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Demystifying the Lorentz Force Equation

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Abstract

The Lorentz force equation $F = q(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B})$, which has been used by the engineering community since the early 20th century to control the motion of electrons on free trajectories, in a wide range of technical applications, is a generalized equation that was originally developed by Hendrik Antoon Lorentz at the beginning of the 20th century, and which treats, in a single formulation, two very different aspects of the behavior of free-moving electrons. This article aims to put into perspective the historical context in which the equation was developed, and to clarify how its two different aspects can be clearly separated for practical computational purposes and used in fundamental research in physics, to help reconcile classical/relativistic mechanics and quantum mechanics with electromagnetism, and in particular how its first term can be related to gravitation while its second term can be related to measurable mass from the electromagnetic perspective.

Keywords

Electron Resonance States, Elementary Electromagnetic Particles, Electromagnetism, Hydrogen Atom

1. Introduction

In 1904, H.A. Lorentz published an article that revolutionized two major aspects of fundamental physics, one pertaining to classical/relativistic physics as applicable at our macroscopic level of magnitude, and one pertaining to the electromagnetic behavior of free moving electrons at the subatomic level of magnitude. His article is largely referenced in the literature in relation with his proposal applicable to relative motion at our macroscopic level, but his analysis of the free moving electron behavior that emerges from the experimental data previously collected by Walter Kaufmann remains mostly obscured behind the popularity and universal reach of his proposal regarding relative motion [1].

The revolutionary development that he proposed regarding relative motion

was meant to account for physical processes observed at the astronomical level that seemed to deviate from classical mechanics as established by Newton, at a time when general knowledge about these issues was much less extensive than what we know today.

His proposition was a set of mathematical transformations meant to address the issue of relative motion of macroscopic masses with respect to each other, as a solution to the apparent impossibility at the time of identifying an absolute reference in the universe, relative to which the motion of all massive bodies could be calculated, a conclusion that resulted from the apparent failure of the Michelson and Morley experiments to demonstrate the existence of such an absolute reference [2].

This development, although meant to resolve issues not addressed by Newton's classical mechanics, was still grounded on the double assumption that the existence of kinetic energy that sustains momentum is caused by the motion of massive bodies and that the total amount of this energy is conservative, in the sense that when a body slows down, this kinetic energy is deemed to progressively convert to potential energy, so that when the body stops completely, all of its kinetic energy has converted to potential energy, and that at all times, the sum of the kinetic energy and of the potential energy remains constant—a concept mandated by the classical Principle of energy conservation ([3], p.217).

The Newtonian mechanics equation that did not seem able to completely address some astronomical observations is precisely related to the relation between the kinetic energy of a moving mass $K = 1/2mv^2$ and its momentum $p = mv$, both equations being related via the relation $K = p^2/2m$. Briefly summarized, Lorentz brought in the picture the idea that the correction required could be addressed by the introduction of the γ-factor in Newton's kinetic energy equation $K = 1/2\gamma m_0 v^2$ and in his momentum equation $p = \gamma m_0 v$, thus defining with symbol m_0 the *rest mass* of a body when its velocity is zero, both equations still being related via the amended relation $K = p^2/2\gamma m_0$, the γ factor now relating the motion of bodies to the perception of an observer in the absence of an absolute reference, by means of the mathematical transformations that he was proposing.

As soon as Henri Poincaré recognized the mathematical validity of the *Lorentz transformations*—term that he coined in his June 5 of 1905 note [4]—Albert Einstein published his major article on relative motion, now known as the Special Relativity Theory (SRT) [5], that integrated the Lorentz transformations as a means by which the relative motion of massive bodies with respect to each other could be mechanically explained, involving the concepts of time dilation and mass length contraction, as well as the γ-factor controlled non-rectilinear increase of the momentum kinetic energy of massive bodies with their increasing velocity toward the speed of light, now established as an asymptotic velocity limit for massive bodies, as a refinement to Newton's original assumption, that assumed a rectilinear increase of their momentum energy with velocity, with no ultimate velocity limit.

The second revolutionary development established by Lorentz in his 1904 article [1] was the confirmation of the validity of the first equation of electromagnetic mechanics initially developed by himself to control the motion of free moving—electrically charged—electrons at the subatomic level, now known as the Lorentz force equation, from experimental data collected by Walter Kaufmann using this equation [6] [7]; free moving electrons whose trajectories could now be controlled by a combination of electric and magnetic $\boldsymbol{E}$ and $\boldsymbol{B}$ fields of separately controllable intensities, which acted directly on the charge of the electron rather than on its mass, contrary to the concept of force imagined by Newton as acting on mass. We will see later that Einstein assumed the two concepts to be equivalent.

But contrary to classical mechanics, that assumed that the amount of momentum energy of an electron depends on the velocity of its mass, the Lorentz electromagnetic mechanics equation involved that the amount of momentum energy of the moving electron does not depend on its velocity, but rather that the opposite relation was involved, that is, that it was the velocity of the electron that depended on the amount of momentum energy communicated to its charge by the variable intensity $\boldsymbol{E}$ and $\boldsymbol{B}$ fields that controlled its trajectory; an energy adiabatically induced in the moving electron as a function of the inverse of the distances that separated the moving electron from other charged particles whose mutual interaction established the controlling $\boldsymbol{E}$ and $\boldsymbol{B}$ fields, as clarified in Reference [8] and in its expanded final republication [9].

But at that time, the concepts of force fields were rather grounded on the conservative duality of kinetic energy versus potential energy as defined in classical mechanics, as Aram d'Abro clearly explained in the 1930s in his excellent synthesis ([3], p. 217). However, according to this perspective, the concept of potential energy in a force field would only appear if the field is derived from a potential:

"*Consider a particle in a conservative field, and two arbitrary points* $\boldsymbol{A}$ *and* $\boldsymbol{B}$ *in the field. The relationship between the potential energy and the particle a*t **A** and at **B** is fur*nished by the following definition*:"

"*Potential energy at* $\boldsymbol{B}$ *minus potential energy at* $\boldsymbol{A}$ = *work* (*positive or negative*) *expended by the field of force when the particle is made to pass from* $\boldsymbol{B}$ *to* $\boldsymbol{A}$"

"*For instance, if we agree that the potential energy at the point* $\boldsymbol{A}$ *is zero, the potential energy at any arbitrary point* $\boldsymbol{B}$ *is given by the work* (*positive or negative*) *expended by the force when the particle is moved from* $\boldsymbol{B}$ *to* $\boldsymbol{A}$…"

So, while a stone is falling from point $\boldsymbol{B}$ *to point* $\boldsymbol{A}$, "*...its potential energy would be decreasing and its kinetic energy increasing at an equal rate, so that the sum of the two kinds of energy would remain constant.*"

"*This rule is general: Whenever a particle is released from a position of rest in a conservative field, it will always start moving towards regions of decreasing potential energy...*"

"*The conservation of energy would not hold in a non-permanent field*; *nor would it be realized in a permanent field which is not derived from a potential*."

This last condition is precisely the case for the ***E*** and ***B*** fields controlled by the Lorentz force equation. Neither field is permanent. And they are not derived from a potential, but depend on specific and modifiable configurations of electric wire windings in which electric current is made to circulate—a current made of electrons moving along the wires—and of ferromagnetic material or permanent magnets, whose magnetic fields depend on non-permanent configurations of electrons captive of atoms in these materials.

The velocity of the electrons flowing in a wire (determined by the voltage) determines the intensity of the Coulomb interaction between the charges related ***E*** field controlled by the first term of Lorentz equation while the related magnetic ***B*** field of his second term is generated about the wire according to the Biot-Savart equation due to the forced magnetic parallel spins alignment of the electrons flowing in the same direction in the wire, complemented, to control the curvature of the free moving electrons trajectories by the controllable ***B*** fields of nearby ferromagnetic material and/or permanent magnets, whose macroscopic magnetic fields are due to forced parallel alignment of the magnetic spins of unpaired electrons in these materials [10] [11].

Let us note that the Coulomb equation $F = q_1 q_2 / 4\pi\varepsilon_0 d^2$ is the means by which the energy adiabatically induced in all charged particles according to the underlying Coulomb interaction can be calculated strictly as a direct function of the inverse of the distances separating them $E = d \cdot F = q_1 q_2 / 4\pi\varepsilon_0 d$, as clarified in Reference [12] and its expanded final republication [13].

Given that the macroscopic ***E*** and ***B*** fields generated by current flowing in wires disappear when the current is made to stop flowing in the wire, that the macroscopic ***B*** field of electromagnets disappears when the current in their wire is cut, and that even the macroscopic ***B*** field of so-called permanent magnets disappears when heated, and is not restored upon cooling when overheated past a critical temperature, d'Abro's condition that "conservation of energy would not hold in a non-permanent field" is realized.

So, when we consider a charged particle in such non-conservative fields, and two arbitrary points in space ***A*** *and* ***B***, the relationship between the energy and the *charged particle* at ***A*** *and at* ***B*** is then provided by the following definition:

"*The energy at* ***B*** *minus the energy at* ***A*** (*positive or negative*) *provided by the non-conservative field of force when the charged particle is made to pass from* ***B*** *to* ***A*** *can only be adiabatic in nature*"

Let us note in passing, that at the beginning of the 20th century, the general consensus was not that elementary charged particles induce energy into each other as a function of the distances separating them as just mentioned, but that energy was induced in each elementary charged particle by an all pervading underlying supposedly conservative electromagnetic field, which muddled the issue of energy induction in elementary charged particles for the rest of the 20th century and a good chunk of the twenty first century.

This relation was clearly described by Einstein in his 1910 article [14]. (The German original of this article having been lost, the quotes in English are made from its initial French translation made the same year by E. Guillaume, which is the only existing translation made from the lost original German version. The formal English translation published in 2021 of the Guillaume version is available from the Minkowski Institute [15]):

"*…the electric and magnetic fields eventually came to be considered to be entities whose mechanical interpretation was superfluous. This led to the view of these fields in vacuum as being particular states of the aether that did not require further analysis.*

A charged particle in motion relative to the aether is like an element of current; the actions of the electromagnetic field on the particle and the reactions of the latter on the field are the only bonds that bind matter to the aether. In the latter, where space is not already occupied by a particle, the intensities of the electric and magnetic field are expressed by Maxwell's equations for the free aether, assuming that the equations are related to a system of axes which is immobile relative to the aether."

By carefully calibrating the intensity of ambient macroscopic electric and magnetic fields, subatomic scale local electric and magnetic $\boldsymbol{E}$ and $\boldsymbol{B}$ fields are consequently locally adiabatically generated in the immediate vicinity of each electron in electron beams, that locally guide each electron on its trajectory according to equation $\boldsymbol{v} = \boldsymbol{E}/\boldsymbol{B}$, equal densities of the $\boldsymbol{E}$ and $\boldsymbol{B}$ fields defining straight line motion of the charged particle, while unequal densities of these induced fields define curved trajectories, each electron being propelled by a local momentum energy which is simultaneously adiabatically induced in each of them [16], that is, a combination of local $\boldsymbol{E}$ and $\boldsymbol{B}$ field energy, the sum of which is equal by structure to the momentum energy which is simultaneously induced, these two induced components constituting the carrier-energy whose momentum component propels the electron [12] [13].

This control method that Lorentz initially proposed in a previous article [17], that involved combining the Coulomb equation to calculate the total $\boldsymbol{E}$ field energy of the electron, to the transverse $\boldsymbol{B}$ field energy relation established by Heaviside [18], to control its velocity and the curvature of its trajectory was then used by Kaufmann [6] to collect data from accelerating free moving electrons in a bubble chamber.

After Abraham in 1902 [19], Lorentz also succeeded in his 1904 article [1] in relating the total amount of $\boldsymbol{E}$ field energy provided by the Coulomb equation to the exact classical/relativistic longitudinal inertia of the free moving electron by introducing the γ-factor—"k" in his paper—(see mass m_1 of his first Equation (30) and related explanations), and by also introducing the same γ-factor to account for the total transverse electromagnetic/relativistic inertia of the electron being deflected—that turned out to be different from the total m_1 longitudinal inertia—(see mass m_2 of his second Equation (30)), the latter value corresponding to the velocity related increase in the total transverse magnetic $\boldsymbol{B}$ field of the

moving electron.

This method, experimentally confirmed by the Kaufmann data as analyzed by Abraham and Lorentz, was immediately adopted by the engineering community to deal with all applications requiring precise control of the trajectories of free moving electrons, typical current applications of which being precise control of the trajectories of electron beams in all CRT screens applications and precise control of charged particle beams in all high energy particle accelerators.

2. The Adoption of the Special Relativity Theory

When Einstein published his article on relativistic motion and non-rectilinear momentum energy increase with velocity towards c, established as a speed limit for massive bodies [5], directly grounded on the Lorentz transformations [1], he had already astonished the physics community with two other groundbreaking articles published only a few months earlier that made the whole community pay heightened attention to his third paper.

The first article, from March of 1905, explained his quantum theory of light [20], grounded on Max Planck's conclusions [21] about the black-body experiments recently carried out by Wilhelm Wien [22], the main conclusion of which can be summarized with this quote:

"*In fact, it seems to me that the observations on "black-body radiation", photoluminescence, the production of cathode rays by ultraviolet light and other phenomena involving the emission or conversion of light can be better understood on the assumption that the energy of light is distributed discontinuously in space. According to the assumption considered here, when a light ray starting from a point is propagated, the energy is not continuously distributed over an ever increasing volume, but it consists of a finite number of energy quanta, localized in space, that move without being divided and that can be absorbed or emitted only as a whole.*"

This conclusion is what led him to the photoelectric effect mechanical explanation that confirmed that the energy of localized electromagnetic photons, as he hypothesized them to be emitted, to propagate and to be absorbed individually, has measurable longitudinal inertia—inertia in the direction of their motion, which eventually earned him the Nobel Prize in 1921.

This discovery also led, in correlation with his soon to be published conclusion that the momentum energy that propelled moving masses has to be a physically existing substance [23]—see further on—and the later proposed double-particle photon hypothesis regarding the possible inner dynamic electromagnetic structure of these localized photons by Louis de Broglie published in the 1930's [24], to the establishment of the LC equation and the related $\boldsymbol{E}$ and $\boldsymbol{B}$ fields equation that mechanically describe their internal electromagnetic structure in an article initially published in 2016 [25], republished in expanded final version in 2021 [26], in complete agreement with Maxwell's equations, describing them as moving separately without spherically expanding from their point-

source, but being emitted, propagating and being absorbed only as a individual separate quanta as concluded by Einstein [20], that is, mechanical absorption, propagation and emission processes that were analyzed and published in 2020 [12] [13].

In May of 1905, another major paper of his was published, drawing attention to a possible explanation to the Brownian motion observed in liquids, according to which the erratic motion of microscopic particles visible with microscopes in liquids could be explained by stochastic collisions with molecules too small to be seen, of which the liquid had to be made, which he concluded could lead to the possibility of calculating the physical dimensions of these molecules [27], a process that was independently discovered and explained by Marian von Smoluchowski one year later [28]. Their conclusions were experimentally confirmed by Jean Perrin en 1912 [29]. The relation between Brownian motion and electromagnetism will be analyzed in Section 13, in which will be explained the reason why these molecules, that Einstein sensed the existence of, keep naturally moving in liquids, which is what makes them collide with the particles visible with microscopes.

So when Einstein's third significant paper was published within a few months of the first two on September 26 of 1905—received June 30—this one grounded on the recently mathematically confirmed Lorentz transformation [1] [4], proposing a logical solution that apparently reconciled electromagnetism as observable at our macroscopic level with classical mechanics, that seemed to resolve the issues not addressed by Newton's classical mechanics regarding the behavior of massive bodies in a comprehensive theory that came to be known as the Special Relativity Theory [5], Einstein's stature as a leading edge theoretician was already overwhelming the community.

Finally, when Einstein published a fourth paper November 21 of 1905—received September 27 [23] as an extension of his June 30 paper [5]—the revolution of physics was completed with the introduction of his conclusion that the energy in excess of a body's rest mass which is transferred to the environment when a body is stopped in its motion had to be a physically existing substance [12] [13], since it was proven to have inertia just like the body's rest mass and just like the energy of localized electromagnetic photons as they hit electrons in massive bodies as demonstrated by the photoelectric effect as described in his previous March 1905 article [20], given that inertia can hardly be expected to be manifested by something that did not have physical existence as a ponderable substance:

"*When a body emits energy L in the form of radiation, its mass decreases by* L/V^2*… The mass of a body is a measure of its energy content; if the energy changes by L, the mass changes in the same manner by* $L/9.10^{20}$*, if the energy is measured in erg and the mass in grams.*"

Obviously, Einstein had in mind here the momentum energy of a macroscopic body that can be measured in addition to the energy making up its rest mass, as conceived in classical mechanics when this energy is communicated to the envi-

ronment when a body is stopped in its motion [8] [9]. The case of a 1 kg mass falling to the ground from a height of 1 meter, to clearly put in perspective what can be experimentally ascertained from our macroscopic level perspective, is analyzed in References [8] [9].

Let us note at this point that his correlation in his September 1905 article of the *inertia* of moving bodies with the "physically-existing-substance" aspect of the energy released when they are stopped in their motion did not attract attention at the time, given that the whole community and Einstein himself immediately became utterly engrossed into endless discussions and further analyses of the "relative-motion aspect" of his SR theory.

One century later, this aspect of the SR theory is still the object of constant arguments and further publications in the community, given the difference between the observable behavior of masses at our macroscopic level and that of the electron mass at the subatomic level as revealed by the Kaufmann experiments, that the same 1904 Lorentz paper also put to light [1], and that we will now examine.

3. Adoption of the First Electromagnetic Mechanics Equation by the Engineering Community

Before getting into the analysis of the 1904 Lorentz conclusions [1] regarding the Kaufmann data [6] [7], that confirmed the first equation that allows complete control of the trajectory and the velocity of a charged and massive elementary particle at the subatomic level, thus establishing the first bridge between classical mechanics, that deals with the control of massive bodies at our macroscopic scale, and electromagnetic mechanics that deals with the control of charged particles at the subatomic level, thanks to the electron simultaneously possessing both an invariant rest mass (m_0 = 9.10938188E−31 kg) and a charge at all times invariant (e = 1.602176462E−19 C), let us briefly put in perspective the knowledge previously established on which his research was grounded.

The mutually perpendicular interaction between the electric $\boldsymbol{E}$ and magnetic $\boldsymbol{B}$ aspects of light moving in vacuum in a direction that can only be perpendicular to both $\boldsymbol{E}$ and $\boldsymbol{B}$ fields, was understood by Maxwell as being the reason why light could move at invariant velocity c in vacuum, as demonstrated by the second partial derivatives of electromagnetic equations drawn from experiments previously carried out by earlier experimentalists [30]. Maxwell came to this conclusion after Faraday informed him in 1845 that he had observed that light passing through a glass plate becomes polarized when he locates the plate between the magnetic poles of his electromagnet, a behavior that was given the name of Faraday Effect.

This information convinced Maxwell that light had to be some form of free moving energy that could only be electromagnetic in nature, propagating in vacuum at the velocity revealed by his second partial derivative calculations, a velocity that was maintained by the interaction of these two separate fields, one

electric, and one magnetic, interacting perpendicularly to each other, and perpendicularly to the direction of motion of the light energy. He was in fact, the first to mathematically associate a velocity to light, that is, to free moving electromagnetic energy, by means of direct calculation [31].

$$c = \frac{\boldsymbol{E}}{\boldsymbol{B}} \tag{1}$$

About 20 years after Maxwell's publication of his conclusions in 1865, Heaviside, simplified Maxwell's 20 equations into the 4 equations that have since been in universal use [17], and also established for the first time that a magnetic field would apply a force, manifested as a pressure on the infinitesimal *ds* surface of the fulcrum of a point-like behaving charged particle in free motion that would determine its velocity—see Section 13 on this particular issue—and that this pressure, or force, could be calculated when the charge of the particle and the strength of the ambient magnetic $\boldsymbol{B}$ field are known:

$$F = q\left(\boldsymbol{v} \times \boldsymbol{B}\right) \tag{2}$$

Given that pressure is defined as a *force* being applied perpendicularly to the surface of an object per unit area (A) over which that force is distributed, the dimensions of a pressure in the SI system come out as "*Newtons per meter squared*" ($P_A = F_A$ = Newtons/m^2). In the case of a point-like behaving charged particle, this surface tends by structure to mathematically reduce to an "infinitesimal surface" meant to represent at the limit the practically dimensionless point-like fulcrum of the point-like behaving particle [26] that can be mathematically represented by an infinitesimal ds surface for calculation purposes, to which the pressure will be applied ($P_{A\to ds} = F_{A\to ds} = F$ = Newtons).

If such a point-like behaving charged particle is immobilized in some stationary electromagnetic equilibrium state, a force applied to this idealized *ds* surface that would be insufficient to overcome this stationary state can only result in the velocity of the particle remaining at zero (v_0) even if the pressure remains fully applied—see Section 13 for further development of this relation between pressure and force:

$$P_{A=ds} = q\left(\boldsymbol{v}_0 \times \boldsymbol{B}\right) \tag{3}$$

But if the *pressure*/*force* ($P_{A=ds} = F_{A=ds}$) exerted on the particle's fulcrum by the magnetic field $\boldsymbol{B}$ is sufficient to overcome the stationary electromagnetic state that immobilizes the charged particle, then the *pressure* applied and constantly maintained on the particle by the magnetic $\boldsymbol{B}$ field will cause the particle to start moving at the corresponding velocity, that can be calculated with the equation previously mentioned, established by Heaviside:

$$P_{A=ds} = F_{A=ds} = F = q\left(\boldsymbol{v} \times \boldsymbol{B}\right) \tag{4}$$

Ten years later, Lorentz had the intuition that if electric and magnetic fields in mutual transverse interaction, as Maxwell conceived them, could propel light energy at velocity c in vacuum, then perhaps they could also be combined to

precisely control the motion of charged particles, such as the electron. So the idea came to him that combining the Coulomb force equation, that allows controlling the intensity of the $\boldsymbol{E}$ fields in the vicinity of an electron $F = e \cdot \boldsymbol{E} = k\left(e \cdot q/d^2\right)$—$q$ being the sum of charges in the vicinity that establish the $\boldsymbol{E}$ field as a function of the inverse square of the mean distances d separating them from the electron e, et $k = 1/4\pi\varepsilon_0$ being the Coulomb constant—to control its acceleration, to the Heaviside force equation $F = e(\boldsymbol{v} \times \boldsymbol{B})$, that provides its velocity as a function of the intensity of the related magnetic $\boldsymbol{B}$ field, all aspects of the motion of the electron could be addressed, resulting in his famous general equation:

$$F = q\left(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B}\right) \tag{5}$$

Kaufmann then proceeded to experiments with free moving electrons, using interacting electric and magnetic fields in the manner suggested by Lorentz, observing and measuring their trajectories in a bubble chamber, and collected the data that Abraham and Lorentz then analyzed, confirming that not only momentum energy was induced in electrons by the Coulomb interaction to explain their longitudinal motion, but that transverse energy was also simultaneously induced in them, that could be measured longitudinally as well as transversely contrary to the momentum energy that could be measured only longitudinally, a transverse energy that added momentary velocity related additional measurable mass to the invariant rest mass of the electron.

In his famous 1904 article [1], in which Lorentz was commenting and correlating the experimental data collected by Kaufmann from 1901 to 1903 [6] [7] [32] [33], previously analyzed by Abraham [19], that confirmed the validity of the force equation that he had established in 1895 [17], he clearly concluded with reference to Equations (30) of his development that:

"*Consequently, in processes in which acceleration occurs in the direction of motion, the electron behaves as if it had mass* m_1, *and in acceleration in a direction perpendicular to the motion, it behaves as if it had mass* m_2. *These quantities* m_1 *and* m_2 *are therefore appropriately named the* '*longitudinal*' *and* '*transverse*' *electromagnetic masses. I will assume that, in addition, there is no* '*real*' *or* '*material*' *mass.*"

Lorentz represents these two measurable perpendicular states of acceleration of the electron, that is, acceleration in the direction of its trajectory, and acceleration perpendicular to it, with the following two equations ([1], Equations (30)):

$$m_1 = \frac{e^2}{6\pi c^2 R}\frac{\mathrm{d}(kl\omega)}{\mathrm{d}\omega} \quad \text{for longitudinal acceleration} \tag{6}$$

and

$$m_2 = \frac{e^2}{6\pi c^2 R}kl \quad \text{for transverse acceleration} \tag{7}$$

And finally, for negligible velocities that reduce the v^2/c^2 ratio of the γ-fac-

tor—represent as k in his equations (explained further down)—to an infinitesimal value, which in turn reduces the value of the γ-factor to 1, the mass of the electron is considered to remain at its rest mass value, that is, the initial mass used in the $F = ma$ acceleration equation as defined in Newtonian mechanics (defined according to our modern notation as m_0), he equates both m_1 and m_2 with the electromagnetic definition of this rest mass, when the electron velocity is theoretically zero:

$$m_0 = m_1 = m_2 = \frac{e^2}{6\pi c^2 R} \tag{8}$$

Also commenting the experiments carried out by Kaufmann [7] by means of the force equation developed by Lorentz, and the calculation also carried out by Abraham from the same Kaufmann data [19], Henri Poincaré concluded in 1905 ([34], p. 137):

"*Abraham's calculations and Kaufmann's experiments have shown that mechanical mass itself is zero and that the mass of electrons, or at least of negative electrons, is exclusively of electrodynamic origin. This forces us to change the definition of mass; we can no longer distinguish mechanical mass from electrodynamic mass, because then the former would disappear; there is no other mass than electrodynamic inertia; but in this case the mass can no longer be constant, it increases with the velocity; and even, it depends on the direction, and a body animated by a notable velocity will not oppose the same inertia to the forces which tend to deviate it from its course, and to those which tend to accelerate or to delay its forward motion.*"

4. The 1907 Turning Point

By his own admission, Einstein had worked in isolation at the elaboration of his Special Relativity Theory for more than 7 years before producing his historical June 30 article [5], just a few weeks after Poincaré published his June 5 note about the Lorentz transformation [4], that was immediately widely distributed as was the habit of the French *Académie des sciences*, and that seemed to confirm what he had been suspecting all along, which is that absolute motion apparently could not be proven to exist in physical reality.

It seems that Einstein's attention was drawn more specifically to this specific conclusion of Lorentz before he published his 1905 paper [1], momentarily paying less attention to the behavior of electrons as analyzed in the Lorentz article, that had been under scrutiny since 1887, initiated by Heaviside [18], then Voigt [35], Lorentz in 1895 [17], and experimentally by Kaufmann in 1901, 1902 and 1903 [6] [7] [32] [33], whose results were analyzed by Abraham in 1902 [27] and by Lorentz himself in 1904, as finally reported by Poincaré in his book *La valeur de la science* published in 1905 [34].

The problem with this situation is that this observed difference between the variation rate of the transverse inertia of the accelerating electron and its differently varying rate of longitudinal inertia now made obvious at the subatomic

level, corresponding to the m_1 and m_2 terms of the Lorentz analysis, had never been observed in any experiment carried out with macroscopic masses, and resulted in Einstein having concluded that the transverse mass of macroscopic masses do not similarly increase with velocity, so the confirmed Lorentz m_1 and m_2 terms were not incorporated into the Special Relativity theory, leaving only the longitudinal momentum energy increasing as a function of the γ-factor to be integrated into SR, since applying it only to momentum energy seemed to satisfy the observable behavior of masses at our macroscopic level.

This apparent contradiction between the behavior of electrons and the behavior of macroscopic masses of course quickly attracted general attention in the community, and a whole series of experiments were carried out, mainly by Bucherer and Neumann [36] [37] all confirming the Kaufmann data. Planck, for example, re-analyzed the Kaufmann data [38] and found no flaw in Kaufmann's analysis, and the same for Poincaré's re-analysis [39]. From Lorentz's own admission, none of the experiments seemed to confirm the length contraction that he had himself introduced with his concept of relative transformations in the same 1904 article [1] on which Einstein's had grounded his 1905 theory, and suggested that more analysis should be carried out [40].

But Einstein did not change his mind [41] [42]:

"*Herr Kaufmann has determined the relation between [electric and magnetic deflection] of β-rays with admirable care... Using an independent method, Herr Planck obtained results which fully agree with Kaufmann... It is further to be noted that the theories of Abraham and Bucherer yield curves which fit the observed curve considerably better than the curve obtained from relativity theory. However, in my opinion, these theories should be ascribed a rather small probability because their basic postulates concerning the mass of the moving electron are not made plausible by theoretical systems which encompass wider complexes and phenomena.*"

Considering that all of his scientific production shows that during his whole life, Einstein was convinced that the key to resolving the gravitation issue involves only interaction between astronomical-sized macroscopic masses, and although he perfectly understood that the electron behaves at the subatomic level in accordance with the Kaufmann data, he could not see how such behavior of the subatomic level could have any bearing in the search for an explanation to gravitation, a pursuit that resulted in his November 4 of 1915 article that describes the main aspects of his General Relativity Theory (GRT), that indeed addresses the gravitation issue only from the astronomical magnitude perspective, but completely dismisses the possibility that the behavior of subatomic masses such as that of the electron could contribute to the final solution.

Einstein's opinion with regard to the Kaufmann data was indeed met with the approval of his colleagues, as revealed by this quote from Abraham Pais ([42], p.159):

"*Special Relativity killed the classical dream of using the energy-momentum-velocity relations of a particle as a means of probing the dynamic origin of its*

mass. The relations are purely kinematic. The classical picture of a particle as a finite little sphere is also gone for good. Quantum field theory has taught us that particles nevertheless have structure, arising from quantum fluctuations. Recently, unified field theories have taught us that the mass of the electron is certainly not purely electromagnetic in nature. But we still do not know what causes the electron to weigh."

The unfortunate outcome of this general opinion in the theoretical physics community at the beginning of the 1900's is that for the past century, although the engineering community has successfully been using the confirmed Lorentz force equation to control free-moving electron trajectories with the highest degree of accuracy in the whole set of functional applications developed to date, including high-energy particle accelerators [43], most in the fundamental physics and astrophysics communities, who rather gave credence to Special Relativity and General Relativity became less and less aware of the confirmed behavior of electrons at the subatomic level, due to all literature pertaining to SR and GR never referencing and explaining the now almost forgotten Heaviside-Lorentz-Kaufmann perspective—except in the engineering community, fortunately—and progressively became convinced without requestioning that the mass of the accelerating electron remains constant at all velocities and that only their γ-factor dependent momentum varies with said velocities, which largely explains why so little theoretical progress has been made in fundamental electromagnetism during the past century.

Given that no further reference was ever made after 1907 in SR an GR textbooks of the collective agreement in the early 1900's physics community that the Abraham and Lorentz analyses of Kaufmann's data was correct, this explains why generation after generation of physicists never heard about this agreement and also why one hundred years later numerous senior physicists, who obviously are not aware of the 1907 collective agreement, strongly assert, grounded on the too restrictive knowledge base provided by these SR and GR reference works, that "*mass gain with velocity is an illusion*".

We will now see that the physics community's general opinion of the early 1900's summarized by Pais was quite premature in light of what was subsequently discovered in the 1930's about the electromagnetic nature of the energy of which the electron rest mass is made, and in the 1960's about the elementary charged and massive subcomponents that make up the inner scatterable structure of protons and neutrons, and finally about the discovery in 2003 that the local transverse $\boldsymbol{B}$ field of a free moving electron increases with its velocity synchronously with its increasing transverse mass as measured by Kaufmann one hundred years earlier.

We will see that it is not the energy-momentum-velocity relations of a particle that can be useful in probing the dynamic origin of the electron mass, but the general Lorentz force equation.

Or course, the naive classical picture of elementary particles as finite little spheres is gone for good. But in light of the more extensive knowledge pool now

available, the notion that the relations between masses could be purely kinematic is contrariwise quite illusory and turns out to effectively be purely electromagnetic in nature.

Moreover, although Quantum field theory (QFT) grounded on the Ludwig Lorenz interpretation, that treats $\boldsymbol{E}$ and $\boldsymbol{B}$ fields as a single unified field, does not lead to conclude that electromagnetic particles may have an internal structure, Electromagnetic Mechanics grounded on Maxwell's initial interpretation, that treats both $\boldsymbol{E}$ and $\boldsymbol{B}$ fields as separate and mutually inducing each other in alternance, does it quite naturally, as we will soon see.

Finally, Contrary to what unified field theories seem to teach us, due to the discoveries made in the 1930's, we know now for certain that the mass of the electron is purely electromagnetic in nature, and that it is the omnidirectional inertia of the energy making up its rest mass plus the additional contribution of the omnidirectional inertia of the adiabatically induced transverse magnetic $\boldsymbol{B}$ field of its carrying energy in addition to its also adiabatically induced momentum energy, that causes the electron to weigh.

5. Mathematical Notation Synchronization

Historically, a trend progressively developed in the physics community according to which the ultimate understanding of Nature should result in the eventual development of a general equation that would summarize all of our knowledge about Nature and from which all useful equations could then be derived.

For a number of idealists in the orthodox physics community, the Friedmann equations developed in 1922 from Einstein's theories are considered to embody this ultimate accomplishment. But of course, as always through history, more and more information about Nature is gathered as time goes by, and much more has now been learned about Nature over the course of the past century, so there is little doubt that a new set of more ideal yet "ultimate equations", so to speak, are likely to be developed on our way to this hypothesized final equation from the now more extensive current pool of accumulated knowledge.

In the specific domain of electromagnetism, the Lorentz force equation is such an idealized equation that summarizes all of what was understood by the end of the 19th century about the nature and behaviour of electrons at the subatomic level. It is in fact an idealized regrouping of the two mathematical developments that for the first time allowed precise control of the motion of free moving electrons trajectories by precise combinations of electric and magnetic field, which was confirmed by the Kaufmann experiments, and by the successful development of many types of high energy accelerators all through the 20th century, from the first cyclotron conceived and built by Lawrence in 1932 [44] to the *CERN Large Hadrons Collider* (LHC) that entered service in 2008.

Being a generalized equation, seemingly summarizing and combining two different equations, it gives by default the impression that a single force results from resolving it. It is indeed generally referred to in the community as "The"

Lorentz force, when in reality two different forces are calculated, one related to the electric field $\boldsymbol{E}$ of the first term and the other related to the magnetic field $\boldsymbol{B}$ of the second term. They act in opposition to each other on the charge of the moving electron, and force it to move in a straight line when they are equal [31].

In this author's opinion, the various aspects of high energy accelerators operation and charged particle beams control are best introduced by Stanley Humphries Jr.'s outstanding reference work titled *Principles of Charged Particle Acceleration* [43].

Note that the symbols used by Lorentz in Equations (6) and (7) to represent velocity and the gamma factor were respectively ω and k, the latter now better known as the Lorentz factor. In the present work, the modern symbols v for velocity and γ for the Lorentz factor will be used.

Coefficient l on its part was function of the velocity, and resolves to 1 when velocity is zero, as does the γ-factor, such as in Equation (8). Let us note also, that coefficient l was meant by Lorentz to relate the electron velocity to the state of motion of an observer. But since we will be studying the Lorentz force equation in relation with the absolute velocity of the electron strictly according to the amount of its instantaneous amount of momentum energy, this coefficient resolves to 1 in all equations and will be ignored.

In his article [1], Lorentz defines the γ factor with his Equation (3):

$$\frac{c^2}{c^2-w^2}=k^2 \quad \text{that is:} \quad k=\frac{c}{\sqrt{c^2-w^2}} \tag{9}$$

Expanding this form to the limit reveals the more familiar modern form:

$$\gamma=k=\frac{c}{\sqrt{c^2-v^2}}=\frac{1}{\sqrt{\frac{c^2-v^2}{c^2}}}=\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \tag{10}$$

But although this last form is generally mentioned in reference works, calculations with scientific pocket calculators are hugely simplified when the following form is used, that leaves only one fraction in the expression:

$$\gamma=\frac{c}{\sqrt{c^2-v^2}}$$

The historical notation used by Lorentz in his 1904 article having now become unfamiliar to most, we will now convert Equations (6), (7) and (8) to their equivalent modern notation before proceeding to their analysis.

The electron rest mass is now symbolized by m_0. This is its well understood invariant mass when its velocity is theoretically zero, that is, when classically assuming that its momentum energy is also zero. This rest mass is established as a physical constant with value m_0 = 9.10938188E−31 kg. Equation (8) will now be resolved as follows when calculated from the Coulomb equation perspective:

$$m_0=m_{1(v=0)}=m_{2(v=0)}=\frac{e^2}{6\pi c^2 R}=\frac{e^2}{4\pi\varepsilon_0 r_e c^2}$$

Resolving to:

$$m_0 = \frac{e^2}{4\pi\varepsilon_0 r_e c^2} = 9.10938188\text{E}-31\,\text{kg} \tag{11}$$

In which r_e is the physical constant known as the classical electron radius (r_e = 2.817940285E−15 m), used with the Coulomb equation to calculate the invariant rest mass of the electron.

Equation (7) represents what Lorentz identified as the varying mass of an electron accelerating in a direction perpendicular to its direction of motion on its trajectory in space, and that he describes as behaving "as if" it was larger than its rest mass m_0 represented by Equation (11), and that corresponds to the rest mass of the electron m_0 plus a mass increment $\Delta m = \gamma m_0 - m_0$, the latter corresponding to the velocity related transverse mass increment whose energy was identified in 2003 by Paul Marmet as causing the increase of the electron magnetic $\boldsymbol{B}$ field as its velocity increases on its trajectory [12] [45], and that corresponds to the second term of the Lorentz force equation $F = e(\boldsymbol{v} \times \boldsymbol{B})$, as will be clarified further on:

$$m_2 = \frac{e^2}{6\pi c^2 R} kl = \gamma m_0 = \gamma \frac{e^2}{4\pi\varepsilon_0 r_e c^2}$$

Resolving for transverse acceleration to:

$$m_2 = \gamma m_0 = m_0 + \Delta m = \gamma \frac{e^2}{4\pi\varepsilon_0 r_e c^2} \tag{12}$$

And finally, Equation (6), representing what Lorentz identified as the varying longitudinal "mass" of the accelerating electron, that is, its measurable inertia in its direction of motion, and that he describes behaving "as if" it was higher for the same velocity than mass $m_2 = m_0 + \Delta m$ represented by Equation (12), itself larger than m_0 represented by Equation (11). The only additional energy that can be identified as acting longitudinally on a moving electron happens to be its momentum energy ΔK.

Note that the term "mass" to which Lorentz refers to, represented by the term m_1, includes the ΔK momentum energy of the electron as a mass increment because in his era, it still was not clearly established that its momentum energy component $\Delta K = \gamma m_0 v^2/2$ did not become part of its actual varying mass $m_2 = \gamma m_0 = \Delta m + m_0$ [12], although it behaves longitudinally—but not transversely—with the same inertia as if it was part of the longitudinal varying mass, which allows, pending further clarification moving on, to momentarily assume that ΔK converts to a "theoretical mass increment", by dividing it by c^2 to clearly establish Lorentz's logical development:

$$m_1 = \frac{e^2}{6\pi c^2 R}\frac{\mathrm{d}(kl\omega)}{\mathrm{d}\omega} = \left(\frac{\gamma m_0 v^2}{2c^2} + \gamma m_0\right) = m_0 + \frac{\Delta K}{c^2} + \Delta m$$

$$= \gamma m_0\left(\frac{v^2}{2c^2} + 1\right) = \gamma \frac{e^2}{4\pi\varepsilon_0 r_e}\left(\frac{v^2}{2c^2} + 1\right)$$

Resolving for longitudinal acceleration to

$$m_1 = \left(\frac{\gamma m_0 v^2}{2c^2} + \gamma m_0 \right) = m_0 + \frac{\Delta K}{c^2} + \Delta m = \gamma \frac{e^2}{4\pi\varepsilon_0 r_e c^2} \left(\frac{v^2}{2c^2} + 1 \right) \quad (13)$$

Of course, equation conversions without numerical confirmation are never guaranteed to be error free, so before proceeding further, we will verify the resulting equations with a well known relativistic velocity to confirm that the modernized forms of Lorentz's equations have been correctly established and remain conform to Lorentz's intent.

The reference relativistic velocity that we will use is the typical reference relativistic velocity related to the mean energy E = 4.359743085E−18 j of the electron when stabilized in the stationary action ground state of the hydrogen atom v = 2187647.561 m/s, whose wavelength is λ = 4.556335261E−8 m and frequency is f = 6.579683909E15 Hz, one cycle of which was discovered by de Broglie in 1924 to correspond to exactly one unit of energy represented by Planck's constant h as clarified in a 2017 article [46] and its 2021 expanded final republication [47], which explains why the frequency of all photons emitted by electrons de-exiting as they return to their stable rest state orbital in atoms are resonance harmonics of this fundamental resonance state.

Of course, the fact that this mean amount of carrying energy E = 4.359743085E−18 j adiabatically induced in the electron when captive in the least action stationary resonance orbital of the hydrogen atom means in no way that the electron is moving on a closed orbit about the proton at this relativistic velocity, as put in clear perspective in Reference [48] and its expanded final republication [49]. This particular issue will be clarified in Section 10.

When so stabilized, the momentum energy component $\Delta K = m_0 c^2(\gamma - 1)$ = 2.179871903E−18 j of this carrying energy can be understood as applying a constant pressure in its vectorial direction of application, if its velocity is impeded, to the fulcrum identified in Reference [26] of the point-like behaving electron, mathematically representable as an infinitesimal ds area, a pressure which is equal in numerical value to the force calculated with the first component the Lorentz force equation, that is, the force calculated with the Coulomb equation for the electron in motion, a_0 being the Bohr radius:

$$P = F = e\boldsymbol{E} = \frac{e^2}{4\pi\varepsilon_0 \alpha_0^2} \quad (14)$$

But it was clearly established in all electron acceleration experiments ever since the first experiments carried out by Kaufmann [7] that when such an amount of carrying energy—momentum energy ΔK plus an equal amount of transverse magnetic field energy corresponding to $\Delta \boldsymbol{B}$ or Δm_m is induced in free moving electrons, they will effectively move at this velocity on their individual trajectories, as verified and confirmed by Planck, Poincaré, Bucherer, Newman and Einstein himself [42], as previously put in perspective. The $\Delta \boldsymbol{B}$ form will be explained further on.

We will now compare the increased amount of mass displayed by a moving

electron with respect to the reference m_0 rest mass formulated as Equation (11), as a measurable longitudinal mass m_1 and a measurable transverse mass m_2 according to Lorentz's conclusions about Kaufmann's experimental data for the chosen test reference relativistic velocity of $v = 2187647.561$ m/s.

The m_0 mass equation of the electron at rest is reposted here for convenience:

$$m_0 = \frac{e^2}{4\pi\varepsilon_0 r_e c^2} = 9.10938188\text{E}-31\ \text{kg} \tag{11}$$

The m_2 transverse mass when the electron is moving at velocity $v = 2187647.561$ m/s—resolving the γ-factor with this velocity—will be:

$$m_2 = \gamma m_0 = \gamma \frac{e^2}{4\pi\varepsilon_0 r_e c^2} = 9.109624417\text{E}-31\ \text{kg} \tag{15}$$

The m_2 mass provided by Equation (15) involves that the transverse magnetic energy of the electron increases by an amount corresponding to the Δm_m mass increase measurable transversely [48] [49], that will be equal to:

$$\Delta m_m = \frac{\mu_0 e^2 v^2}{8\pi r_e c^2} = 2.425337715\text{E}-35\ \text{kg} \tag{16}$$

Then:

$$\begin{aligned} m_0 + \Delta m_m &= 9.10938188\text{E}-31\ \text{kg} + 2.425434194\text{E}-35\ \text{kg} \\ &= 9.109624423\text{E}-31\ \text{kg} \end{aligned}$$

The measurable longitudinal m_1 "mass" of the electron moving at velocity $v = 2187647.561$ m/s will then be:

$$m_1 = \left(\frac{\gamma m_0 v^2}{2c^2} + \gamma m_0\right) = 9.109866957\text{E}-31\ \text{kg} \tag{17a}$$

That can also be calculated by addition:

$$\begin{aligned} m_1 &= m_0 + \left(\Delta K/c^2 + \Delta m_m\right) \\ &= 9.10938188\text{E}-31\ \text{kg} + 4.850868388\text{E}-35\ \text{kg} \\ &= 9.109866957\text{E}-31\ \text{kg} \end{aligned} \tag{17b}$$

We observe that longitudinal "mass" m_1 is higher than transverse mass m_2 by an amount of 2.425402292E−35 kg, and that transverse mass m_2 is higher than rest mass m_0 by a practically equal amount of 2.425434576E−35 kg, for a total amount in excess of rest mass m_0 of 4.850836867E−35 kg. Converting this amount to energy in joules resolves to 4.359714795E−18 j, which is the amount of energy adiabatically induced in the electron when stabilized at the mean ground state distance from the proton in a hydrogen atom, and that can be directly calculated with the Coulomb equation to be applying a pressure of $P = e^2/4\pi\varepsilon_0 a_0^2$ = 8.238721806E−8 Newtons oriented towards the proton against the infinitesimally small ds area of the fulcrum of the electron stabilized in axial resonance state at this mean distance of the proton, or alternatively, to the infinitesimally small ds area of the fulcrum of an electron moving on a free trajectory at relativistic velocity $v = 2187647.561$ m/s.

In summary, when transposed to modern classical/relativistic notation in replacement of Lorentz's era archaic classical/relativistic notation, this is what Lorentz calculated from the data provided by Kaufmann, calculations that were subsequently confirmed as valid by the leading edge physicists of his era, including Einstein ([42], p.159), and whose electromagnetic calculation equation—the Lorentz force equation—has been in use ever since by the engineering community, but that the decision to ignore it in the establishment of the Special Relativity Theory that these leading edge physicists made in 1907, in agreement with Einstein's opinion, caused it not to be referred to nor to be taken into consideration afterwards in the subsequent search to resolve the gravitational issue.

6. Discoveries Made after the Fateful 1907 Turning Point

In 1923, Louis de Broglie came to the conclusion that the only way that the electromagnetic spectra of the different atoms could be explained was that all electrons must be stabilized in a series of resonance states by observing that the frequencies of their electromagnetic spectra were all ordered according to a sequence of integers similar to the known macroscopic resonance states, and discovered that this sequence was related to the energy of one cycle of the energy of the electron stabilized in the Bohr orbit of the hydrogen atom, a cycle whose energy value is exactly equal to Planck's constant [46] [47] [48] [49] [50].

Three years later, end of 1926, Erwin Schrödinger introduced the wave equation that he meant to account for the resonance states and resonance volumes hypothesized by de Broglie [51].

One year earlier, end of 1925, Werner Heisenberg had published the first paper on his matrix mechanics, meant to account for the distribution of the energy within the limits of the resonance volumes that de Broglie hypothesized and that Schrödinger's wave equation was to shortly define [52]. Both methods were then merged into what was to become Quantum Mechanics, later completed by Feynman's path integral method [53]. The very idea that electronic orbitals were supposed to be resonance volumes of a permanently localized electron as understood by de Broglie and Schrödinger was eventually neglected and forgotten.

The common purpose of de Broglie and Schrödinger was to eventually succeed in establishing the emission mechanics of the electromagnetic photons that constitute the electromagnetic spectra of atoms when electrons stabilize in the various stationary action resonance states that they become captive into when captured by ionized atoms, and the absorption mechanics of such photons that cause electrons to be ejected from these stationary states [48] [49] [54] [55]. More on this emission and absorption mechanics further on.

But given the fact that Heisenberg's method seemed to locate the electron with greater probability in the vicinity of the Bohr radius, his method was preferred in the community, and the search to identify the mechanics of emission and absorption of electromagnetic photons by electrons in their capture and ejection processes from stationary resonance states in atoms did not raise any real interest in the community, as put in perspective in References [48] [49]. This me-

chanics has now been established [12] [13].

In 1932, Cockcroft and Walton succeeded in converting some nucleon mass into energy by bombarding Lithium$_{7,3}$ nuclei with protons (Hydrogen$_{1,1}$), that resulted in the fusion of protons with Lithium nuclei, momentarily producing unstable Beryllium$_{8,4}$ nuclei that immediately fissioned into two Helium$_{4,2}$ nuclei, releasing a large amount of electromagnetic energy during the process. Einstein considered this experiment as proof that the mass of elementary particles was made of energy, meaning that it proved the validity of equation $E = mc^2$ [56], proving by the same token that the mass of atomic nuclei was made of electromagnetic energy.

A further step was taken a year later, in 1933, when Carl Anderson proved experimentally that photons of energy of 1.022 MeV or more emitted as electromagnetic by-products of cosmic radiation spontaneously convert into massive electron/positron pairs when they graze massive atomic nuclei [57], a process that came to be known as "materialization". Expanding our understanding of the relationship between "energy" and "mass", Anderson's discovery confirmed that the energy of which the "mass" of electrons and positrons is made was also "electromagnetic" in nature, prompting de Broglie to formulate in 1937 a first hypothesis on a possible internal electromagnetic structure of free-moving photons consistent with Maxwell's equations [24], which led to the subsequent establishment of the LC and field equations of electromagnetic photons [25] [26] (see Equations (27) and (28) further on).

In the last years of a whole life of relentless continued research, at the beginning of the 1950's, Einstein had become more and more doubtful about his SR and GR theories and finally communicated the opinion that gravitation likely follows the pattern of electromagnetism. However, the whole orthodox community apparently immediately rejected his recommendation without a second look, as reported in 1995 by Archibald Wheeler, a major physics community opinion leader ([58], p.391):

"*A distinguished physicist even published in his very last years' works, the main point of which is to claim that gravitation follows the pattern of electromagnetism. This thesis, we cannot accept, and the community of physics, quite rightly, does not accept.*"

In 1969 was published the outcome of the experimental exploration of the internal volumes of protons and neutrons, carried out by means of electron beams energetic enough to penetrate the volume occupied by individual protons and neutrons to non-destructively scatter against whatever could be physically existing inside their volumes, at the freshly activated Stanford Linear Accelerator (SLAC).

Martin Breidenbach and his colleagues reported that some of the electrons had been back scattered in a highly inelastic manner from inner scatterable components of protons and neutrons, that were thus physically detected [59], which revealed that these particles had to be electrically charged and also had to have

masses in the same range as that of the electron, this latter characteristic revealed by the highly inelastic character of the electron rebounds observed. Deep analysis revealed that two types of such inner elementary components physically existed with masses different from each other, both close to the electron rest mass, that were named up and down quarks, in relation with the theories of Gell-Mann and Zweig that had previously predicted their existence.

In 1997, Kirk McDonald *et al.* succeeded at the SLAC facility to produce electron/positron pairs by focusing two beams of photons towards a single point in space, one beam involving photons of energy in excess of the 1.022 MeV decoupling threshold, with no heavy nucleus present in the vicinity, which established that electromagnetic energy could convert to mass by mere photons interactions without any mass present in the vicinity [60].

In the same year, although the results of the experiment were not published until 2013, an important seminal experiment was performed with magnetic fields whose two poles coincide geometrically with the center of the field [10], which by similarity must be the case for the electron's magnetic field, since it always behaves in a punctual way during experiments of mutual collisions, a behavior which was confirmed one year later, in 2014, by an experiment carried out with real electrons [61], which confirms that such fields interact according to the inverse of the cube of the distances separating them, and that their two poles cannot be simultaneously present at this punctual location.

7. Resumption of Fundamental Research in Electromagnetism

In fact, it was the realization that no fundamental research had been conducted in electromagnetism since at least the 1950s, as revealed by Wheeler in 1995 ([58], p.391), despite Einstein's recommendation, that triggered the resumption of such research in the late 1990s. This section presents a brief overview of the different aspects of electromagnetism discussed in a series of articles published between 2000 and 2013, aiming at drawing more attention to the electromagnetic aspect of physical reality.

Investigation of the historical record clearly showed that all research carried out in electromagnetism for the past century had been attempts at reconciling electromagnetism as established from the Ludwig Lorenz gauge perspective with the classical concepts of the Lagrangian and the Hamiltonian, themselves grounded on the classical principle of universal conservation of energy.

Further investigation revealed that Maxwell disagreed with the Lorenz gauge concept because it negated the possibility of the existence of the displacement current that was built-in into the Gauss equation for the electric $\boldsymbol{E}$ field, which is in fact the Coulomb equation minus one of its built-in double charges, since that in the Coulomb equation, as analyzed in References [62] [63], the force, and consequently the energy $E = d \cdot F = q^2/4\pi\varepsilon_0 d$ induced by the force into each charge depends on no other criterion than on the inverse of the distance d sepa-

rating both charges, a distance that can only vary in an infinitesimally progressive manner between all moving charged particles, which is inconsistent with the very principle of universal conservation of energy that underlies the classical concepts of the Lagrangian and the Hamiltonian when applied to charged particles, but are in direct harmony with Maxwell's initial interpretation and most importantly, with de Broglie's hypothesis about a possible inner structure of free moving electromagnetic photons [24]:

$$F = q\boldsymbol{E} = q_1 \frac{q_2}{4\pi\varepsilon_0 d^2} = \frac{q_1 q_2}{4\pi\varepsilon_0 d^2} \tag{18}$$

Let us note here that Equation (18) is the fully expanded form of the first term of the Lorentz force equation (see Equation (5) analyzed earlier).

In July of 2000, after 160 years of neglect, attention was drawn again at CONGRESS-2000 to Maxwell's initial interpretation from which emerged the trispatial geometry that offered a new potential development perspective in the exploration of the subatomic level of magnitude, that is, a perspective that was out of reach of the Lorenz gauge approach [64].

Three years later, in 2003, Paul Marmet, probably the most advanced experimenter and theoretician in electromagnetism of the late 20th century, brilliantly established the following equation, by means of a flawless derivation from the Biot-Savart equation, that revealed that the increasing energy of the transverse magnetic field of the accelerating electron is the same energy measurable as an increase in the transverse mass of the electron, that Kaufmann had measured 100 years earlier as increasing with the velocity of the electron [45], *i.e.* the energy that Lorentz had related to the transverse mass m_2 of the electron (see Equations (7) and (12) analyzed previously), *i.e.* an identity relation that had not been noticed at the time:

$$\frac{\mu_0 e^2}{8\pi r_e}\frac{v^2}{c^2} = \frac{m_e}{2}\frac{v^2}{c^2} \tag{19}$$

In 2007, a first wave of derivations from this revolutionary equation was published in the same *Kazan State University* engineering journal that had previously published Marmet's article [65], that separated for the first time the invariant magnetic $\boldsymbol{B}$-field of the invariant rest mass of the electron, from the variable magnetic $\Delta\boldsymbol{B}$-field of its carrying-energy, the sum of both turning out to be the $\boldsymbol{B}$-field of the second term of the Lorentz force equation (see Equation (2) previously analyzed).

The invariant magnetic field of the rest mass of the electron being:

$$\boldsymbol{B} = \frac{\mu_0 \pi e c}{\alpha^3 \lambda_C^2} \tag{20}$$

in which λ_C is the electron Compton wavelength, and the variable magnetic field of the electron carrying-energy being:

$$\boldsymbol{B} = \frac{\mu_0 \pi e c}{\alpha^3 \lambda^2} \tag{21}$$

in which λ is the wavelength of the carrying energy of the electron. The sum of Equations (20) and (21) provides the combined $\boldsymbol{B}$-field of the second term of the Lorentz force equation:

$$\boldsymbol{B} = \frac{\pi\mu_0 ec\left(\lambda^2 + \lambda_C^2\right)}{\alpha^3\lambda^2\lambda_C^2} \tag{22}$$

Similarly, Marmet's derivation allowed separating the invariant electric $\boldsymbol{E}$-field of the invariant rest mass of the electron:

$$\boldsymbol{E} = \frac{\pi e}{\varepsilon_0\alpha^3\lambda_C^2} \tag{23}$$

from the variable $\boldsymbol{E}$-field of its carrying-energy:

$$\boldsymbol{E} = \frac{\pi e}{\varepsilon_0\alpha^3\lambda^2} \tag{24}$$

The vectorial product of which provides the combined $\boldsymbol{E}$-field of the first term of the Lorentz force equation:

$$\boldsymbol{E} = \boldsymbol{E} \times \Delta\boldsymbol{E} = \frac{\pi e}{\varepsilon_0\alpha^3} \frac{\left(\lambda^2 + \lambda_C^2\right)\sqrt{\lambda_C\left(4\lambda + \lambda_C\right)}}{\lambda^2\lambda_C^2\left(2\lambda + \lambda_C\right)} \tag{25}$$

In the case of the $\boldsymbol{E}$-field of the electron in motion, the vectorial product approach is required due to the fact that the trispatial geometry reveals that the invariant $\boldsymbol{E}$-field of the electron rest mass is perpendicular to the variable $\Delta\boldsymbol{E}$-field of its carrying energy within electrostatic Y-space [16].

Simultaneously varying wavelength λ of the electron carrying-energy of both Equations (22) and (25) over the whole range of possible values effectively yields the very same relativistic velocity curve obtained by Abraham and Bucherer, that Einstein candidly admitted "fit the observed curve considerably better than the curve obtained from relativity theory" previously quoted from Abraham Pais' book ([42], p.159) by means of this equation for straight line motion of the electron:

$$v = \frac{\boldsymbol{E}}{\boldsymbol{B}} \tag{26}$$

It can be noted that Equations (20) and (23) establishing the precise invariant $\boldsymbol{E}$ and $\boldsymbol{B}$ fields corresponding to the rest mass of the electron are only specific cases of the general Equations (21) and (24) that can be used to calculate the whole possible range of $\boldsymbol{E}$ and $\boldsymbol{B}$ fields for free moving photons.

Equations (21) and (24) also allowed converting the photon LC equation previously developed [66] to the corresponding fields equation [25] [26]:

$$E\vec{I}\vec{i} = \left(\frac{hc}{2\lambda}\right)_X \vec{I}\vec{i} + \left[2\left(\frac{e^2}{4C}\right)_Y \left(\vec{J}\vec{j}, \vec{J}\vec{j}\right)\cos^2(\omega t) + \left(\frac{Li^2}{2}\right)_Z \vec{K}\sin^2(\omega t)\right] \tag{27}$$

$$E\vec{I}\vec{i} = \left(\frac{hc}{2\lambda}\right)_X \vec{I}\vec{i} + \left[2\left(\frac{\varepsilon_0\boldsymbol{E}^2}{4}\right)_Y \left(\vec{J}\vec{j}, \vec{J}\vec{j}\right)\cos^2(\omega t) + \left(\frac{\boldsymbol{B}^2}{2\mu_0}\right)_Z \vec{K}\sin^2(\omega t)\right]V \tag{28}$$

A second outcome of this first wave of derivations from the Marmet Equation (19) is the following variation on the Coulomb equation that allows calculating the energy of any free moving photon by use of its wavelength, without any need to use the Planck constant:

$$E = hf = \frac{e^2}{2\varepsilon_0 \alpha \lambda} \tag{29}$$

After it had become obvious that the LC and fields equations of the carrying-energy of the electron were identical to the LC and fields equations of free moving photons, and that even the actual invariant rest mass of the electron could be represented by such LC and Fields equations [16] [66] [67]:

$$E\vec{\mathbf{0}} = m_e c^2 \vec{\mathbf{0}} = \left[\frac{hc}{2\lambda_C}\right]_Y \vec{J}\vec{i} + \left(2\left[\frac{(e')^2}{4C_C}\right]_X \left(\vec{I}\vec{j}, \vec{J}\vec{j}\right)\cos^2(\omega t) + \left[\frac{L_C i_C^2}{2}\right]_Z \vec{K}\sin^2(\omega t)\right) \tag{30}$$

and

$$m_0\vec{\mathbf{0}} = \frac{V_m}{c^2}\left\{\left[\frac{\varepsilon_0 \boldsymbol{E}^2}{2}\right]_Y \vec{J}\vec{i} + \left[2\left(\frac{\varepsilon_0 v^2}{4}\right)_X \left(\vec{I}\vec{j}, \vec{J}\vec{j}\right)\cos^2(\omega t) + \left(\frac{\boldsymbol{B}^2}{2\mu_0}\right)_Z \vec{K}\sin^2(\omega t)\right]\right\} \tag{31}$$

it became possible to upgrade Newton's non-relativistic kinetic energy equation to full relativistic electromagnetic status and to develop equations that required only the energies or the wavelengths of the electron and of its carrier-photon to trace by this means the very same relativistic velocity curve as Equation (26) and those of Abraham and Bucherer [68]:

$$v = c\frac{\sqrt{4EK + K^2}}{2E + K} \tag{32}$$

and

$$v = c\frac{\sqrt{\lambda_C(4\lambda + \lambda_C)}}{2\lambda + \lambda_C} \tag{33}$$

This development allowed for the first time in history to derive the Lorentz γ-factor equation (Equation (9)) from an electromagnetic equation in an article published in 2013 [68], that is, from Equation (33) previously mentioned, thus confirming the relativistic nature of the adiabatic energy induced in all elementary charged particles by the Coulomb interaction, classically represented via the first term of the Lorentz force equation $F = e\boldsymbol{E}$ or directly by the Coulomb equation (see analysis of Section 5).

Then, by means of the general form of the Coulomb Equation (29) and of this other form developed even further, considering that ($\varepsilon_0 = 1/(4\pi c^2 \cdot 10^{-7})$ [69],

$$F = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{d^2} = \frac{4\pi c^2 \cdot 10^{-7}}{4\pi}\frac{e^2}{d^2} = e^2 \cdot 10^{-7}\frac{c^2}{d^2} \tag{34}$$

it became possible to unify all classical force equations by deriving the fundamental force equation $F = ma$ from each of them [69], which mathematically demonstrates that all classical force equations, even Newton's so fundamental F

= *ma* acceleration equation, all are variations of the Coulomb force equation.

$$F = G_p \frac{M_p \cdot m_e}{r_o^2} = k\frac{e^2}{r_o^2} = ev\boldsymbol{B} = e\alpha\boldsymbol{E} = m_e a \tag{35}$$

The trispatial geometry that naturally emerges from Maxwell's initial interpretation then allowed establishing a coherent decoupling mechanics of electromagnetic photons of energy exceeding the minimal decoupling threshold of 1.022 MeV into massive electron/positron pairs when the required circumstances are met [16].

The mechanics of the Einstein-de Haas and Barnett effects could then be explained [11] in context of the trispatial geometry, as well as the difference between permanently compensated stable orbital or resonance stationary action states and uncompensated metastable orbital or resonance states at the astronomical magnitude level as well as at the subatomic magnitude level.

The electron magnetic moment anomaly was then analyzed and explained [70] by revealing the existence of a gyroradius related drift of the electron carrier-photon energy from the $\Delta\boldsymbol{E}$ electric state to the $\Delta\boldsymbol{B}$ magnetic state that was found to match Julian Schwinger's calculations [71] about this so-called anomaly that he carried out in 1948, thus providing in an unexpected way the first clue leading to the explanation of the fractional charges of the up and down quarks.

Actually, when adapting Equations (32) and (33) to establish the gyroradius at the mean ground state distance of the electron in its stationary action orbital in the hydrogen atom, the electron g factor first established by Schwinger as $\alpha/2\pi$ for this orbit naturally falls out of both of these equations:

$$\text{Magnetic drift} = \frac{\delta\mu}{\mu_B} = \frac{\sqrt{4EK + K^2}}{2\pi(2E + K)} = \frac{\alpha}{2\pi} = 1.161386535\text{E}-3 \tag{36}$$

E = 8.18710414E−14 j being the rest mass energy of the electron and K = 4.359743805E−18 j being the carrying energy of the electron in the Hydrogen atom ground state, and

$$\text{Magnetic drift} = \frac{\delta\mu}{\mu_B} = \frac{\sqrt{\lambda_C(4\lambda + \lambda_C)}}{2\pi(2\lambda + \lambda_C)} = \frac{\alpha}{2\pi} = 1.161386535\text{E}-3 \tag{37}$$

λ_C = 2,426310215E-12 m being the electron Compton wavelength and λ = 4,556335256E-8 m being the wavelength of the energy induced at the Bohr radius of the hydrogen atom.

For the first time in history, vacuum constants ε_0 and μ_0 were derived from first principles in Reference [31], and it was demonstrated that Equation (34), on top of allowing all classical force equations to be derived from each other, also is at the heart of all electrodynamics equations, that is, that they all involve charges being accelerated.

Indeed, the inverse product term for term—to take into account the mutual orthogonality of the electrostatic and magnetostatic states—of the two vectorial equations derived from first principles in Reference [31], that account for the

mutually opposite electric and magnetic transverse forces that apply to a moving electron in the trispatial geometry, in agreement with Maxwell's theory:

$$\frac{\overrightarrow{\boldsymbol{F}_B}}{\overrightarrow{\boldsymbol{F}_E}} = \frac{\overrightarrow{4\pi c^2 \boldsymbol{K}}}{\overrightarrow{4\pi c^2 \boldsymbol{J}}} \frac{10^{-7}}{10^{-7}} \tag{38}$$

could be related to the constant expression that emerges from the second partial derivatives equations of the instantaneous magnetic and electric fields of a propagating electromagnetic wave in vacuum with respect to distance and time initially derived by Maxwell, that is,

$$\frac{\partial^2 \boldsymbol{B}}{\partial x^2} = \mu_0 \varepsilon_0 \frac{\partial^2 \boldsymbol{B}}{\partial t^2} \quad \text{and} \quad \frac{\partial^2 \boldsymbol{E}}{\partial x^2} = \mu_0 \varepsilon_0 \frac{\partial^2 \boldsymbol{E}}{\partial t^2} \tag{39}$$

Given that this constant is the product of ε_0 and μ_0, which product is equal to $1/c^2$ by structure [31], and also that $\varepsilon_0 = 1/4\pi c^2 \cdot 10^{-7}$ and that $\mu_0 = 4\pi \cdot 10^{-7}$, by converting Equation (38) to its scalar form and substituting these values for their standard symbols ε_0 and μ_0, the constant velocity relation that emerges from Maxwell's second partial derivative Equations (39) can be directly obtained from Equation (38):

$$1 = \frac{4\pi c^2 10^{-7}}{4\pi c^2 10^{-7}} = \left(\frac{1}{4\pi c^2 10^{-7}}\right)\left(4\pi 10^{-7}\right) c^2 = \varepsilon_0 \mu_0 c^2 \tag{40}$$

With regard to the calculation of the speed of light for individual photons, using the wavelength of any photon as the only variable required to establish their $\boldsymbol{E}$ and $\boldsymbol{B}$ fields with Equations (21) and (24), the invariant speed of light can systematically be calculated with the following standard equation:

$$c = \frac{\boldsymbol{E}}{\boldsymbol{B}} \tag{41}$$

From the trispatial fields equation that could be established for the muon particle in Reference [72],

$$m_\mu = \left\{ \left[\frac{\varepsilon_0 \boldsymbol{E}_e^2}{2} \right]_Y + \left[2 \left(\frac{\varepsilon_0 \left(\nu_e + \nu_\mu \right)^2}{4} \right)_X \cos^2(\omega t) + \left(\frac{\left(\boldsymbol{B}_e + \boldsymbol{B}_\mu \right)^2}{2\mu_0} \right)_Z \sin^2(\omega t) \right] \right\} \frac{V_m}{c^2} \tag{42}$$

A coherent mechanics of separation of neutrino pairs that reduces the metastable muon mass to the electron rest mass could be established.

And final development regarding the nature of stable elementary particles at the subatomic level from the trispatial perspective, Einstein's conclusion that energy has to be a physically existing substance, and the fact that the Coulomb interaction turns out to be the physical agent that induces this *physically existing substance* in the form of electromagnetic carrying-energy into each charged particle as a function of the inverse square of the distance separating them, the mechanics of the adiabatic establishment of the least action highest intensity stationary action energy states in the universe, that is, the proton and neutron structures, has been analyzed, resulting in the establishment in Reference [73] of the up and down quarks electromagnetic mass fields equations,

$$m_U = \frac{E}{c^2} = \frac{V_{m_U}}{c^2}\left\{S_U\left[\frac{\varepsilon_0 \boldsymbol{E}_U^2}{2}\right]_Y + \left(2 - S_U\right)\left[2\left(\frac{\varepsilon_0 v_U^2}{4}\right)_X \cos^2\left(\omega t\right) + \left(\frac{\boldsymbol{B}_U^2}{2\mu_0}\right)_Z \sin^2\left(\omega t\right)\right]\right\} \quad (43)$$

and

$$m_D = \frac{E}{c^2} = \frac{V_{m_D}}{c^2}\left\{S_D\left[\frac{\varepsilon_0 \boldsymbol{E}_D^2}{2}\right]_Y + \left(2 - S_D\right)\left[2\left(\frac{\varepsilon_0 v_D^2}{4}\right)_X \cos^2\left(\omega t\right) + \left(\frac{\boldsymbol{B}_D^2}{2\mu_0}\right)_Z \sin^2\left(\omega t\right)\right]\right\} \quad (44)$$

that turn out in the trispatial geometry to be normal electrons and positrons whose mass and charge characteristics are warped into these altered states due to the extreme stresses imposed on them by the intensity of their mutual interactions at such short distances when they reach the ultimate electromagnetic equilibrium states in which they are forced to stabilize as they establish the stable internal structure of protons and neutrons.

Ultimately, the trispatial geometry provides a mechanical explanation to the creation of protons and neutrons from triads of the two possible mixes of electrons and positrons when the local electromagnetic circumstances cause them to be thermal enough to have insufficient energy to escape each others' interaction, which causes them to accelerate and end up ultimately stabilizing as protons and neutrons [73].

This summarily completes the general overview of the main conclusions drawn in the first set of articles published from 2000 to 2013 to establish the internal structure and individual interactions of photons and of the set of stable charged elementary electromagnetic particles of which all atoms are made, from the perspective given by Maxwell's initial interpretation, in light of Einstein's conclusion about the physical nature of energy as a substance, de Broglie's hypothesis about the inner electromagnetic structure of photons, that Einstein understood have to be continuously localized, and of Marmet's discovery that the increase of the transverse mass of accelerating electrons observed by Kaufmann can only be related to a simultaneous increase of their transverse magnetic field.

8. Immediate Implications for the Atomic, Macroscopic and Astronomical Orders of Magnitude

Two other articles were published in 2013, that put in perspective the immediate implications that emerge, at the atomic, macroscopic and astronomical levels, of the conclusions drawn at the subatomic level about the internal electromagnetic structure and the interactions of the set of stable elementary charged particles, in light of the trispatial perspective [74] [75].

In particular, the intensity of the energy released in the form of three highly energetic bremsstrahlung photons—each estimated to be in the vicinity of 155 MeV—that must be emitted upon the evacuation of the momentum kinetic energy of each accelerating charged particle when each electron-positron-electron or positron-electron-positron triad stabilizes in stable stationary action states as neutron and proton at the end of their acceleration sequence [73], has clearly provided a possible explanation for the still unexplained sustained temperatures of 2

to 3 million degrees Kelvin that are often observed with higher peaks in the solar corona.

These temperatures exceeding one million degrees in the corona of the sun are about 200 times those of the photosphere and chromosphere of the sun. This extreme average temperature in the corona turns out to be an equilibrium temperature [76], which is revealed by the fact that it remains constant in spite of the enormous energy losses that the corona undergoes through the constant inwards exchanges with the chromosphere on one hand, and the constant outward ejections of matter via coronal mass ejections (CMEs) on the other, which means that these energy and mass losses must necessarily be compensated for by a yet to be understood constant internal coronal process.

It turns out that according to the mechanics of adiabatic energy increase provided by the Coulomb interaction, which is a function of the inverse of the decreasing distances between charged particles [8], the trio of bremsstrahlung photons of about 155 MeV each, emitted at the moment of ultimate stabilization of each of the two possible initial triads in their final high energy proton or neutron configuration, happens to correspond to a 227-fold increase in the ambient energy level, which falls precisely within the range of excess ambient energy observed in the solar corona, and could sustain these temperatures consistently if nucleons were continuously generated in the corona in a continuous low-level chain reaction that remains to be understood [74].

Such a permanent low level chain reaction nucleon generation process that would have been active since the Sun ignited even opens the door to the possibility that all of the matter making up the planetary system and other lesser bodies in the solar system could have been generated locally, and also opens the door to the possibility for us to learn to control this nucleon generation process as a source of reaction mass for propulsion requirements and as a source of unlimited energy for other purposes, as will be put in clearer perspective in Section 12.

The adiabatic nature of the progressive energy increases of all electrons captive of the orbitals that define the volume of each atom, as they are progressively forced closer to each their central atomic nucleus due to the mutual increasing pressure that atoms exert on each other as the depth increases within celestial bodies, also brings an explanation to the adiabatic increase in temperature with increasing depth in the Earth, which is estimated to reach 5100 degrees Kelvin in the center of the planet [77], and also brings a mechanical explanation to the actual cause of ignition of stars and subsequent high intensity chain reaction fusion for proto-stellar masses as they reach the ignition threshold pressure in their center during their initial phase of primordial hydrogen accumulation [75].

What leads to this conclusion is that the adiabatic compression suffered by the electronic escorts of all atoms as pressure increases with depth in large celestial bodies such as stars masses, becomes sufficient when critical ignition temperature is reached in their central areas for the unreleasable adiabatic energy induced in the electrons of hydrogen atoms for these electrons carrier-photon to

reach the 1.022 MeV threshold decoupling level at a distance of less than 0.2E−15 meter from their proton nucleus, which is the radius of the volume within which protons and neutrons structures reach the highest energy stationary state of least action that can be established in the universe by natural application of the Coulomb force, that is, the volume within which the pressure axially applied by the ΔK momentum energy of their charged sub-components falls into equilibrium against the mutually repulsive counter-pressure exerted between these subcomponents by their magnetic energy.

Now, the energy in excess of that of the rest mass of a moving elementary charged particle such as an electron, has clearly been established from the Kaufmann data and the Lorentz analysis, combined with Marmet's discovery in light of de Broglie's hypothesis regarding the possible inner electromagnetic structure of free moving photons, as having the very same electromagnetic characteristics as those of such free moving photon, as analysed in References [25] [26] [68], the only difference being that in the case of a moving electron, this excess energy has to "carry", so to speak, the intrinsically inert massive electron to which it is related, hence the name carrier-photon adopted to qualify the electron carrying energy.

It can then be fully expected that this carrier-photon, if it were to reach the 1.022 MeV threshold, would also be susceptible to decoupling into an electron-positron pair, which, being totally thermal, given that all of its 1.022 MeV of energy converts to the two 0.522 MeV/c^2 masses of the newly decoupled pair, will be unable to evade maximum interaction with the formerly carried electron now also totally thermal given that its carrying energy has now disappeared, the threesome will immediately start accelerating due to their mutual Coulomb interactions into converting to neutron state, releasing the 3 highly energetic bremsstrahlung photons inherent in the neutron creation process, a neutron that would then immediately form a deuterium nucleus with the close by proton [75].

Thus would be initiated the high energy chain reaction that ignites a proto-star mass, a self-sustaining chain reaction due to the now increasing pressure at the center of the star being born, that will then create more and more neutrons as the mass of the new star increases.

One particular aspect of the compression of the electronic orbitals of atoms larger than the hydrogen atom, due to mutual increasing pressure of atoms against each other with the increasing depth in celestial bodies, is that, contrary to the shrinking of the distances between the electronic escorts and the central nucleus of each atom involved, the nucleons (protons and neutrons) making up their nuclei are so relatively far inside their electronic escorts that this adiabatic pressure applied from outside to their individual electronic escorts is insufficient to force a similar contraction of the nucleon triads located far inside their electronic escorts.

Considering that if the proton in a hydrogen atom was theoretically enlarged

to reach the size of the Sun, its electron would stabilize as far as Neptune if its mean ground state distance was extended in the same proportion. Then contrariwise, as the pressure increases with depth in celestial bodies against the electronic escorts of neighboring atoms, the nuclei of these atoms will obviously drift closer to each other as the overall volume of each electronic escort shrinks.

The logical outcome can only be a progressive "outward pull" on the internal charged structure of each nucleon of all nuclei now getting closer to each other, with the Coulomb force increasing between them as the distances separating the nuclei decrease, since the force induces an increasingly large outwardly directed momentum kinetic energy amount in each charged quark of each triad. As each triad increases its internal interaction radius, their relativistic-velocity/energy-level can only decrease in proportion, reducing their total rest mass accordingly.

Reference [75] analyzes all aspects of this adiabatic variation of atomic and nucleon volumes—and relativistic masses in the latter case—as a function of the local state of the Coulomb interaction dependent gravitational gradient. Particularly informative are the 3D graphs in Section VIII of Reference [75].

Another unexpected and somewhat surprising outcome of the immediate reactivity of all charged elementary particles captive in atomic structures to any variation in the unidirectional pressure applied by their momentum energy, is that when small masses are taken away from a large mass such as that of the Earth, the "outward pull" exerted on their electronic escorts as well as on the internally charged subcomponents of their nuclei by the sum of the charged particles constituting the atoms of the large Earth mass will decrease as the small mass gains altitude, causing the internal mutual Coulombian interaction between the charged particles within each atom of the small mass moving away to contract their electronic orbitals towards their respective nuclei, as well as those of the nucleons of which their nuclei are made, thus causing more momentum kinetic energy directed towards the nucleus of each atom to be induced in each captive electron of the orbitals being brought closer to their respected nuclei.

The consequence, easily observable in some cases, such as in the case of atomic clocks whose periodicity depends on the specific frequency of 9,192,631,770 Hz—measured at ground level—of the bremsstrahlung photon emitted when an electron jumps to its reference hyperfine electronic rest orbital after having been excited to jump to the other reference metastable electronic orbital, located further away from the nucleus of the caesium 133 atom, is that the frequency of this bremsstrahlung photon will increase with altitude due to the fact that the two reference orbitals move closer to the caesium nuclei as the distance between the earth's mass and the clock increases, a behavior that, from the point of view of the special relativity theory is interpreted as if time was running faster at higher altitudes, while in reality the increased frequency of the photon emitted during the reference jump is obviously due, from the electromagnetic point of view, only to the fact that the reference jump is now performed between reference levels that are now closer to the nucleus of each caesium atom. This issue is also analyzed in Reference [75].

Another related outcome is the as yet unresolved issue of the of the so-called "*anomalous residual acceleration directed towards the Sun*" of the Pioneer 10 and 11 spacecrafts on their hyperbolic trajectories leading them out of the solar system, which is an issue that was observed to also affect other spacecrafts [78]. All of these spacecrafts behave exactly as if they were slightly more massive as they run their trajectories than was measured at the surface of the Earth before launch, which is also consistent with the analysis that we have just summarized, and which was completely analyzed in Reference [75].

Many other "apparently unexplained" observations are also addressed and analyzed in Reference [75], that also proposes an easy to carry out experiment that could confirm the dependence of nucleon masses to the local intensity of the gravitational gradient. See Subsection 11.1 further on in this regard.

It must be mentioned in context that the rest mass of the electron on its part is not dependent on any variation of the gravitational gradient since it is a confirmed elementary particle—in the sense that it is clearly established that it is not made of smaller subcomponent particles in mutual interaction like protons and neutrons, that are not elementary particles, but systems of elementary particles captives of their mutual electromagnetic interactions, just like the solar system is not a heavenly body, but a system of heavenly bodies captive of their mutual electromagnetic interactions. The rest mass of the electron turns out to be universally invariant, whatever the local intensity of the gravitational gradient.

9. Other Developments at the General Level

Seven more articles were published from 2016 to 2020, all selected for republication in final form from 2017 to 2021 as chapters in specialized collections that preselect articles deemed worthy of interest from the global offer that few researchers and doctoral students find the time to investigate in depth to locate all new developments relevant to their respective disciplines. A brief overview of the issues addressed in each of these articles will be provided in this section.

The first of these articles explains the seminal considerations that initially led to the development of the expanded Maxwellian space geometry that naturally emerges from Maxwell's initial interpretation, and to the establishment of the LC and fields equations of the free-moving photon according to Louis de Broglie's hypothesis about the double-particle photon [24], that Marmet's derivation had led to understand mandatorily had to possess the same internal electromagnetic structure as the carrier energy of free-moving electrons [45] [65], originally published in 2016 [25], republished in final version in 2021 [26].

Then followed in 2016 a second article [8] that was republished in final version in 2021 [9], analyzing in depth the adiabatic nature of the physically existing energy which is continuously induced by Coulomb interaction in all charged particles as a function of the inverse of the distances that separate them, and whose quantities vary in an infinitesimally progressive manner as the distances vary, in addition when they are in the process of approaching each other, or in

subtraction when they are in the process of moving away from each other. This article also proposes a high-tech experiment meant to demonstrate the adiabatic nature of the energy that would result from the acceleration of the electron-positron-electron or positron-electron-positron thermal triads that would lead to the creation of neutrons and protons according to the trispatial perspective [73]. See Subsection 11.2.

A synthesis article was then published in 2017 [62], republished in final version in 2020 [63], to put into perspective the sum of the separate analyses presented in the series of articles published since 2000, to serve as a guide in the 2017 monograph that laid the foundation of an electromagnetic mechanics grounded on Maxwell's initial interpretation, by regrouping all of these articles [79]. This article also analysed in depth the concept of "force" as applicable to the subatomic level in light of the possibility that electromagnetic energy could be a physical substance as concluded by Einstein [23]—see Section 2 on this issue—and presents a first glimpse of the universal gravitational gradient that emerges from these considerations. See Section 13 for a final analysis of the gravitational issue from this perspective.

In 2017 article [46] was published, republished in a final version in 2021 [47], that puts in perspective the sum of what all experimental scattering experiments revealed about stable and metastable elementary particles. It also gives an overview of the past attempts to expand the spatial geometry in view of solving the currently unresolved issues that 3D-4D spatial geometry seemed insufficient to solve, and explains how the trispatial geometry leads to a first possible mechanical explanation of the existence of charges. Then follows an overview of the set of new electromagnetic mechanics equations that now come in complement to the first equation of electromagnetic mechanics, that is, the Lorentz force equation, subject of this in-depth analysis.

In 2018 was published article [48], republished in final version in 2020 [49], that analyzes how electromagnetic mechanics, classical/relativistic mechanics and quantum mechanics can be reconciled. For example, the very first definition of mass strictly from electromagnetic parameters is proposed:

$$\Delta m_m = \frac{\mu_0 e^2}{8\pi r_e}\frac{\left(\boldsymbol{E}/\boldsymbol{B}\right)^2}{c^2} = 2.425337726\text{E}-35\ \text{kg} \tag{45}$$

which is in fact Equation (16) in which parameter v is replaced by its electromagnetic version $v = \boldsymbol{E}/\boldsymbol{B}$—Equation (26)—that defines the moving electron velocity, taking as usual the standard example of the energy induced in the electron when stabilized in the hydrogen atom ground state (relativistic velocity v = 2187647.566 m/s is used to resolve the γ-factor), Δm_m being the relativistic mass contribution of the transversely oscillating electromagnetic energy of the electron carrier-photon, which, when combined with the following equation to calculate the related momentum energy:

$$\Delta K = m_0 c^2\left(\gamma - 1\right) = 2.179784832\text{E}-18\ \text{j} \tag{46}$$

allows establishing the following equation to describe the total electron carrier-photon energy:

$$\text{Electron carrier-photon} = \Delta K + \Delta m_m c^2 = 4.359743805\text{E}-18 \text{ j} \tag{47}$$

which is the direct classical/relativistic equivalent of LC Equation (27) and fields Equation (28), and when adapted as follows, provides the longitudinal m_1 mass measured by Kaufmann as established by Lorentz:

$$m_1 = \Delta K / c^2 + \Delta m_m + m_0 \tag{48}$$

while m_2 resolves to:

$$m_2 = \Delta m_m + m_0 \tag{49}$$

The first mechanical explanation of the stability of the hydrogen atom is also proposed in this article in context of the trispatial geometry, as it puts in perspective how the momentum energy of the electron applies a constant pressure on the infinitesimal surface of the electron's fulcrum to maintain in a stable resonance state the constantly oscillating magnetic energy spheres of the electron and of the subcomponents of the proton, which are in permanent mutual repulsion due to the fact that their magnetic spins are in constant parallel alignment by structure, as established in Reference [10].

The simultaneous invariant electron oscillation frequency and the varying carrier-photon oscillation frequency that need to be considered in establishing the electromagnetic mechanics compliant varying beat wave equation of a free moving electron and the additional varying proton oscillation frequency that must be added to the varying beat wave equation of the free moving electron when the electron is captive in axial resonance state in atomic orbitals are described, although the related varying beat wave equations have not yet been developed.

Two years later, in 2020 was published article [12], selected the same year for republication in final version [13], that summarizes all aspects of the electromagnetic mechanics of the set of stable elementary electromagnetic particles at the subatomic level, that emerges from Maxwell's initial interpretation. The considerations previously put in perspective in References [62] and [63] are also elaborated on in greater details, including the establishment of the trispatial energy-momentum equation:

$$E_e = \Delta K + \Delta m_m c^2 + m_0 c^2 \tag{50}$$

The main feature of references [12] and [13] is the introduction of the emission mechanics of a bremsstrahlung electromagnetic photon when an electron becomes captive in orbital resonance state in an ionized atom, and also the absorption mechanics of an incoming electromagnetic photon that energizes a captive electron sufficiently for it to jump to a further away metastable orbital from which it instantly jumps back to its rest orbital, releasing the bremsstrahlung photon that we record as part of this atom's spectrum, or is completely ejected from the atom, which is the photon emission and absorption mechanics

that Schrödinger and de Broglie had been looking to establish in the 1920's [54] as put in perspective in References [48] [49].

In 2020 also was published a second monograph [80] regrouping and synthesizing these last three articles [12] [48] [62], as an introduction to electromagnetism according to Maxwell's initial interpretation.

Reference [80] also relates the 4 first level electromagnetic equations for the subatomic order of magnitude that were developed during the first wave of derivations after Paul Marmet's discovery, published in 2007 [65], with the 4 Maxwell equations that were synthesized by Heaviside for application at the atomic, macroscopic and astronomical levels of magnitude.

Finally, an article was republished in final version [81] that was initially published in 2016 [82] that proposed the hypothesis of the progressive establishment and growth of the Universe strictly from electromagnetic considerations, as suggested by Einstein towards the end of his life, describing the possibility of the progressive adiabatic energy increase in the universe from a hypothetical zero energy level in vacuum at the beginning of the universe inspired by Maxwell's initial interpretation, as an alternate solution to the Lorenz gauge grounded Quantum Field Theory (QFT) postulated stable conservative zero-point energy level in vacuum and to the conservative Big Bang theory that emerges from Einstein's General Relativity theory.

The function of time in the universe is also analyzed from this new perspective, and going a step further than References [12] into addressing the gravitational issue, Reference [81] summarily describes the universal trispatial vector field that emerges from Maxwell's initial interpretation, as a possible alternative to the universal Hilbert vector field that emerges from the Lorenz interpretation. See also Section 13.

10. Gyroradius vs Mean Distance of Electromagnetic Resonance

In the Special and General Relativity Theory, the concept of force does not exist as such and is completely replaced by inertial motion due to the axiomatically hypothesized space-time curvature in which astronomical masses are deemed to always follow the least action slope of the space-time curvature. From this perspective, inertial motion can occur only if a body has not reached some stationary action state along the slope of some geodesic line, which establishes any variation of the longitudinal inertia of massive bodies as being due to its motion, thus to its instantaneous velocity during its acceleration along such a geodesic line. The transverse inertia of moving bodies seems not to be addressed from this perspective except for local rotational inertia variation of a moving body.

For charged and massive particles in electromagnetism on the other hand, the kinetic energy induced by the underlying Coulomb interaction is fundamental and does not depend on the motion of the particle, but strictly on its distance from other charged particles. It is the momentum half of the physically present

energy induced in excess of the energy of which the inert mass of the particle is made, that causes the particle to move if its motion is not hindered in some way by local electromagnetic circumstances, in which case this momentum energy will instead apply an equivalent pressure in the vectorial direction in which it would force the electron to move if not hindered.

When a "charged" electron is moving freely, its momentary "relativistic" mass, made of its rest mass m_0 plus the Δm_m mass increment provided by the other half of the energy induced in excess of that of which its rest mass is made, can at face value be interpreted as being velocity dependent, but it must be emphasized that its instantaneous velocity at any given moment is dependent only on the instantaneous amount of ΔK carrying-energy momentum that the electron is adiabatically induced with at this moment. See Reference [68].

It must also be made clear that when a "charged" electron ends up captive in resonance state in an atom's orbital, even if the local electromagnetic equilibrium may not allow it to actually translate about the nucleus, both ΔK and Δm_m components of its carrying energy remain physically present, increasing its mass in the case of the Δm_m electromagnetic component, and applying pressure in the direction of the nucleus in the case of its ΔK momentum component, against the resistance offered by the mutually repelling parallel spin aligned magnetic energy spheres of the electron and of the elementary subcomponents of the atomic nucleus [48] [49].

It is on account of their incompatibility with the permanent physical presence of the adiabatically varying energy with distance of the momentum ΔK of the electron and of its transverse electromagnetic complement Δm_m that the traditional classical conservative concepts of momentum, of the Lagrangian and of the Hamiltonian become unable to properly account for the stability of the hydrogen atom, because they are grounded on the traditional concept that momentum depends on velocity, and which is supposed to vanish in favor of a non-existent "potential energy" when the motion of the particle is impeded. Reference [62] analyzes this issue in depth. In an electromagnetic context, an expressed velocity is not a cause, but an effect whose expression depends on the freedom of motion allowed to a "charged" mass by the local electromagnetic equilibrium state. See Section 10.8 in Reference [79] on this particular issue.

One other example of what more clearly perceiving that the carrying energy of elementary charged particles is a physically existing substance allows understanding is the following. In frozen water, for example, the momentum energy of individual molecules is obviously completely hindered, but when its melting point is reached, some motion of the individual molecules becomes possible and the pressure applied by their momentum energy can now be expressed as motion against the now weakened resistance of the surrounding molecules, causing the molecules to easily move about with respect of each other in the now liquid mass. This brings a mechanical explanation to the motion of microscopic particles observed in liquids, known as the Brownian motion, as these microscopic particles—relative giants compared to the individual molecules of which the liquid

is made—are now repeatedly collided against by the now more freely moving molecules of the surrounding liquid [27] [28]. When in gaseous state, each molecule is now freed from any hindrance, and the ΔK momentum energy of each molecule can be fully expressed as a velocity.

Another example of the cause/effect reversal involved in a well-known physical process as considered from the electromagnetic perspective, is the case of the adiabatic compression of gases. Adiabatic compression is classically defined as causing an increase in the temperature of a gas, whereas it can be understood from an electromagnetic point of view that it is the reduction of the volume in which a gas is captive that causes the increase in temperature, by making the gas molecules—all made of charged elementary particles—getting closer to each other, each of them consequently undergoing an adiabatic increase of their carrying energy, which increases their momentum, therefore their speed and their longitudinal inertia, which in turn causes the increase in the pressure that they exert on the walls of the enclosure.

Whenever the term "translating" is used in this article for simplicity's sake with regard to electrons or up and down quarks captive in stable electromagnetic resonance states in orbitals inside atoms and nuclei, it must be kept in mind that such translation motion is at best theoretical, and that the term only implies that the energy required to potentially sustain such translating motion is permanently induced in the particle, and can just as well sustain an axial resonance oscillation of the particle about the mean distance of its orbital resonance volume with respect to the center of the atom, an axial oscillation maintained by the pressure exerted by its momentum energy towards the nucleus that prevents the mutually repelling oscillating parallel-aligned magnetic spin energy spheres of the electron and nucleus from flying away from each other (see References [48] or [49]).

So, given that the same amount of energy is induced adiabatically in a charged electron, whether it is actually orbiting the proton in an isolated hydrogen atom, as de Broglie assumed, or simply oscillating locally in axial resonance, as the electromagnetic perspective reveals, no conceptual or mathematical error is introduced by referring to the electron as oscillating on a closed orbit, on which the momentum energy is expressed as a velocity, or simply oscillating locally axially towards the nucleus, during which oscillation the momentum energy is expressed as a pressure towards the nucleus of the atom, both cases being the two limiting cases of the same process. See Reference [70].

So, in context, even if the Lorentz force equation was successfully developed to account for and control the actual relativistic velocities and trajectories of moving electrons, it can just as well account for the axial resonance motion of electrons and nucleon charged subcomponents if they are prevented from actually moving on closed orbits inside atoms.

Reference ([43], Equation (3.38)) provides the standard equation used in all existing closed circuit high energy accelerators, including the recently activated LHC, to calculate the radius of a closed orbit for a charged particle (see also Reference [70] for complementary developments). This equation was established by

equating the second term of the Lorentz force equation, that is, Equation (2) developed by Heaviside, with the fundamental acceleration equation $F = ma$:

$$F = q(\boldsymbol{v} \times \boldsymbol{B}) = ma = \frac{\gamma m_0 v^2}{r} \tag{51}$$

In which, when isolating the radius of the orbit to be established and simplifying provides the following equation:

$$r = \frac{\gamma m_0 v}{q\boldsymbol{B}} \tag{52}$$

In which the magnetic $\boldsymbol{B}$ field of the moving particle can be calculated with Equation (22). The interesting feature about this standard equation that was meant to calculate actual circular orbits for moving charges, is that it is directly adaptable to calculate the mean distance of the resonance volumes of electronic orbitals with respect to their central nuclei, whether the electron happens to be possibly orbiting the nucleus as in the case of an isolated hydrogen atom [83] or is simply captive locally in axial resonance, by using the invariant rest mass and invariant charge of the electron:

$$d = \frac{\gamma m_0 v}{e\boldsymbol{B}} \tag{53}$$

As an example of the potential usefulness of using this equation for this purpose, **Appendix A** provides the method to be used to obtain the estimated atomic radii for isolated atoms, as calculated by means of Equation (53), a few examples of which are provided in Table 1.

11. Confirming Experiments

Of course, an analysis leading to the conclusion that even macroscopic masses increase with velocity in sheer contradiction with the observed fact that no experiment with macroscopic masses ever carried out at the surface of the Earth ever gave any clue to this possibility due to their too slow velocities, even if, despite the unawareness in the current physics community—due to lack of referencing—that all physicists of the beginning of the 20th century verified, understood and agreed that the mass of the electron indeed increased with velocity according to the data collected by Kaufmann, requires more proof than only such logical reasoning and references to the formal historical accounts of these events that occurred more than a century ago.

All the more so since the same logical reasoning reveals that the rest mass of macroscopic bodies can only vary with the intensity of the local gravitational gradient, and that such variation, if confirmed, would definitely disqualify the conclusion of the 1972 Hafele and Keating experiments [84] that asserts that the increasing frequency of the caesium atoms reference photons with increasing altitude proves that the "velocity" of the "flow of time" increases as the distance increases between the clock and the large mass of the Earth, but would rather prove that this increase in frequency of the reference photons simply is due to

the perfectly natural mass increase of the caesium nucleons with increasing distance from the Earth, which in turns draws in reaction all electronic orbitals closer to the caesium nuclei of the clock, causing the energy, thus the frequency, of the reference photons to consequently increase, leaving the time element completely out of the picture.

It is entirely understandable that such doubts would dominate in the community, given that any measurable macroscopic mass increase with velocity could not begin to be measurable unless velocities achievable with macroscopic masses were way higher than those possible at our macroscopic level, since they would have to reach the 2000 km/sec range to even become measurable, which is easy for electrons at the subatomic level, as revealed by the Kaufmann data. Just like it is understandable, that the physicists of the beginning of the 20th century could have concluded that such mass increase concerned only the subatomic level, given the impossibility to detect any such mass increase for macroscopic bodies.

But we now have such clues even at our macroscopic level that were unavailable 100 years ago, that were provided by the behavior of space probes Pioneer 10 and 11 on their escape trajectories from the solar system [85] [86] [87] [88], due in part to their velocities much higher than those that are possible here on Earth, in relation with the fact that their mass was measured before launch here on Earth before they were raised in altitude to then travel in deep space, far from any large planetary mass. It is to be noted that the behavior observed with the Pioneer 10 and 11 spacecrafts also characterizes the behavior of all spacecrafts, and even of natural bodies in the solar system [78].

A very low tech and easy to carry out experiment was proposed in 2013 [75], mentioned again in 2016 [8] and in 2021 [9], that could simultaneously demonstrate that the rest masses of atoms m_0 increase when the intensity of the local gravitational gradient diminishes, such as when small macroscopic masses are taken up in altitude away from the Earth's surface, and that the velocity of the time flow is unrelated to the process, since it is impossible that the masses of the two types of atoms to be used as test masses in the experiment would increase according to different time rates as they are simultaneously lifted in altitude.

Note that this experiment was also proposed in an article submitted to the *Bureau International des Poids et Mesures* (BIPM) and to the *National Institute of Standards and Technology* (NIST) at the beginning of March of 2011 [89].

11.1. The Equal-Arms Balance Experiment

If protons and neutrons are in reality triads of electrons and positrons that accelerated until they reached a stable stationary action electromagnetic equilibrium state within a volume whose radius is in the 1.2E−15 m range, that would warp their mass and charge characteristics into those observed after they stabilized in up and down quark state, this would mean that the better part of nucleon's masses can only be relativistic in nature since the verified possible mass ranges of the up and down quarks making up their scatterable inner structure have been

experimentally confirmed to amount to barely 2% of the total mass of the proton and 2.4% of the total mass of the neutron. See References [73] and [90].

This relativistic mass must then be related to the highly relativistic velocities or carrying-energy levels—see Section 10—that the up quarks (presumably accelerated positrons) and down quarks (presumably accelerated electrons) have to maintain at the very short mean axial resonance gyroradii at which this electromagnetic equilibrium state forces them to stabilize. These velocities/carrying-energy-levels and all other related parameters are analyzed in Reference [73].

Given that the relativistic velocities—or energy levels—of their internal charged and massive subcomponents would be involved, this means that the measurable masses of protons and neutrons are directly dependant on the local intensity of the Coulomb field gradient that establishes and maintains the level the carrying energy of their charged subcomponents.

Consequently, if a small quantity of atoms is taken away from a large mass such as that of the Earth, these distances between the charged quarks within the nucleons of the small quantity are bound to shorten somewhat as the distance increases between this small quantity and the Earth, due the "diminishing outward pull" of the charged quarks of the atoms making up the large mass of the Earth as a function of the increasing distance, which will unavoidably cause the relativistic-velocities/carrying-energy-levels to increase within the nucleons of the small mass in process of moving away, which in turn will cause an increase of the relativistic energy component of this smaller mass, and thus its measurable mass.

This also means that the less densely packed nuclei of lithium or magnesium for example, are likely to have a nucleon contraction gradient towards their maximum density in deep space—far from any large mass—that would be more pronounced than that of denser elements such as uranium or osmium, as the intensity of the ambient Coulomb field gradient decreases if they are simultaneously lifted in altitude away from the surface of the Earth, given that they contain much fewer nucleons in volumes of about the same order. The diameter of denser atoms being estimated to be only about 3 times that of hydrogen, so the volumes ratio between the lowest density and highest density metals will be lower yet. See **Table 1**.

This can be verified in a very simple manner. Only an equal arms balance would be required to conduct the experiment, in which two equal masses of elements of widely different densities would be set in perfect equilibrium at ground level, or better yet, at the bottom of the deepest mine shaft possible. This assembly would then be lifted in altitude.

Why not 10 km, as was done with the first caesium atomic clocks experiment by Hafele and Keating [84]? If the nucleon contraction gradients really are different for low and high density elements, as hypothesized here, then the side holding the low density element should go down for a moment at least as altitude increases, showing that it is becoming more massive than the higher density element. Proof would then be obtained that the rest masses of nucleons do vary

in accordance with local variations of the gravitational gradient, the consequence of this increase in nucleon density as altitude increases will obviously be a tightening of all electronic orbitals about the now more massive nuclei.

The fact that two types of atoms of two different density display different rest mass increase rates with increasing distance from the Earth mass would also confirm that the velocity of the time flow can in no way be involved, since both types of atoms display these different rest mass increase rates while being simultaneously raised in altitude.

This experiment would also prove out of any possible doubt that varying relativistic velocities and/or varying carrying-energy levels are involved inside nucleons, which would definitely give substance to the possibility that nucleons could come into being by means of the apparently irreversible adiabatic acceleration process allowed from Maxwell's initial interpretation perspective [73].

11.2. Reversing the Adiabatic Process of Nucleon Creation

Other than the previously described low-tech experiment, a high-tech experiment could also be conducted that would directly confirm that up and down quarks actually are simple electrons and positrons whose mass and charge characteristics are warped into these altered states by the extreme stresses imposed on them by these most energetic stationary action equilibrium states that they can potentially be forced into by their mutual electromagnetic interaction, that is, the proton and neutron stable states.

Of course, since protons and neutrons are stable states, the adiabatic acceleration process that causes the increase in energy that ultimately add up to constitute their rest mass seems not to be reversible. But, given that the establishment of a hydrogen atom involves the stabilization of an electron into its least action orbital about a proton according to the adiabatic process described in References [8] [9], accompanied by the ejection of a 13.6 eV bremsstrahlung photon that we can detect, and that this process can be reversed by forcing the ejection of this electron when the same amount of energy of 13.6 eV is communicated to the electron, it can be surmised that the establishment of nucleon structures from triads of the two possible mixes of thermal electrons and positrons could be subject to the same reversible adiabatic process.

This could theoretically be realized by causing an immobilized proton to simultaneously absorb 3 photons of energy slightly higher than 154.8696007 MeV [73], which is the momentum energy that each incoming electron and positron was adiabatically induced with at the moment of final stabilization, and that would have been liberated as three bremsstrahlung photons, as the triad stabilized as the inner charged subcomponents that established the proton stable structure.

Similarly for the neutron, the theoretical simultaneous absorption of 3 photons of energy slightly higher than 155.2289185 MeV [73] should free in this case also the captive positron and the 2 electrons, causing the non-releasable adiabat-

ic energy that they accumulated during their initial acceleration to adiabatically reduce to zero.

In practice however, considering the difficulty inherent in producing and precision guiding such high energy photons, it is possible to consider using more numerous lesser energy photons amounting to or exceeding the required 465 MeV liberation energy being simultaneously absorbed by an immobilized target proton, coming from arrays of high power lasers.

If successful, such an experiment that would simultaneously eject the three inner scatterable subcomponents of a proton as detectable a free moving electron and two free moving positrons, accompanied by the disappearance of the adiabatically induced unreleasable energy that made up the major part of the proton rest mass, which would constitute the physical proof out of any possible doubt of the reality of the processes described in the present analysis, and that up and down quarks really are only normal positrons and electrons whose mass and charge characteristics are warped into these altered states by the stresses imposed on them by these most energetic electromagnetic stationary action axial equilibrium states that electrons and positrons can reach in nature, and by the same token, would bring the proof that the energy induced by the Coulomb interaction is of adiabatic nature.

12. Potential New Sources of Energy

Coming back to the summary description of what occurs in the solar corona presented in Section 8, the possibility that the million + temperatures ambient in the solar corona plasma could be due to some sort permanent slow chain reaction that would continuously generate nucleons as analyzed in Reference [74], the establishment of each of which would release the energy that maintains these temperatures, of course brings to mind the possibility that this process, if confirmed, could possibly be controlled to our benefit [75].

12.1. The Corona Engine

It is not difficult to imagine what could become possible if we were able to consistently manufacture highly massive protons and neutrons from way less massive electron-positron pairs generated from the decoupling of simple massless 1.022 MeV electromagnetic photons [73], that the 3-spaces model clearly hints as being a definite possibility in explaining the corona's extreme temperatures as analyzed in Reference [74], which amounts to manufacturing matter from energy, instead of painstakingly extracting energy from matter as has been our only possibility up to now.

To put it bluntly, and not even taking into account the 227 fold increase in free energy that would results from each nucleon creation, controlling as a first stage such a conversion process of two 1.022 MeV photons into 2.044 MeV/c^2 of mass (two electron-positron pairs), and then as a second stage, adiabatically converting these 2 MeV/c^2 of mass to about 938 MeV/c^2 of effective mass (one

hydrogen atom, that is one proton with its associated electron, or alternatively one neutron with a free positron to spare) through an entirely natural and irreversible acceleration process, would provide us with about 470 times our stake mass wise.

From all probabilities, the solution would fundamentally involve bombarding thin targets of still to be identified materials with massive amounts of highly focused photons of exactly 1.021998 MeV energy, so that the decoupling pairs are immediately thermal and have no momentum energy to spare to escape each other while being produced in sufficiently high concentrations and proximity for the triads to have a chance to engage the mutual interaction acceleration process.

Regarding space exploration, it becomes possible to envision propulsion systems fuelled by such massless photons, some sort of "corona engine" that would eject matter fundamentally created from pure energy in such huge quantities that constant acceleration possibly up to 1 g could possibly be envisioned, in spaceships whose masses would no longer be a factor, as put in perspective in Reference [75].

It would become possible to design hulls as thick as required, profile and magnetize them to efficiently protect crews against cosmic radiation and other particles, mostly produced as cosmic radiation high energy protons collide with the hull, at the huge relative velocities that could be achieved.

Travel to the farthest reaches of the solar system could be reduced to months while trips to Mars for colonization purposes would be reduced to weeks. The nearest stars could be round-trip reached within a time frame compatible with the duration of a human life.

Interestingly, the new generation of Free Electron Laser wigglers (FEL wigglers) already is a type of accelerator that could possibly be modulated to generate precise coherent beams of bremsstrahlung photons of the right threshold frequency required for eventual pair production when directed to appropriate target material.

In 2009 already, experimentalists succeed in accelerating coherent electrons beams in a stable manner to energies of ~0.8 MeV by bombarding a silicon dioxide target with a system of highly collimated double laser pulses at a 500 times per second frequency [91].

This means that if the conclusions which, according to this analysis, emerge from Maxwell's initial interpretation, correspond to reality, the day is not far when the magical carrier-photons 1.021998 MeV energy threshold will be reached, generated by coherent electron beams with such simplified devices that will be more easily adaptable for miniaturization and spacecraft motorization, and provide us with a source of energy available in unlimited quantities when completely controlled.

12.2. The Star Ignition Process

The present analysis reveals that only two stable stationary action resonance in-

tensities of the fundamental electromagnetic energy can be related to mass at the subatomic level, the electron mass energy intensity level and the nucleon mass energy intensity level.

The first stable energy intensity level, involving the establishment of electron and positron masses from free moving photon energy is entirely reversible and involves no adiabatic component [16]. The second one however, involving the establishment of protons and neutrons, also seems to be theoretically reversible, and involves an adiabatic component, unsuspected up to now, that opens up a very promising perspective [73].

With regard to the star ignition process also discussed in Section 8, related to the critical level of compression of hydrogen atoms located at the very center of proto-star mass accumulations, that causes the carrier-photons of the hydrogen atom electrons to come close enough to the central proton of each of these atoms for them to reach the precise decoupling triggering energy level of 1.021998 MeV, that causes the carrier-photon to immediately destabilize into converting to the required totally thermal electron-positron pair, which can immediately trigger the neutron creation process for each atom involved by combining with the now thermal carried electron, it is doubtful that such pressure could be maintained at the exact value required for successive occurrences of such decoupling events to remain totally thermal except fleetingly in any attempt to reproduce this process as a continuous sequence.

There exists however a two step process already well within our current technological capabilities, which consists in first accelerating coherent electron beams to the required precise velocity that would cause their carrier-photons to reach the critical 1.021998 MeV energy decoupling level, which in joules amounts to 1.637420828E−13 J.

As analyzed in Reference [75], this level of energy of the electron carrier-photon is reached at the fantastic critical velocity of 259,627,884 m/s, which is 86.6% of the speed of light. If these electrons are then caused to interact with catalyzing materials that will simulate the proximity of the hydrogen proton nuclei in the central area of stars, the outcome should be crowds of deuterium nuclei that could be used to sustain hydrogen fusion if coupled with the process analyzed for the corona.

Readers familiar with high energy accelerators are well aware that such velocities are easily reached and even exceeded by far up to 99.99…% of the speed of light for beams of collimated electrons in the storage rings of synchrotron accelerators and in betatron accelerators, and this since the 1960's for synchrotrons and since the 1940's for the Betatron design [92].

The following question now comes to mind: Shouldn't we have observed this neutron generating phenomenon quite often for such critical and supercritical velocities? Random occasional nucleon production were quite probably often observed as a fleeting by-product of scattering experiments carried out to observe the outcome of unrelated other elementary particles scattering processes!

It must be clearly understood at this point that the decoupling into pairs of high velocity electron carrier-photons does not depend only on the electrons having reached the critical velocity. Some destabilizing condition must be present to trigger the process at the precise triggering velocity required, otherwise this velocity will be exceeded, which will immediately prevent any pair generated from remaining thermal enough for triads to mutually capture and start accelerating. It is well understood that electrons can be pushed as far into the supercritical range that technology will allow without any decoupling of their carrier-energy to occur.

At the precise critical velocity required however, the least interference in the path of an electron beam by any other particle in the immediate vicinity of the beam, be it stray or planned, is likely to trigger decoupling. The explosive traces of such occurrences must have been recorded for the past 5 decades and these records remain available for eventual re-study.

But since the traditional purpose of all experiments carried out in high energy accelerators have been attempts at detecting ever more massive partons that technology allowed, these collisions have traditionally been carried out at the highest possible velocities. The carrier-photons' energy of the particle beams then systematically exceed the precise amount of 1.021998 MeV that must be maintained for the process to trigger, which makes it doubtful that more than a few stray neutrons would have been directly produced, which seems to be precisely what was observed [93]. See also Reference ([66] Section 20.2).

13. Gravitation

Now that all aspects of the Lorentz force equation have been clearly explained with respect to the direction of motion in which the electron is propelled by its carrier-photon momentum energy, a momentum energy that applies its pressure perpendicularly against the quasi-punctual *ds* surface of the fulcrum that connects it with its longitudinally inert transversely oscillating $\boldsymbol{E}$ and $\boldsymbol{B}$ fields energy complement, on top of against the electron also longitudinally inert invariant rest mass energy, the issue of gravitation in the universe can finally be addressed from this perspective.

Actually, Einstein himself set the stage for this issue to be resolved from the electromagnetic perspective when he concluded in his fourth 1905 article [23] that when a body emits energy in the form of radiation, its mass decreases as a consequence (see Section 2).

Given, according to simple common sense, that if the mass of a macroscopic body is made of a physically existing substance, which is proven by the fact that it verifiably occupies a volume in space that no amount of experimentation allows denying, it can also be concluded that if any amount of this *physically existing substance* is removed from this body, that results in this body's mass diminishing, this removed amount has to continue existing as a *physically existing substance* after removal.

Einstein's conclusion in this regard must be related to a conclusion from his previously published article on the creation and transformation of light into kinetic energy [20]:

"*According to the view that the incident light consists in energy quanta of energy* $(R/N)\beta v$, *the generation of cathode rays by light can be understood as follows. Energy quanta penetrate into the surface layer of the body and their energy is transformed at least partially into the kinetic energy of electrons. The simplest assumption is that a light quantum transfers all of its energy to a single electron; we shall assume that this is the case. However, it shall not be excluded that electrons absorb the energy of light quanta only partially.*"

Obviously, he was considering that the incoming energy quanta convert to momentum energy in a manner that simply adds it to whatever momentum energy the electrons may have previously possessed, that is, a mechanical absorption process that was analyzed and explained in References [12] [13] as previously put in perspective. This means that incoming photon kinetic energy can only be of the same nature as this previously existing momentum energy previously possessed by the electron.

It is quite clear by now that this previously existing momentum energy of the electron is induced by the Coulomb interaction, given that electrons are charged particles. And this is what establishes the difference between the classical concept of momentum energy, and the electromagnetic concept of electromagnetic momentum energy, an electromagnetic momentum energy that we know now makes up only half of the total energy amount induced by the Coulomb interaction, and that "when emitted by a body in the form of radiation causes its [longitudinal] mass to decrease" as Einstein concluded in his fourth 1905 article [23].

This means in turn that this electromagnetic momentum energy can only be a "physically existing substance" that keeps on existing while electrons are captive within atomic structures prior to the moment when it is emitted in the form of radiation, a condition that Einstein identified with respect to macroscopic bodies as causing a decrease in the mass of the body [23], and that when this electromagnetic momentum energy is unable of manifesting its existence as a velocity of the electron, can consequently only exert a corresponding pressure in the same vectorial direction.

The question now is: Exerting a *pressure* against what exactly?

In the case of the point-like behaving electron, this pressure will obviously be exerted against the point-like location that the electron is known to occupy in space whenever it is recorded as scattering point-like against any other elementary particle, a point-like location that must logically coincide with the center of the energy quantum of which the measurable rest mass of the electron is made.

This point-like location can be mathematically represented as an infinitesimal *ds* surface, as first introduced in Section 3, an idealized infinitesimal surface deemed to represent the actual fulcrum, or "point of application" on which the momentum energy exerts its pressure against the center of the electron energy quantum.

Let us now consider how this point of application of the momentum energy pressure of a photon or carrier-photon can be represented in the trispatial geometry.

With reference to Figure 1, the vector cross-product of the ***E*** and ***B*** fields, resulting in a third vector perpendicular to the first two is a quite familiar reference in the physics community (Figure 1(a)). To establish the trispatial geometry, each of these three linear vectors needs to be expanded into a full 3D vector space of its own (Figure 1(b) and Figure 1(c)), Y-space representing an idealized "*electrostatic space*", in which the energy displays electric characteristics, while Z-space represents an idealized "magnetostatic space", that will be the seat of all magnetic characteristic of energy, and finally X-space representing the idealized "normal space" within which momentum energy remains located in constant unidirectional mode, applying a *pressure* to the central point-like location at which the three mutually perpendicular vector spaces meet at the center of any physically existing electromagnetic energy quantum [12] [13] [25] [26].

Conceptually speaking, the universal vacuum as defined in Quantum Field Theory (QFT) can be overlaid by a vectorial Hilbert space that establishes an overall continuous vector field [94] [95] [96], each individual vector of which requires two point-like objects to be defined.

Similarly, in the alternative electromagnetic concept of an absolute void with zero energy as it could theoretically have existed at the beginning of the universe, a zero energy that would have increased adiabatically to the level which is ambient in the universe today, a minimum of two point-like behaving trispatial electromagnetic photons must have appeared simultaneously for the first electromagnetic relationship to have existed, since the individual existence of each of the two photons depends on the simultaneous existence of the other, since this existence depends on their mutual interaction. In the case of point-like behaving electromagnetic particles, pairs of electric charges of opposite signs are mandated by structure.

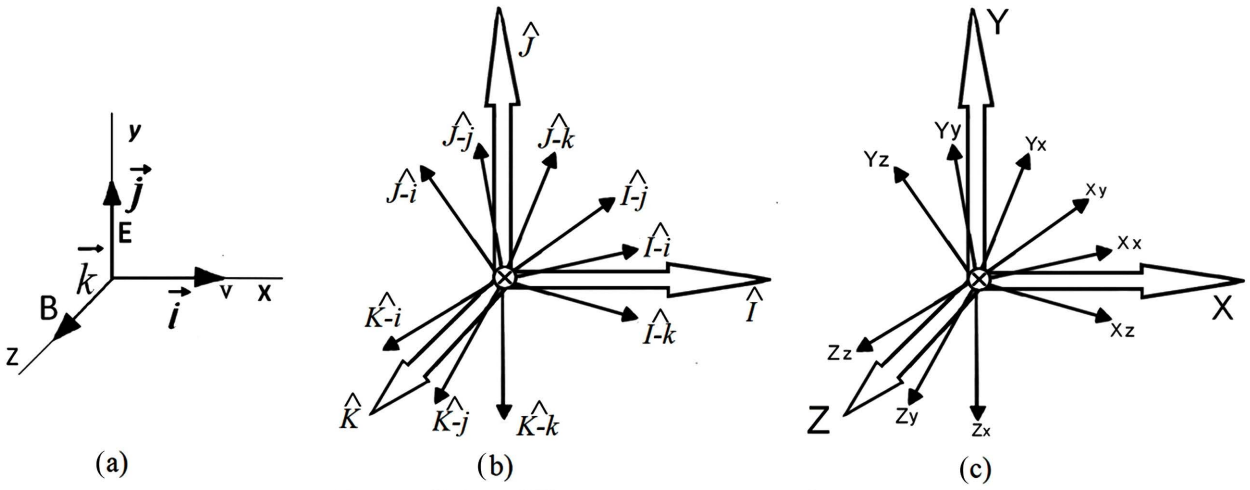

Figure 1. The Major and minor vector sets applicable to the trispatial geometry.

So, a pair of opposite signs charges would give rise in X-space to a pair of oppositely oriented vectors representing the momentum energy of each member of the pair, oriented so as to map their tendency to move towards each other with a progressively increasing adiabatic energy, function of the inverse of the diminishing distance separating them, while a pair of like signs charges would give rise to a pair of oppositely oriented vectors representing the momentum energy of each member of the pair, oriented so as to map their tendency to progressively decrease their adiabatic energy as they move away from each other as a function of the same inverse of the distance rule.

For the vectorial and energy symmetry to be maintained, two more pairs of opposite vectors are established in standing mode at the level of each point-like behaving particle, perpendicularly to the momentum vector, within Y-space for one pair, and within Z-space for the other, each pair being perpendicular to the other by structure, each pair cyclically reversing direction and inducing the other perpendicular pair in alternance in stationary standing mode with respect to the particle's point-like location at the frequency of the energy of the particle represented in the trispatial orthogonal vector structure.

What is interesting about this thee-way mutually perpendicular vector structure is that if the amount of energy represented by the two oscillating transverse pairs is made equal by structure to the energy represented by the momentum vector [81], since they represent a physically existing energy substance cyclically moving from one maximum to another oriented perpendicularly, then by structure, the energy oscillating transversely is subjected to two acceleration sequences perpendicular to each other, whose maximum velocity will reach but cannot exceed the speed of light, when half of the energy *substance* has transferred from one orientation to the other, if the velocity of the *substance* is to return to zero when at maximum in either perpendicular orientation [12] [13]; the half-half equilibrium between the momentum energy half and the transversely oscillating energy half being what ensures that the momentum energy of the particle establishes the invariant speed of light of the photon in vacuum, which was mathematically confirmed in References [31] and [67] for both transverse and longitudinal velocities.

First will now be presented a series of figures that were developed to illustrate the internal oscillation of the energy within elementary electromagnetic particles in the trispatial geometry. Then will be addressed the relation between the charges of the elementary particles of which all atoms are made and gravitation.

The representation of **Figure 2** is an exploded sequence of the successive transverse states that the oscillating half of an electromagnetic photon's energy travels through during one of its transverse oscillating cycles, first introduce in Reference [67], and of the unidirectional momentum energy half-quantum that propels the transversely oscillating half at the speed of light in vacuum.

The same description applies to the carrier-photon of an electron in free motion, with the difference that in addition to propelling its transverse oscillating

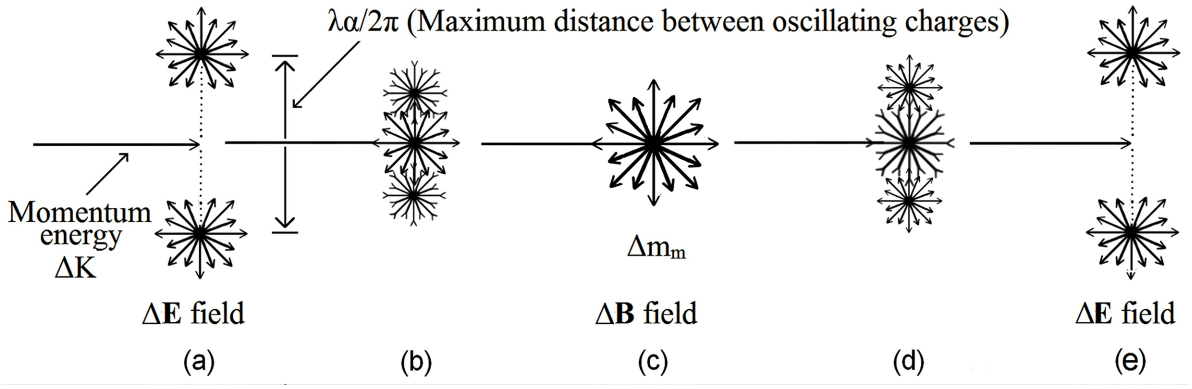

Figure 2. Representation of the transverse oscillation cycle of the electromagnetic half-quantum of a photon or of an electron carrier-photon.

inert other half, the momentum energy of the carrier-photon also has to propel the inert transverse rest mass energy of the electron—not illustrated in **Figure 2**, causing the ratio propelling-momentum-energy/propelled-transverse-energy to limit the momentum component to forever account for less than half of the sum total of the energy of which the carrier-photon and the carried-electron are made, thus preventing the electron from ever reaching the speed of light, as analyzed in Reference [68].

The representation of **Figure 3** shows the same sequence with the successive aspects of the transverse oscillation cycle regrouped on the same transverse plane with respect to the momentum energy of the quantum, both the longitudinal momentum half and transverse oscillating half of the carrier-photon energy being united into a single quantum through the central quasi-punctual location within each photon or carrier-photon that also acts as the fulcrum against which the momentum energy is applying its pressure, in this plane wave treatment representation.

The representation of **Figure 4** describes the internal oscillating field energy structure of the rest mass of the electron, of the up quark state and of the down quark state, corresponding to Equation (31) for the electron rest mass, to Equation (43) for the up quark rest mass state and to Equation (44) for the down quark rest mass state. Equation (31) was established in Reference [16] and the neutrinic field was analyzed in Reference [72]. Equations (43) and (44) were established in Reference [73].

Let us note that the carrying-energy of the electron is not represented in **Figure 4**. The combined energy of the electron rest mass and of its carrier-photon can be calculated with Equation (32) from their separate energy values, and with Equation (33) from their separate wavelengths. The combination of their trispatial fields equations is available as Table I in Reference [16].

The $\boldsymbol{E}$ fields of the electron, of the up quark and of the down quark correspond to their respective electric charges, which are the only charges that exist inside the hydrogen atom. By structure, the electron stabilized in the hydrogen atom ground state has a charge of C_e = 1.602176462E−19 Coulomb, and the three

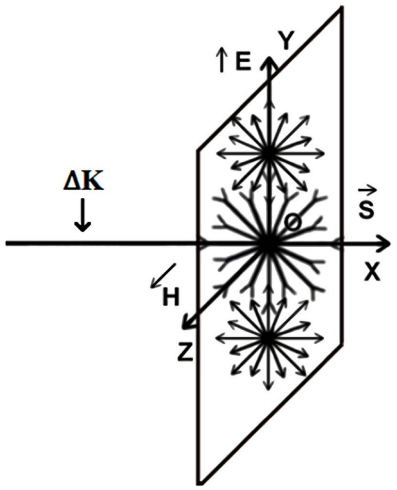

Figure 3. The plane wave concept being applied to a permanently localized photon or carrier-photon.

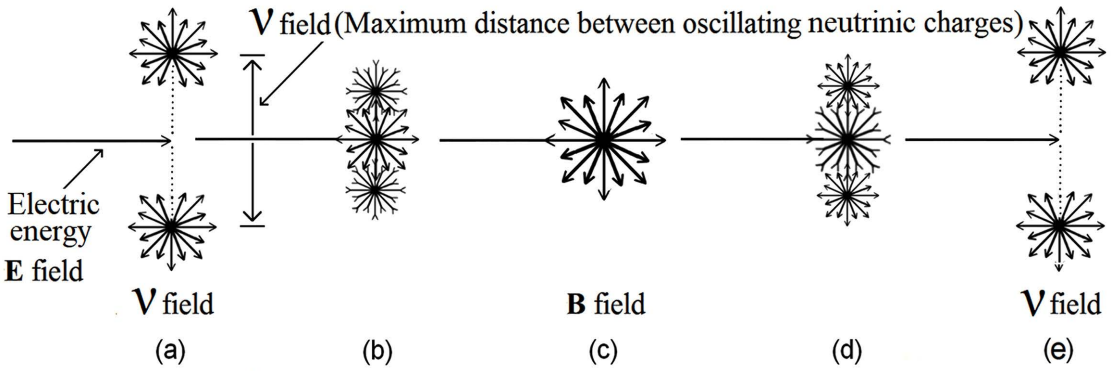

Figure 4. Representation of the transverse oscillation cycle of the invariant magnetic field corresponding to half of an electron invariant rest mass and of the invariant electric field of the other half of its invariant rest mass.

charges of the proton are two up quark charges C_u = 1.068117641E−19 Coulomb, and one down quark charge C_d = 5.340588207E−20 Coulomb, for a total of 4 charges making up the internal structure of the hydrogen atom. They are being constantly induced carrying energy by the permanently present underlying Coulomb interaction as a function of the inverse of the distances separating them, and these energy levels are subject to vary according to any variation in intensity of the local gravitational gradient that determines these distances.

Consequently, from the electromagnetic perspective, the hydrogen atom is not a system of two massive bodies in mutual interaction as still currently considered in classical/relativistic mechanics, but is rather a system of four charged electromagnetic elementary particles in mutual interaction, stabilized in electromagnetic resonance stationary action state [62].

The same transposition from the traditional perspective of interacting masses to the perspective of interacting electromagnetic charged elementary particles seems to be required for all existing atoms as well as for all macroscopic and astronomical sized masses, so that it becomes possible to clearly understand how

the gravitational gradient is dependent on the Coulomb interaction.

This in no way implies that calculations carried out according to the masses interaction perspective are inappropriate or inexact, only that the strict masses interaction perspective does not allow relating the universal Coulomb interaction to the universal gravitational gradient, due to the absence of any reference to the known intimate relation that physically exists between the invariant charge of the electron and its invariant rest mass in all current theories, and this, despite the fact that this relation was clearly established by Einstein himself in his 1910 article [14], as analyzed in References [80] and [81]:

"*We can, for example, obtain in this way the equations of motion of a material point of mass m carrying an electric charge e* (*for example an electron*) *and subjected to the action of an electromagnetic field. We know, in fact, the equations of motion of a material point at the moment when its velocity is zero. According to Newton's equations and the definition of the electric field strength, we have*."

$$(2)\quad m\frac{\mathrm{d}^2x}{\mathrm{d}t^2}=e\boldsymbol{E}_x \quad ([14], \text{p. } 143)$$

To analyze a tentative first draft procedural example to realize this transposition operation from the traditional perspective of interacting masses towards the perspective of interacting charges at the general level, we will use both the hydrogen atom internal mass structure and its internal charges structure as a test case.

From this perspective, the hydrogen atom mass involves adding the standard mass of the electron to the standard mass of the proton (m_e = 9.10938188E−31 kg and m_p = 1.67262158E−27 kg), that is, m_h = 1.673532518E−27 kg.

Let us now calculate the force applied to a hydrogen atom at ground Earth level by means of the established acceleration value due to gravity at mean Earth ground level [11]:

$$a=\omega^2 r=\frac{v^2}{r}=g=9.80665\ \mathrm{m/s^2} \tag{54}$$

Let us note that this standard acceleration value is the mean acceleration value between the precise acceleration of 9.83208 m/s^2 at the poles and the precise acceleration of 9.78036 m/s^2 at mean sea level at the equator [90]. The force obtained with the mean acceleration value for a hydrogen atom at the surface of the Earth is:

$$F=m_h\cdot g=1.641174767\mathrm{E}-26\ \mathrm{N} \tag{55}$$

Given that this is the mean force at the surface of the Earth, multiplying this force value by the estimated mean radius of the Earth r = 6378140 meters [90] will give us the amount of adiabatic carrying energy induced in the hydrogen atom at ground level:

$$E=F\cdot r=1.641174767\mathrm{E}-26\times 6378140=1.046764243\mathrm{E}-19\ \mathrm{j} \tag{56}$$

Converting this value into electronvolts for comparison purposes by dividing it by the unit charge of the electron (e = 1.602176462E−19 Coulombs) gives

0.653338922 eV. As established for the energy induced by the Coulomb interaction in the electron stabilized at the mean orbital distance of the ground state of the hydrogen atom, half of this energy self-orients perpendicular to the other half to oscillate between the electric and magnetic states, increasing the measurable mass of the hydrogen atom, while the other half remains unidirectionally oriented toward the center of the Earth as momentum energy, applying its pressure on the hydrogen atom oriented towards the center of the Earth.

Now, given that the hydrogen atom inner structure involves 4 elementary charged particles, and that only two of them are interacting in attraction with the other two, only the possible attraction between these two charges and the charges of opposite sign of the Earth will be considered, since as analyzed in Reference [75] the repelling relations between same sign charges become infinitesimal at very close range and can be ignored, while the attractive relations between opposite signs charges constantly increases with the diminishing distances between them, so the amount of energy calculated with Equation (56) will be shared in equal parts by both attractive charges of the hydrogen atom.

Now, as established in Reference [69], all classical force equations have been proven to be derivable from each other and from the $F = ma$ fundamental acceleration equation—see Equation (35) in Section 7—including the Coulomb force equation. This means that the force just calculated with Equation (55) can be directly related to the Coulomb force equation, in agreement with Einstein's conclusion in his 1910 article previously quoted [14].

It is at this point that the jump can be made from the interacting masses perspective to the interacting charges perspective between bodies lying at the surface of the Earth and the Earth itself. Given that the two charges of the hydrogen atom that will interact in attraction with the opposite sign charges of the Earth can be assumed to be at the same distance from the center of the Earth, given the infinitesimal parallax angle that the diameter of the hydrogen atom offers when considered from the center of the Earth, we will also assume, for simplicity's sake in this demonstration that both have the same electric charge, that is, the charge of the electron. Multiplying then this charge of the electron by 2 gives us the charge of the hydrogen atom that can be put in charges-pairs attractive relations with opposite charges of the Earth:

$$q_1 = 1.602176462\text{E}-19 \times 2 = 3.204352924\text{E}-19\ \text{C} \tag{57}$$

The composite attractive charge of the Earth can then be calculated by isolating q_2 in the standard Coulomb equation (see Equation (14)), using the force calculated with Equation (55), the composite attractive charge of the hydrogen atom calculated with Equation (57) and the radius of the Earth previously given:

$$q_2 = \frac{F 4\pi\varepsilon_0 r_e^2}{q_1} = 2.318254855\text{E}-04 \quad \text{Coulomb} \tag{58}$$

If we then divide q_2 by the unit charge, we obtain the number of attractive charges that theoretically account for half the mass of the Earth:

$$A_E = \frac{q_2}{e} = 1.446941027\text{E}15 \quad \text{attractive elementary charges} \tag{59}$$

Multiplying this value by 2 will then give the estimated number of elementary charges of which the whole mass of the Earth is made (A_E·2 = 2.893882054E15).

Similarly, the attractive force exerted on the Earth mass by the Sun can be calculated with the traditional gravitational equation [69], in which M represents the estimated mass of the Sun (M = 1.9891E30 kg), r represents the mean radius of the Earth orbit (r = 1.4959787E11 m), m represents the estimated mass of the Earth (m = 5.9742E24 kg), G is the gravitational constant (G = 6.673E−11 Newton·m^2/kg^2) [90]:

$$F = G\frac{Mm}{r^2} = 3.543289846\text{E}22 \text{ N} \tag{60}$$

Knowing the composite attractive charge of the Earth established with Equation (58) and using it as charge q_1 in the Coulomb equation, the attractive force of the Sun calculated with Equation (60), and the radius of the Earth orbit, the composite attractive charge of the Sun can be calculated by isolating charge q_2 in the Coulomb equation:

$$q_2 = \frac{F4\pi\varepsilon_0 r_e^2}{q_1} = 3.805878467\text{E}38 \quad \text{Coulomb} \tag{61}$$

Dividing q_2 by the unit charge, we obtain the number of attractive charges that theoretically account for half the mass of the Sun:

$$A_S = \frac{q_2}{e} = 2.375442754\text{E}57 \quad \text{attractive elementary charges} \tag{62}$$

Multiplying this value by 2 will then give the estimated number of elementary charges of which the whole mass of the Sun is made (A_S·2 = 4.750885508E57).

The same procedure can be applied to all atoms of the periodic table that make up all masses lying at the surface of the Earth and of any other heavenly body, to all masses in orbits in the Solar system and to all masses in the universe, to calculate the number of charges of which they are made and calculate the gravitational force exerted on each of them by means of the Coulomb equation.

Regarding massive bodies resting at the surface of the Earth, that provide our first clues to the reality of gravitation, the weight of an object as measured at the Earth's surface can only be a measure of this pressure exerted by the sum of the individual momentum energies vectorially oriented towards its centre of mass, belonging to half of the whole set of separate charged particles of the atoms that constitute the measurable mass of this object [12] [13]. For example, when we climb on a bathroom scale to verify our "*weight*", it is this pressure that the sum of the momentum energies that this half of the crowd of elementary charged particles, of which our body is made, exerts toward the ground that we are measuring. In other words, what we name "*the force of gravity*" can be seen as an "*impeded velocity*" expressed as a "*pressure*" due to the fact that the unidirectional momentum energy induced in bodies oriented towards the ground cannot

be expressed as motion.

At the astronomical level, the celestial bodies of the solar system seem to be captive in stable stationary action resonance states at mean distances from the Sun similar to that which de Broglie assumed to apply to the electron in the hydrogen atom [48] [49], *i.e.* a state of axial resonance of celestial bodies on closed orbits, limited by very precise minimum and maximum stable distances from the central star, which are their perihelion and aphelion. These two boundary distances combined with the mean radius of the elliptical orbit of each celestial body constitute the three stable references that allow clearly defining the volumes of space visited over time by each celestial body about the central star.

On the other hand, unlike the case of the hydrogen atom, as analyzed in References [48] [49], for which the intensity of the momentum energy level induced in the electron at the mean Bohr radius distance from the proton with respect to the electron mass, that clearly favors a local high frequency axial resonance motion rather than a translational motion on a closed resonance orbit at the same average distance from the proton, the ratio of the adiabatic energy induced in each charged particle of the Earth's mass at the average distance of the Earth's orbit from the Sun, with respect to the energy making up the mass of the Earth, being insufficient to generate such a high frequency axial oscillation, given the inertia of the macroscopic mass of which each charged particles is captive, rather favors the stabilization of celestial bodies in the observed stationary action closed orbital motion.

The volume of space visited over time by each celestial body about a central star can evolve into fairly complex shapes for celestial bodies that have satellites, which induces beat frequencies that cyclically modify the otherwise regular volumes visited by bodies that do not have satellites. In fact, all bodies stabilized in such axial resonance systems mutually influence each other's trajectories and the shape of the resonance volumes that they visit. It is this type of interaction, combined with the occultation process of the central star as these bodies pass between this star and our position in space that allowed the identification of the many planets orbiting nearby stars that have recently been discovered.

14. The Analysis Method

The analysis method used all through the *Electromagnetic Mechanics of Elementary Particles* project is described in Reference [97], republished in final version as Reference [98], and the mathematical method used is described in Section 27 of Reference [99], republished in final version as Reference [100].

15. Conclusions

One major aspect of Lorentz's 1904 article was mentioned but not discussed in this work because it was out of direct context, since it pertains to the reason why Lorentz was proposing his transformations, that is, the apparent impossibility to prove absolute motion. This issue was analyzed as part of this project, but would

require a too lengthy introduction to be addressed as a side issue in this already long article. The pertaining final analysis is available in Subsection 3.5.1 of Reference [80], and in Subsection 17.8 of Reference [26], following a preliminary analysis in Reference [25].

As mentioned in Section 9, the trispatial wave equations of this model remain to be developed. They minimally comprise the varying wave equation required to describe the resonance volume visited by a free moving photon, the varying single beat wave equation required to describe the resonance volume of an electron moving freely, and the varying double beat wave equation required to describe the motion of an electron captive in axial resonance state in an electronic orbital.

A recently published example of wave function development that exemplifies the recent evolution of ideas in new directions in fundamental physics, that the trispatial approach presented in this article is part of, is the development by Declan Trail of interesting wave functions for the electron and the positron, which are stable solutions to the Schrödinger's wave equation [101].

Coming back to the trispatial model, as mentioned in the conclusions of References [8] and [9], considering the relative simplicity of implementation of the experiments described in Section 11, that could confirm whether the initial irreversible acceleration sequence of newly created elementary charged particles is subject or not to the Principle of conservation, and the potentially unlimited energy source that could become available from controlling the process as described in Section 12, if this conclusion emerging from the trispatial model is confirmed, it is to be hoped that the physics community will become interested in having these experiments carried out sooner than later.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix A

This Appendix establishes the procedure to calculate the atomic radii for unbound atoms by means of the second term of the Lorentz force equation traditionally used to calculate the radius of circular orbits for charged particles in high-energy accelerators, considering that the same amount of energy is required to maintain an electron on a closed resonant orbit about the nucleus of an isolated hydrogen atom, or to maintain it in an axial resonance state at the same mean distance from the nucleus without it necessarily moving on a closed orbit as explained in Section 10, by calculating the mean distance between the nucleus and the outermost orbital of atoms using the wavelength of the first ionization energy of each atom (Column A). Some of these radii for atoms mentioned in this paper are shown in Table 1 (Columns D and E).

A.1. Calculation Procedure

Calculation of the values of Column E was carried out with a Texas Instrument TI-89 Titanium calculator.

Taking the Helium atom first ionization energy value of 24.58741 eV (Column A in Table 1) as an example, here is how each atomic radius of Column E can be calculated by means of Equation (53), repeated here for convenience (see Section 10):

$$d = \frac{\gamma m_0 v}{e\boldsymbol{B}} \tag{53}$$

First, the first ionization value in eV of the atom—here that of the helium atom—is converted to joules by multiplying it by the invariant charge of the electron (1.602176462E−19 C):

$$E = 24.58741 \cdot e = 3.939336956\text{E} - 18 \text{ j} \tag{A.1}$$

This value is then doubled to account for both components of the carrying energy induced by the Coulomb interaction at the corresponding mean distance from the helium nucleus, corresponding to the first two terms of Equation (50), corresponding in fact to Equation (47), reproduced here for convenience:

$$2E = \Delta K + \Delta m_m c^2 = 3.939336956\text{E} - 18 \times 2 = 7.878673913\text{E} - 18 \text{ j} \tag{47}$$

The related wavelength is then calculated by means of the standard equation:

$$\lambda = \frac{hc}{2E} = 2.521284145\text{E} - 8 \text{ m} \tag{A.2}$$

Making use of the electron Compton wavelength (λ_c = 2.426310215E−12 m), the corresponding relativistic velocity is calculated by means of Equation (33):

$$v = c\frac{\sqrt{\lambda_C\left(4\lambda + \lambda_C\right)}}{2\lambda + \lambda_C} = 2940812.243 \text{ m/s} \tag{33}$$

The term $\gamma m_0 v$ of Equation (53) can then be resolved as follows, resolving the γ-factor with the velocity obtained from Equation (33):

$$\gamma m_0 v = \frac{2E}{v} = 2.679080901\text{E} - 24 \tag{A.3}$$

The value of the magnetic field $\boldsymbol{B}$ corresponding to wavelength λ calculated with Equation (A.2) is then obtained with the following equation:

$$\boldsymbol{B}_{(\lambda)} = \frac{2\pi(2E)}{ce\alpha^2\lambda} = 7676725.6829 \text{ T} \tag{A.4}$$

Then, given that the variable values of Equation (53) have been resolved, it can in turn be resolved for the first ionization energy of the helium atom with the values provided by Equations (A.3) and (A.4) to provide the related atomic radius:

$$d = \frac{\gamma m_0 v}{e\boldsymbol{B}_{(\lambda)}} = 2.178341596\text{E}-11 \text{ m} \tag{53}$$

in which d would be the approximate radius of the isolated helium atom as estimated via the second term of the Lorentz force equation. This value is listed rounded in picometers in column D of **Table 1** for direct comparison with the values of Columns B and C, and listed in meters in column E in standard physics notation with the radii of other atoms of the periodic table.

Column A provides the list of the first ionization values for each atom of the periodic table, taken from Reference ([90]. p.10-178).

For comparison purposes with other atomic radii calculation methods, columns B and C respectively list the values for the Empirical Bound Ionic Method [102] and the Calculated Atomic method [103].

Table 1. Table of atomic radii—not bound.

		A	B	C	D	E
	Symbol	Ionization energy in eV	Empirical bound ionic	Calculated atomic	Calculated not bound $\gamma m_0 v/e\boldsymbol{B}$ rounded	Calculated not bound $\gamma m_0 v/e\boldsymbol{B}$
1	H	13.59844	25	53	53	5.296111314E−11
2	He	24.58741	120	31	22	2.178354555E−11
3	Li	5.39172	145	167	212	2.121269975E−10
12	Mg	7.64624	150	145	125	1.256073509E−10
76	Os	8.4382	130	185	108	1.083459614E−10
92	U	6.19405	175	No data	172	1.722756745E−10