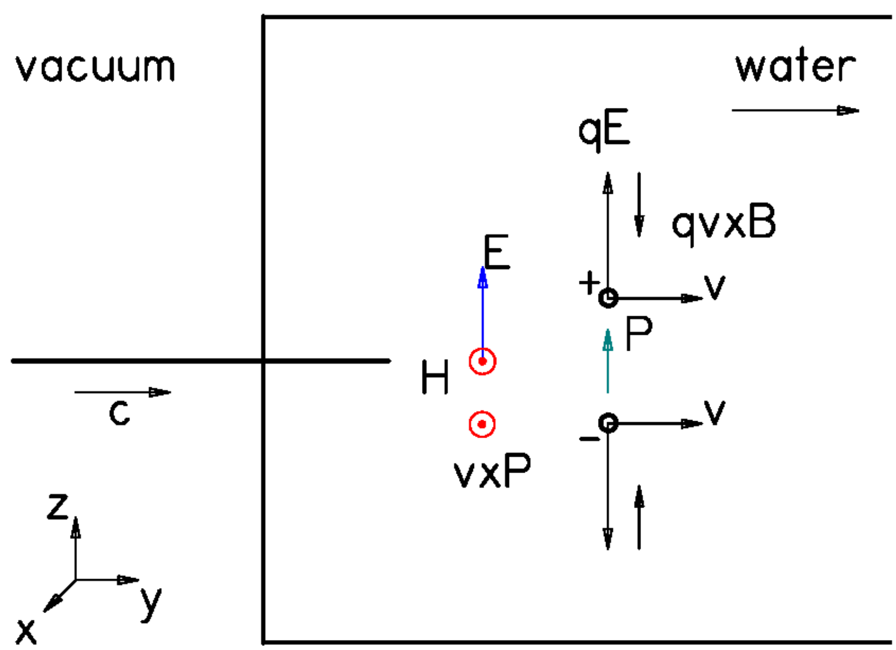

Figure 2: Fizeau water tube experiment

Water being a dielectric the electric field of the wave produce dipoles in water, dipoles which move with the water with velocity v in the direction of wave propagation in the case illustrated in figure 2. This movement being relative to vacuum produce in turn three effects. First additional Lorentz forces act over the charges that form the dipole in the presence of the wave magnetic field. These forces oppose to electric forces if water move in the direction of wave propagation (like in figure 2), or assist the electric forces if water move against the direction of wave propagation. Second and the most important the dipole moving relative to vacuum induce an additional magnetic field which assist or oppose the magnetic field of wave depending by water direction of movement in relation with wave direction of propagation. More precisely the term $\boldsymbol{D}\times\boldsymbol{u}$ from induction equation (33), because $u=-v$, become $\boldsymbol{v}\times\boldsymbol{P}$, the $\varepsilon_0\boldsymbol{E}$ term from the expression of electric displacement being immobile relative to vacuum. And third this additional magnetic field induced by moving dipole also produce an additional Lorentz force over the charges that always oppose to electric forces.

We will use the following notations: $\varepsilon=\varepsilon_0\varepsilon_r$, $\mu=\mu_0$, Z, c_n electromagnetic properties of water at rest; ε_v, μ_v, Z_v, c_v electromagnetic properties of water in movement. The speed of electromagnetic field propagation is relative to vacuum and apparatus. In water at rest we have the polarization

$$\boldsymbol{P}=\varepsilon_0\left(\varepsilon_r-1\right)\boldsymbol{E}$$

in this case we also have

$$\frac{E}{H}=Z$$

when water move in the particular case from figure 2 we have

$$\boldsymbol{P}=\varepsilon_0\left(\varepsilon_r-1\right)\left(\boldsymbol{E}+\boldsymbol{v}\times\boldsymbol{B}\right)=\varepsilon_0\left(\varepsilon_r-1\right)\left[E-v\mu\left(H+vP\right)\right]\mathbf{k}$$

$$P\left[1+\left(\varepsilon_r-1\right)\frac{v^2}{c^2}\right]=\varepsilon_0\left(\varepsilon_r-1\right)\left(E-v\mu H\right)$$

if we note

$$\xi=1+\left(\varepsilon_r-1\right)\frac{v^2}{c^2}$$

we have

$$P=\frac{1}{\xi}\varepsilon_0\left(\varepsilon_r-1\right)\left(E-\frac{v\mu E}{Z}\right)=\frac{1}{\xi}\varepsilon_0\left(\varepsilon_r-1\right)\left(1-\frac{v}{c_n}\right)E$$

the electric displacement become

$$D=E\left[\varepsilon_0+\frac{1}{\xi}\varepsilon_0\left(\varepsilon_r-1\right)\left(1-\frac{v}{c_n}\right)\right]=\varepsilon_v E$$

The moving water impedance is

$$Z_v=\frac{E}{H+vP}=\frac{Z}{1+\frac{v}{\xi}Z\varepsilon_0\left(\varepsilon_r-1\right)\left(1-\frac{v}{c_n}\right)}$$

The speed of light in moving water relative to vacuum is

$$c_v = \frac{1}{\varepsilon_v Z_v} = \frac{\xi + vZ\varepsilon_0\left(\varepsilon_r - 1\right)\left(1 - \dfrac{v}{c_n}\right)}{\xi Z\varepsilon_0 + Z\varepsilon_0\left(\varepsilon_r - 1\right)\left(1 - \dfrac{v}{c_n}\right)}$$

Considering the equalities

$$\varepsilon_r = n^2$$

$$c_n = \frac{c}{n}$$

$$Z\varepsilon_0\varepsilon_r = \frac{1}{c_n}$$

after some calculations result

$$c_v = \frac{\xi c_n + v \cdot \dfrac{\varepsilon_r - 1}{\varepsilon_r}\left(1 - \dfrac{v}{c_n}\right)}{1 - \dfrac{\varepsilon_r - 1}{\varepsilon_r}\left(\dfrac{v}{c_n} - \dfrac{v^2}{c^2}\right)}$$

and finally

$$c_v = \frac{\xi\dfrac{c}{n} + v\left(1 - \dfrac{1}{n^2}\right)\left(1 - \dfrac{nv}{c}\right)}{1 - \left(1 - \dfrac{1}{n^2}\right)\left(\dfrac{nv}{c} - \dfrac{v^2}{c^2}\right)} \tag{64}$$

which is the propagation speed of light when water move in the direction of propagation. Because in the case of Fizeau experiment the water velocity was much smaller than c, the propagation speed can be approximate as

$$c_{v0} = \frac{c}{n} + v\left(1 - \frac{1}{n^2}\right) \tag{65}$$

which is the Fresnel formula confirmed by Fizeau in his water tube experiment. In equations (64 and 65) the water velocity v become -v in the case of a changed water flow.

6 Conclusion

The vacuum background known as quantum vacuum at a microscopic level can explain electrodynamics and gravitational phenomena without the necessity of Lorentz invariance. Simple Galilean invariance which preserve causality, can be used to understand these phenomena if we take into consideration that the vacuum background is intimately connected with gravity. In fact the gravity and vacuum background represent the same thing, the observable gravitational effects are only the effect of properties variations in the vacuum background.

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